DETERMINANTS OF POST-HARVEST MILK LOSSES AMONG MILK PRODUCERS AND TRANSPORTERS IN THE DAIRY VALUE CHAIN IN NYANDARUA NORTH SUB-COUNTY, KENYA

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A thesis submitted to the Graduate School in partial fulfillment for the requirements for the Master of Science Degree in Agribusiness Management of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been submitted in this or any other university for the award of any degree.

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Recommendation

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DEDICATION

To my dear parents and beloved family the late Mr. Ndungu Munyori, Mrs. Elizabeth Munyori, Karanja Munyori, Mugo Munyori, Serah Mathai, Elias Mathai, Andy Mathai and Liz Mathai for all their support throughout my studies. God bless you.

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ABSTRACT

Nyandarua County has enormous milk production potential and has a high amount of milk due to large population of dairy cows coupled with the huge milk market demand from within and without. Despite this potential, milk post-harvest losses have posed a major challenge to the dairy sector in the county. The objectives of the study were: to characterize the socio economic and milk handling attributes of milk producers, to estimate mean milk losses attributable to milk producers and transporters and to establish factors that contribute to the choice of a milk marketing channel and causes of losses among milk producers. A total of 188 milk producers were selected through proportionate to size sampling from each of the nine locations of the Sub-County. A census of 43 transporters was undertaken as well identified through a list provided by the two main milk processors in the sub county. Statistical analysis as well as quantitative analysis were done with the help of Microsoft Excel, STATA and SPSS ver 21. The findings reveal that the mean landholding size was 3.96 acres, and the mean age was 47 years. Mean milk production was 18 and 9 litres during the high season and low season respectively per day. Results of losses experienced indicated that milk losses were higher for milk producers sampled in the formal chain (84%) than in the informal chain (16%). The mean milk losses among transporters was 104 litres per transporter per month. It was further noted that milk transporters who used high speed means like use of motorbikes and vehicles experienced significantly higher losses than those using low speed means like walking, bicycles and donkey carts. The first step Heckman results indicated that gender of household head, total milk output, keeping of records and type of milk container significantly influenced the choice of milk marketing channel while the the major contributors of milk losses were gender of household head, total milk output, use of detergent to clean milk containers, type of milk container and keeping of production records. The study recommends that the policy implementers and dairy stakeholders should prioritise efforts to minimise post-harvest milk losses considering that the implications of these losses directly affect the economic wellbeing and livelihood of farmers. Milk marketing channels, both formal and informal, need to be re-evaluated based on returns and convenience with emphasis on proper post-harvest milk management and handling. Training and awareness creation on milk handling attributes among milk producers and transporters should be a priority especially for county governments. This will reduce on the losses and additional cost incurred by milk producers and transporters ultimately resulting to higher economic returns for the respective chain actors in the dairy value chain.

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ACRONYMS and SYMBOLS

EAAPP	Eastern Africa Agricultural Productivity Project
EADD	East African Dairy Development
FSC	Food Supply Chain
GDP	Gross Domestic Product
IIRR	International Institute of Rural Reconstruction
KAPAP	Kenya Agricultural Productivity and Agribusiness Project
KALRO	Kenya Agricultural and Livestock Research Organization formerly the Kenya Agricultural Research Institute (KARI)
KCC	Kenya Cooperative Creameries
KDB	Kenya Dairy Board
KEBS	Kenya Bureau of Standards
KNBS	Kenya National Bureau of Statistics
KES	Kenya Shillings
LDCs	Least Developed Countries
MoA	Ministry of Agriculture
MoL and FD	Ministry of Livestock and Fisheries Development
MoLD	Ministry of Livestock Development
PHL	Post-harvest Losses
RTI	Royal Tropical Institute
UNIDO	United Nations Industrial Development Organization
USA	United States of America
VC	Value Chain
AI	Artificial insemination

CHAPTER ONE
INTRODUCTION

1.1 Background information

Kenya has a vibrant dairy industry with an estimated value of 4% of gross domestic product (GDP). This vibrancy is anchored on the increasing domestic milk production (averaging 5.3% per year), processing capacity (averaging 7% per year), annual per capita milk consumption (averaging 5.8% per year, currently at 110 litres) and export potential (Rademaker, 2016). Kenya's dairy industry, the single largest livestock production sub-sector contributes about 3 percent of national Gross Domestic Product (GDP) and employs over 2 million smallholder farmers (FAO, 2011). The industry plays an important role in food security, employment creation, income generation and enhances the livelihoods of dairy farmers, traders, processors and all participants engaged in the entire milk value chain. The total dairy cattle herd estimated at 3.4 million heads produces about 3.1 billion liters of milk annually (Muia *et al*., 2011). The industry supports an estimated 500,000 waged jobs and over 750,000 jobs in related services (Kenya Dairy Board, 2008). These farmers do practice mixed farming, cultivating food crops, fodders and cash crops with the crops by-products being used as cattle feeds in the dairy production. It is estimated that central Kenya region earned close to 30 billion KES from the value of milk produced and that 70% of this income went to smallholder dairy farmers (Mbugua *et al*., 2012). However, it has been revealed that despite this significant contribution to the national economy and household incomes, post-harvest losses are a major problem in the dairy sector (Lore *et al*., 2005). Post-harvest losses in the dairy industry can be described as losses at the farm level after milking and through the market chain to consumption. Losses can either be through spillage and/or spoilage. There is a category of loss commonly referred to as "forced consumption", which occurs due to limited market opportunities (Muriuki, 2003).

According to Food and Agriculture Organization (FAO, 2014), Kenya loses about 95 million litres of milk annually accounting for a loss of up to US$ 22.4 million (approximately KES 2.24B) per year, the impact of which is being felt the most at farm level. According to Muriuki (2003) and verbal communication with MoALD district staff, the losses by the farmers and the co-operative societies were between 5 and 10 percent of the milk marketed through the co-

operative pathway. Extension agents in Nyandarua claim a loss of about 45 percent by some societies during wet seasons. Such high loss is recorded when the processors impose unilateral rationing or milk quotas of the amount delivered to their processing plants. The effect of post-harvest losses includes reduced benefits of the efforts put into milk production and lowers marketing efficiency as well as farmers' income. In the long run unnecessary job losses may take place. It is apparent that the magnitude of the post-harvest milk and dairy products losses in Kenya is not adequately documented and available statistics on this are not based on scientific evidence but on assumptions (Muriuki, 2003). One of the major factors affecting the quality of dairy products is related to the practice of proper milking procedures and cleanliness of the milking utensils (Gonfa *et al*., 2001). Over the years, significant changes in the traditional dairying have occurred resulting in a major shift towards market-oriented smallholder production. This has been possible mainly due to the suitable climatic conditions, significantly improved fodder technology and dairy cattle population, high urban population, incomes and the high consumption of milk and dairy products. However, it is apparent that milk, like other agricultural products is prone to losses in between production and consumption. (Muia *et al*., 2011)

Losses at the farm level after milking extend through the market chain to the consumption where it is commonly referred to as food waste. This is the milk, either raw, fresh or in its various products forms ready for consumption that gets spoilt due to poor handling and lack of cooling facilities. Food is lost or wasted throughout the supply chain from initial agricultural production down to final household consumption. In medium and high-income countries, food is to a significant extent wasted at the consumption stage, meaning it is discarded even if it is suitable for human consumption. Significant losses also occur early in the food supply chain in the industrialized countries. Comparatively, in the low-income countries like Kenya, food is lost mostly during the early and middle stages of the food supply chain; much less food is wasted at the consumer level (Gustavsson *et al.*, 2011). The dairy value chain starts at the pre-production point, to input provision, production, distribution and marketing, processing and consumption. The shortage of milk in the country is worsened by the wastages that take place along the value chain and specifically at farm level, during transportation and at the processing stage. The economic and welfare implication of this scenario is felt most at farm level. In

addition, the wastage along the value chain occurs at five main stages that includes; production, post-harvest handling, processing, distribution, and consumption where forced consumption, spillage, spoilage, and processing conversion losses being the major points of losses.

The significance of dairy farming and the milk market is reflected across a number of levels, providing quick returns for small-scale livestock keepers. However, a study done on East Africa and Near East by International Livestock Research Institute (ILRI) indicates that despite this significant contribution to the national economy and household incomes, the dairy industry is besieged by a number of technical, economic and institutional problems, which seem to have escalated in the recent past (Lore *et al*., 2005). Nyandarua County has enormous milk production potential and it produces the high amounts of milk due to its higher population of dairy cows as compared to the other regions in Central Kenya (Ministry of Livestock and Fisheries Development, 2007). Due to the importance of the dairy sector in the Sub-County, the major agriculture based value chain is that of dairy. Overall milk production during the year 2012 in Nyandarua North Sub-County was 45 million litres which reflected an increase from 34 million litres attained the previous year. Average milk production was 5 – 7 Kgs/cow per day with an average milk price per litre of KES 25.00. Other value chains in the Sub-County include the mushrooms value chain (Odendo *et al.*, 2010), potato value chain, horticulture (snow peas and cabbages), apiculture (bee keeping) and meats (indigenous poultry). According to the Kenya Agricultural Productivity and Agribusiness Project (KAPAP) Nyandarua County final report 2015, eighty percent (80%) of the county's farm families are engaged in dairy production with an average production of 7 -10 litres of milk per cow per day. Most of the farmers are small scale farmers and the majority of them have less than 1 acre of land to grow fodder. This means that the dairy farmer has to practice free-range rearing in times of scarcity which results in low milk production. Most of these farmers sell their milk at the farm gate level with very few farmers selling their milk as a group or through a cooperative.

1.2 Statement of the problem

Nyandarua north Sub-County has enormous milk production potential due to large population of dairy cows coupled with the huge milk market demand from within and without. Despite this, milk post-harvest losses have posed a major challenge to the dairy sector in the Sub-

County. Given the perishable nature of milk, losses are experienced among producers and transporters along the dairy value chain between production and delivery to the processor. Milk producers have different channels through which they can sell their milk. However, the factors that compel farmers to use a certain channel are not known. This study seeks to fill this gap by identifying the underlying factors influencing the choice of a milk marketing channel and losses incurred under each channel as well as losses incurred during milk transportation. This would contribute to better understanding of underlying challenges and formulation of policies that will lead to an efficient and effective dairy value chain that considers milk producers and milk transporters as important actors in this chain.

1.3 General objective

The general objective of the study was to contribute to the reduction of milk losses among milk producers and milk transporters in Nyandarua North Sub-County.

1.3.1 Specific objectives

i. To characterize the socio economic and milk handling attributes of milk producers in Nyandarua North Sub County.
ii. To estimate the mean milk losses among milk producers and transporters in Nyandarua North Sub County.
iii. Determine the factors influencing choice of milk marketing channels among milk producers in Nyandarua North Sub County.
iv. Determine the causes of milk losses among milk producers in Nyandarua North Sub County.

1.4 Research questions

i. What are the socio economic and milk handling attributes of milk producers in Nyandarua North Sub-County?
ii. What are the mean milk losses attributable to milk producers and transporters in Nyandarua North Sub-County?
iii. What are the factors that influence choice of a milk marketing channel among milk producers in Nyandarua North Sub-County?

iv. What are the causes of milk losses among milk producers in Nyandarua North Sub-County?

1.5 Justification

Dairy farming provides relatively quick returns for small-scale livestock keepers. The vast majority of milk produced in milk producing regions of Kenya, Nyandarua included comes from small-scale milk producers. It not only provides families with a balanced, nutritious food, but sales of extra milk can play an important role in bolstering household food security and reducing poverty. Furthermore, Nyandarua farmers have always been experiencing losses amounting to millions due to poor milk handling and processing capabilities subsequently leading to post-harvest milk losses especially during glut periods. Estimated waste percentages for milk in Sub-Saharan Africa, Kenya included are production stage 6%, post-harvest handling and storage 11%, processing and packaging 0.1%, distribution 10% and consumption 0.1% (Gustavsson *et al*., 2011). The highest percentage of losses comes from production and post harvest handling and distribution. Reducing losses and waste in agricultural and food systems could relieve part of the pressures on scarce resources and enhance food security as consumers will benefit by saving the money which they can use elsewhere (on food or non-food products) and it lowers the price of the remaining food that is consumed in the market (Rutten, 2013).

Demand for milk and dairy products in COMESA and EAC countries is predicted to grow at 3.5 % annually upto 2020 hence the need for interventions to support growth and exploit the opportunity. Opportunities at production level include improving overall management of the smallholder's farms through well directed extension approaches (Mbugua *et al*., 2012). The report further states that there exists transport and marketing challenges including poor roads, low access to cooling facilities in milk surplus areas and lack of appropriate milk transport equipment. There is also the huge challenge of unmarketable milk quantities due to low production and many farmers who are not organised into efficient marketing systems. Some of the cooperatives existing in the milk producing area also experience organizational and management challenges coupled with negative perception by the farming community and other stakeholders.

1.6 Scope / Limitations of the study

This study focused on Nyandarua County, since it has the largest numbers of dairy cattle in central Kenya region. It targeted dairy farmers and milk transporters, with a specific focus on the post-harvest losses of milk. This study focused on factors significant in the initial stages along the value chain, which are at production and during transportation, where main losses are experienced. Losses occurring at the end of the value chain (that is retail and final consumption) were not considered. Some limitations in this study included the language barrier since most of the targeted respondents use the local dialect that was overcome by the use of enumerators from the locality. The study was also constrained by failure of farmers to give accurate information due to poor record keeping and reliance on recall data.

1.7 Definition of Terms

A value chain refers to the chain of activities, which transform raw materials into something that can be purchased by a final consumer or user. A VC is characterized by the sequence of production which include; provision of inputs, primary production, intermediary trade, processing, marketing, final consumption/use and, the quality of linkages and coordination between business partners in the VC.

Food losses refer to the decrease in edible food mass throughout part of the supply (e.g. production, post-harvest and processing stages, retail and discarding) that specifically leads to edible food for human consumption.

Infrastructure and facilities refer to the stock of basic facilities or capital equipment needed for the functioning of the dairy industry. Examples include milk coolers, roads, trucks, water and electricity.

Post-harvest losses in the dairy industry are losses at the farm level after milking and through the market chain up to the consumption. This is the milk, either raw, fresh or in its various product forms that gets spoilt due to spillage, spoilage, poor handling and lack of cooling facilities.

Smallholder farmers in this study refer to milk producers producing less than 50 litres of milk per day.

Milk transporters involved those using high speed means (vehicles and motorbikes) and those using low speed means (walking, use of bicycle and donkey carts)

CHAPTER TWO
LITERATURE REVIEW

2.1 Smallholder dairying in Kenya

Dairy production is an important activity among smallholder farmers in Kenya. Commercial dairying was introduced into Kenya in the early twentieth century, but indigenous Kenyans were not involved in it until the mid-1950s. After independence, most dairy cattle were transferred to the indigenous people, marking the beginning of smallholder domination of the dairy industry (Muriuki, 2011). The report further indicates that milk production is mainly from cattle (3.5 million head of Friesian, Ayrshire, Jersey and Guernsey breeds and their crosses, and 9.3 million indigenous animals), camels (1 million) and goats (13.9 million). Dairy cattle produce about 70 percent of total national milk output (more than 3 billion litres). According to Rangnekar and Thorpe (2001), dairy production creates employment opportunities through both the informal and formal market channels with the informal sector being more efficient in terms of prices, net incomes and employment creation. It has been argued that the road to dairy development cannot be through the informal sector, but the reality as seen in many developing countries is that the sale of raw milk, which drives the informal sector, is going to continue for a long time to come.

In Kenya, two main types of cattle are kept for milk production and other purposes. These are the exotic breeds and their crosses (Karanja, 2003). Milk production in Kenya is predominantly by small scale farmers, who own one to three dairy animals, and produce about 80 percent of the milk in the country (Wambugu *et al*., 2011). Kenyan milk production systems can be divided into two general categories: large-scale and small-scale. The small-scale or smallholder dairy production system dominates. The differences between the two dairy systems are in their sizes of operation, level of management and use of inputs. Dairy cattle in smallholdings feed mainly from forage and very small quantities of concentrate, but some small-holder dairy farmers are highly commercial and well versed in dairy production, with high-quality management (Ndungu *et al*., 2016). With at least 3 million improved dairy cattle, most of which are kept by smallholder farmers, Kenya is one of the developing world's most successful milk producing countries mainly due to the strong local culture of milk consumption and the favourable

agroclimate of its tropical highlands (Staal *et al*., 2003). Kenya has a long history of dairy farming, and the dairy subsector has always been a priority for policy makers (Schreiber, 2002).

In a study carried out in Kiambu district, Central province located in Kenya highlands by Mburu *et al*. (2007), the results of the survey showed that dairy enterprise was the most important income generating farming activity in 96% of households in Kenya highlands. Revenue in a dairy enterprise accrues from sale of milk and animals, and milk consumed by households and calves. Though some farms had negative gross margins, on average revenues significantly exceeded costs and the dairy enterprise returned a profit. In central Kenya farmers are shifting away from the extensive and less productive grazing systems. Trends in most study areas revealed an increasing shift towards stall feeding with some grazing (Lukuyu *et al*., 2011). Further interventions aimed at improve feed productivity and sufficiency on small-holder dairy farms should be undertaken in a sustainable way using participatory approaches aimed at improving farmer training, access to information and strengthen linkages with stakeholders. A coalition approach where all the potential stakeholders are brought on a common platform has a demonstrated effect on the uptake of new technology. Schreiber (2002) adds that both large and small-scale producers in Nyandarua rely mainly on grazing to feed their cattle, with some seasonal supplementation. The report however adds that in Nyandarua, the demand for improved pasture and fodder crops, water supply, and feed conservation technology reflects the constraints still imposed on dairy production by the natural environment.

Dairy production in Kenya is undertaken under various production systems. These systems in order of their production intensity and occurrence include, smallholder zero grazing, smallholder open grazing and large-scale open grazing. In most of the dairy producing areas, milk collection is organized along collection routes. Individual farmers deliver the milk to the pick-up point or marketing agents collect the milk directly from the farms. Further, Kenya ranks among the lowest countries in terms of cost of production per litre of milk. This therefore means that Kenya is in the league of nations that have been able to create a thriving dairy export industry. The country has the production capacity having the largest and well-developed dairy herd in Sub-Saharan Africa (Karanja, 2003). Staal *et al*. (2003) further states that available evidence suggests that smallholder Kenya dairy farmers will continue to do well under a variety

of production systems even though seasonal fluctuations may have temporary adverse effects on some groups. Schreiber (2002) further indicates that distance to market, an unfavorable environment, and poor infrastructure prevent markets and services from developing in Nyandarua. Through the supply chain analysis, the study concludes that the emerging structure of post-liberalization dairy sector in Kenya is characterized by lack of co-ordination between production, processing and marketing. This lack of vertical co-ordination continues to impact negatively on the performance and efficiency of the sub-sector (Karanja, 2003).

2.2 Post harvest milk losses in the dairy sector

Post-harvest milk losses in the dairy industry can be described as losses at the farm level after milking and through the market chain to the consumption. This is the milk, either raw, fresh or in its various products forms that gets spoilt due to poor handling and lack of cooling facilities. Inefficiencies and ineffectiveness of management practices in food value chains are one of the major reasons for food losses (Amentae *et al.,* 2016). Negi and Anand (2017) also note that supply chain loss in the post-harvest management of agri produce is one of the major determinants of the food problem in most developing countries. The major concern for fresh Agro Supply Chain Management is the post-harvest wastage. Agriculture in general, and dairy production in particular, is both knowledge and technology-intensive (Schreiber, 2002). Reducing food losses offers an important way of increasing food availability without requiring additional production resources, and in Least Developed Countries (LDCs) it can contribute to rural development and poverty reduction by improving agribusiness livelihoods (Hodges *et al*., 2011). The study further reports that in LDCs, the main cause of loss is biological spoilage. Livestock products, fish, fruit and vegetables lose value very quickly without refrigeration. PHLs in LDCs are also relatively unknown and are mostly guesstimates derived from questionnaires rather than actual measurements.

In Kenya, information on post-harvest losses is minimal and where available it is not backed by scientific analysis (Muriuki, 2003). A report by TechnoServe Kenya (2008) indicated that smallholders are limited by low levels of production, product quality, market infrastructure, low feed and fodder quality, post-harvest losses and lack of processing equipment. Karuga (2009) noted that according to various studies, the performance of the dairy industry in Kenya is still

below its full potential. The studies primarily attributed this to a number of constraints among them high post-harvest losses due to poor roads infrastructure, cooling facilities and handling techniques. At macro level, post-harvest losses have an effect on imports. Substitution of imports can represent a good growth strategy for a territory, given that local production usually represents savings in transportation and post-harvest losses. For this to succeed, a list of key products imported which include dairy products needs to be prepared. Afterwards, demand trends will be examined as well as purchasing requirements based on this saving (Ostertag *et al*., 2005).

A World Bank report (2012) further indicated that African smallholder farmers who sell surplus harvest typically receive less than 20 percent of the market price of their products with the rest being eaten away by various transaction costs and post-harvest losses which is a clear disincentive to produce for the market (Brenton and Isik, 2012). Moreover, in low-income countries, these so-called losses in edible food mass destined for human consumption predominantly occur in agricultural production, post-harvest and processing stages - over 40% in the latter two stages (Rutten, 2013). In Uganda, a dairy report on post-harvest milk losses noted that considerable attention must be given to hygiene practices, preservation, and appropriate container use at all market levels in order to avoid quality deterioration due to bacterial buildup. It should also be noted that spoiled milk on farm and even at collection points may not be fully "lost", in that soured milk has value and may often be consumed. Its value per unit may nevertheless have declined compared to fresh milk. Both formal and informal losses are mainly based on estimates which appear to combine both complete losses (spillage) with partial losses (spoilage in some settings) (Staal and Kaguongo, 2003).

The United Nations predicts that 1.3 billion tons of food is lost globally every year (Gustavsson *et al.*, 2011). With the current world population expected to reach 10.5 billion by 2050, the loss if prevented can feed future generations. Food losses in developed countries occur primarily at the consumer level, although some losses occur on the fields or at other stages of the supply chain. Field losses occur because of farmers' decisions to forgo harvesting due to tough market standards. Losses in developing countries, in contrast, occur mostly during the field-to-market stages, with the smallest share of losses occurring at the consumer level. Premature harvesting,

poor storage facilities, lack of infrastructure, lack of processing facilities, and inadequate market facilities cause high food losses in developing countries along the entire Food Supply Chain (FSC). Poor post-harvest food loss (PHL) estimates affect the quality of food availability data. Food security assessments and other analyses, which consider projections of future food needs, rely on food balance-sheet information (Aulakh, 2013). However, the magnitude of post-harvest losses in Kenya is not well documented. Milk losses through co-operative societies may be between 1 to 5 percent on average but can go up to over 10 percent in the wet season when delivery rejections are common. Lack of market for the milk produced that is above home needs can also be termed as a loss and estimates for "forced consumption" of such milk depend on seasons and can go as high as 50 percent (Muriuki, 2003).

A value chain describes the entire range of activities undertaken to bring a product from the initial input-supply stage, through various phases of processing, to its final consumer, and it includes its disposal after use. For instance, agro-food value chains encompass activities that take place at the farm level, including input supply, and continue through handling, processing, storage, packaging, and distribution. As products move successively through the various stages, transactions take place between multiple chain stakeholders, money changes hands, information is exchanged and value is progressively added. Macroeconomic conditions, policies, laws, standards, regulations and institutional support services (communications, research, innovation, finance) -which form the chain environment - are also important elements affecting the performance of value chains (UNIDO, 2009). The dairy value chain provides a platform where challenges experiences by chain actors can be addressed. Better integration, especially in the initial steps of the value chain, would allow for more cost control, and profit maximization.

According to UNIDO (2009), policy-makers have increasingly focused on the development of effective agro-value chains as a means of further expanding the leading role played by agriculture in economic growth and poverty reduction. Such chains uniquely integrate natural sources of supply with the dynamics of food and fiber demand. Their development has a positive impact on business linkages as well as building responsible and sustainable relationships among chain actors and enhances food security by reducing post-harvest losses and by extending the shelf life of food and fibers for rapidly growing urban populations. Post-

harvest losses in percentages are minimal in industrialized countries but are as high as 40% in developing countries. In a value chain, each actor bears certain types of risks including low rainfall, economic losses resulting from prices below the production costs, glut that pushes down prices, low demand, post-harvest losses among a myriad of other risks. It is also important to note that people who provide services to chains also face risks (Peppelenbos, 2008).

It is important to realize agricultural production does not end at harvest time; rather there is a production-consumption continuum which includes a variety of post-harvest activities. Rural producers need effective connections to the next links on the postharvest chain. Research thus does and should not stop with the reduction of post-harvest losses, but include institutional arrangements, processing industries, enterprise development, market information systems, and commercialization (Golletti and Wolff, 1999).

The lack of market infrastructure and institutions in rural areas means that many markets are thin and imperfect (Sinja *et al*., 2006; Muia *et al.,* 2011). The latter also reports that most of the milk produced during the wet season in Nyandarua was not marketed due to the poor road network and long distance to the markets. Since milk is highly perishable and farmers did not have the means to invest in milk cooling equipment, the high volumes of milk produced during the wet season were therefore associated with high-post harvest losses. Kiaya (2014) further notes that marketing is the final and decisive element in the post-harvest system, although it can occur at various points in the agro-food chain and cannot be separated from transport, which is an essential link in the system. Interventions in PHL reduction are seen as an important component of the efforts of many agencies to reduce food insecurity, increasingly aimed at realizing agricultures full potential to meet the worlds increasing food and energy needs.

2.3 Contributors of milk losses at farm level

Small-scale dairy production is an important source of cash for subsistence farmers in East-Africa (Sinja *et al*., 2006). Smallholder dairying dominates both milk production and marketing in Kenya. Dairy marketing in Kenya mainly involves liquid milk where over 80% is sold raw with itinerant milk traders (hawkers) controlling about 28% of market. The presence of a large population of dairy cattle, a large and growing human population who include milk as part of their diets and a supportive environment are indications of the opportunities that exist for

smallholder dairying in Kenya (Rangnekar and Thorpe, 2001). The report further adds that dairy sector also creates employment opportunities through both the informal and formal market channels with the informal sector is the more efficient in terms of prices, net incomes and employment creation. It has been argued that the road to dairy development cannot be through the informal sector, but the reality as seen in many developing countries is that the sale of raw milk, which drives the informal sector, is going to continue for a long time to come.

According to Omiti *et al*. (2009) Kenya is currently the leading milk producer in the East African Community. Consumer demand for milk is estimated to be growing at 3.6% per year, largely due to the increase in population, improvement in purchasing power and increasing market penetration into (previously) non-milk consuming areas. This growing demand offers scope for wealth creation among small-scale farmers and poor remote households in Kenya. Bebe *et al*. (2003), further adds that Kenya is recognized among developing countries for its success in integrating dairy into smallholder farming systems, particularly in the highland areas. The major determinants of this success were colonial history, its favourable agroecology, supportive agricultural policies and the importance of milk in rural and urban diets. The report further states that in response to agricultural policies, market opportunities and human population pressure on land, smallholders have changed their farming systems by introducing the Friesian and Ayrshire breeds, keeping smaller herds with fewer heifers but more cows, increasing stocking rates through stall-feeding, growing fodder, purchasing feeds and becoming more dependent on external inputs and services. As a result, they can sell more milk. Dutta *et al.* (2013) also notes that increased productivity is an essential component of a vibrant agricultural sector and improved pre and post-harvest technology is essential to ensure high yield, quantity and quality of products.

Farm level milk losses resulting from poor handling of milk at the farm tend to account for the biggest proportion of all milk losses within the typical milk value chain especially in Sub - Saharan Africa. A report seeking to quantify actual milk losses in Sub- Saharan Africa and the near East found that in terms of quantity, significant milk losses occur at the farm level (8.4, 28.6, 46.4 and 54.2 million liters of milk per year for Uganda, Ethiopia, Tanzania and Kenya, respectively) valued at approximately 0.9–11 million US dollars. Post-harvest losses of milk at

the farm represented 1.3 to 6.4 percent of the value of available milk at the farm level (Lore *et al*., 2005). Most of the milk is produced by smallholder farmers but an estimated 18% of the product is lost due to inadequate cold chain storage and inefficient distribution (Postharvest Loss Challenges Discussion Paper, 2013). At the farm level, commercialization is mainly affected by agro-climatic conditions and risks; access to markets and infrastructure; community and household resource and asset endowments; the development of local commodity, input, and factor markets; laws and institutions; and cultural and social factors affecting consumption preferences, production, and market opportunities and constraints (Omiti *et al*., 2009).

In Kenya, total farm-level losses were quantified as 4.5 per cent of milk value available at the farm. This includes physical loss of milk through spillage and spoilage (3.8 per cent of milk production) and economic loss through "forced consumption" of evening milk and surplus milk above normal household requirements (2.4 per cent) (Lore *et al*., 2005). A case study of Njoro Dairy Cooperative Society done by Land O' Lakes (2008) noted that there are high post-harvest milk losses because small scale farmers often mix the evening milk that is kept under poor storage conditions with morning milk before delivery which is often rejected by the processors. The availability of milk marketing outlets ensures the cooperative can sell the milk without incurring high post-harvest losses for the members through communal marketing arrangements or sell to the hawkers. The communal marketing arrangement involves common transport with some farmers having to milk their animals as early as 4.00 a.m. Some farmers put the evening and morning milk in different cans while others bulk their small quantities for convenience of reaching the market and making transport costs more effective. According to Lore *et al*. (2005), causes and influencing factors of milk losses at the farm may be as a result of Inadequate markets, failure to access remote markets and market rejection, Poor roads, lack of cooling facilities and unreliable or non-existent electricity supply, lack of technical knowledge on safe handling of milk; use of inappropriate milk containers among others

The government of Tanzania acknowledges that post-harvest losses due to poor storage technologies pose a major challenge to the agricultural sector and overall food security in the country. This is attributed to low adoption of improved storage technologies by poor farmers due to either lack of knowledge or poor delivery. The government therefore plans to increase

awareness and access to these technologies as a potential solution to the post-harvest losses. There is need to underscore the central role of storage methods as a way of managing the post-harvest losses in the agricultural sector (Ndiritu, 2013). Hooton and Omore (2007) also noted that a change in attitude and behaviour towards raw milk marketing has been evident in Kenya since around 2000, reflected in marked changes in implementation of dairy marketing regulations by KDB paving way for piloting of alternative approaches supportive of informal small scale-milk traders.

2.4 Contribution of transport and infrastructure to post-harvest milk losses

The poor state of the roads in Nyandarua was evident in a study by Muia *et al*. (2011) where only 30% of the households had access to good roads and hence could purchase inputs and market their farm produce throughout the year. The report further stated that during the rain seasons, most of the roads were impassable particularly in the upper highlands with firm clay and clay loam soils hence farmers were unable to sell their farm produce. Due to the poor road network and long distance to markets, cost of transportation was high rendering smallholder dairy production uncompetitive. Infrastructure' plays a very vital role and is the backbone for the supply chain of any industry. In fruits and vegetables supply chain, it comprises cold chain facilities; transportation infrastructure like road conditions, connectivity, network, port infrastructure; food processing facilities for semi processing, sorting, grading, packaging and marketing facilities among others (Negi and Anand, 2017).

Milk losses at the transport level tend to be as a result of poor choice of containers to move the milk, or poor choice of means of transport vehicle. In a study of milk losses in the Ethiopian dairy industry, spillage of milk is reported to be high when milk is transferred from producers premises to collection points and when retailing. The large amount of loss being reported when transporting is through spillage amounting to 1.5% of the milk transported along the informal channel with children carrying the milk in inappropriate containers. The formal channels also record spillage losses during transportation (Aytaged and Tolesa, 2004).Often in the informal sector, milk is transported in non-food grade plastic containers by bicycle over poor rural roads from the farm to rural milk collecting centers. Plastic containers are difficult to sterilize and thus their use for milk handling contributes to milk spoilage. For this reason, the regulatory

authorities do not approve of using plastic containers in marketing milk (Lore *et al*., 2005). The Rapid Appraisal study by Omore *et al*. (1999), estimated that 30 percent of milk production from several districts is lost annually due to the poor state of roads. It has been further noted that lack of cold chain may be a major factor contributing to post-harvest milk losses (Omore *et al.*, 2001). Negi and Anand (2017), further attribute the major causes for losses and wastages in the logistics and supply chain management of fresh agro food produce are poor infrastructure, large number of intermediaries, poor transportation, storage and handling among others. They further add that there have been huge losses in the dairy sector due to ill-equipped and weak cold chain infrastructure.

Infrastructural challenges directly influences the level of milk losses resulting from transportation. Long distances to market result in significant losses due to spoilage. This is often compounded by the poor road infrastructure that hinders timely access to markets; especially in the wet season (Lore *et al*., 2005). The biggest single infrastructure contributor to milk losses is the poor state of roads in milk producing regions. Losses occur either because the transport from the collecting agent cannot reach the villages or the farmers are unable to reach the collection centre. In both cases, the cause is the poor condition of the roads during the wet season. However, it was reported in many instances that this occurred during only a short period of the year. Whereas this may be seen to reduce the potential number of days when a loss can be realized, it is also true that while the farmer is able to reach the milk collection centre, the condition of roads further from the centre may cause the milk collection vehicles not to come to the centre (Smallholder Dairy Commercialization Programme, 2010). Kiaya (2014) notes that primary challenges in the transportation stage of the supply chain include poor infrastructure (roads, bridges, etc.), lack of appropriate transport systems, and a lack of refrigerated transport. In most developing countries, roads are not adequate for proper transport. According to Lore *et al.* (2005), The major causes and influencing factors of milk losses along the distribution chain are low standards of milk hygiene, use of inappropriate containers; lack of training, Poor roads, lack of cooling facilities, irregular electricity supply and Lack of access to markets among others. Raw milk is highly perishable and, thus, requires rapid transportation to consumption centres or for processing into less perishable forms. Milk loses limit marketing

options for small and remote dairy producers, raise transaction costs, and imply greater losses due to spoilage than for commodities such as grain (Sinja *et al.*, 2006)

It is apparent that the major source of milk losses in Kenya is the seasonal imbalance between supply and demand and problems of milk collection associated with poor infrastructure such as rural roads, water and sources of power to service and maintain a cold chain. Although some of the losses, like "forced consumption" will require a long term investment planning, use of quality assurance measures along the whole milk market chain will significantly reduce the losses in the short run (Muriuki, 2003). In addition, Heifer's International East African Dairy Development (EADD) project solved the high post-harvest milk losses problem by facilitating the establishment of refrigerated chilling plants at strategic locations where farmers can bring their milk for storage and pickup by commercial dairies (Land O'Lakes, Inc., 2008). Cooling remains a challenge primarily due to the high cost and lack of availability of pre-cooling facilities, inadequate training on pre-cooling technology at the commercial scale, and lack of information on cost benefits of pre-cooling technology (Kiaya, 2014).

Transport as a crucial factor could be managed by the bulking or chilling plant, optimizing routes and minimizing costs. Increases in volumes benefit all those in the chain; producers, transporters, chilling plant owners, processors and other dairy stakeholders (TechnoServe Kenya, 2008). Negi and Anand (2017) further note that proper measures to improve the supply chain efficiency and development of cold chain infrastructure and food processing units will improve the scenario of fresh agro produce and will give better returns to the farmers and also help to enhance and improve the food economy. Staal *et al*. 2003 further notes in areas of significant milk surplus, where most milk must be transported to urban centres to be sold, transportation costs can have a significant effect on the price farmers receive for their milk

2.5 Theoretical framework

This study is based on the Utility maximization theory and is built on the assumption that a milk producer's decision to participate in a particular milk channel is based on whether or not they will maximize their utility. A milk producer in the formal channel maximizes utility through

assured markets while those in the informal channel maximize utility through higher milk prices. The same applies for transporters who aim at maximizing their profits.

In the context of this study, the impacts of tackling food losses and waste differ from the size of food losses and waste and depend, in addition, on the extent to which they are avoidable, factors that cause them to arise and the costs associated with measures to reduce them. Interactions within the food supply chain and the broader economy also affect the impacts. Trade-offs occur on the demand side where a reallocation of spending on previously wasted foods cause some producers to be worse off and some to be better off. Over time, producers tackling losses may have to incur welfare losses in the short run with gains in terms of increased revenues, if any, occurring later. These losses have an impact on milk supply and demand dynamics and ultimately, milk price which determines the farmers' income. Losses and wastage economically speaking have a huge impact on the farmers' income and the national economy. Furthermore, milk waste at production end of the value chain is indicative of the country's level of development. This can be explained by the fact that developed countries do experience loss at consumption normally referred to as food waste. The level of milk lost and wasted at production end is minimal in developed countries. This can lead to a conclusion that management of milk losses within the entire dairy value chain is directly related to development of the dairy sector and the economy as a whole. This can be further illustrated by use of low-dimension partial equilibrium analysis (Rutten, 2013).

Figure 1 depicts the market for a food commodity, d, with a standard upward sloping supply curve and a standard downward sloping demand curve. The price mechanism ensures that demand equals supply. The equilibrium is reached at point A, where the price is P0 and the quantity traded is Q0. The depicted situation is best interpreted as capturing the full supply chain from farm to fork, but concealing the various intermediate stages in supply (for example, storage, transport, processing).

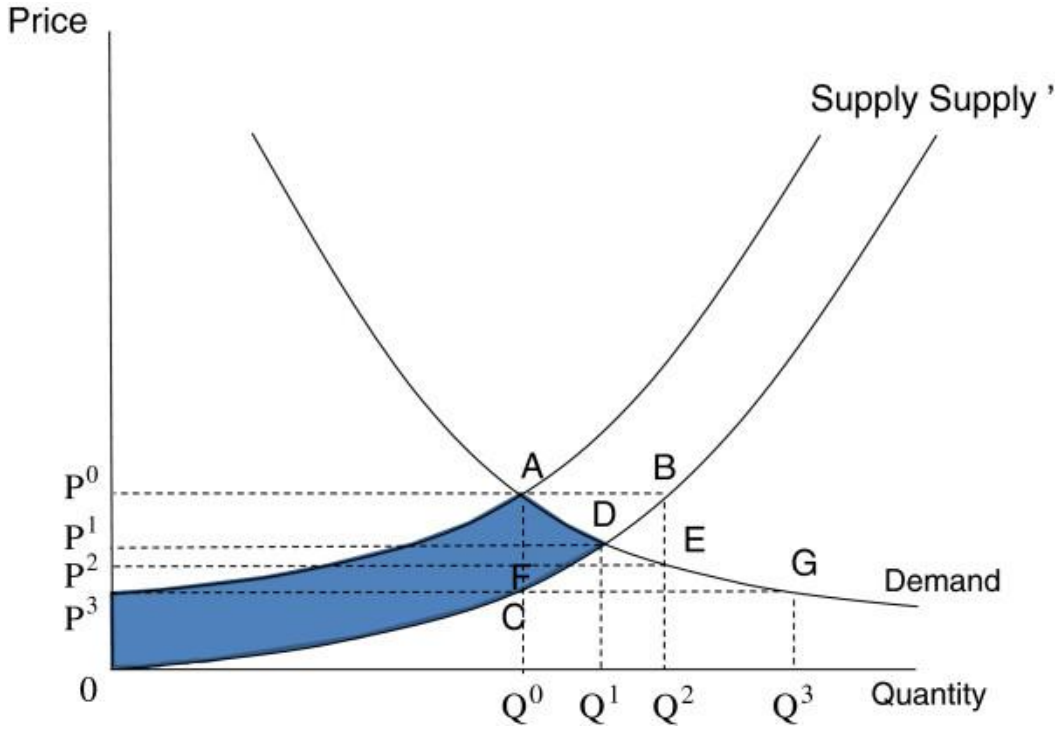

Figure 1: Low-dimension partial equilibrium analysis

Source: Rutten, 2013

Assuming that there are losses in the production and supply of this food commodity, the socially optimal supply curve, or the supply curve of this food commodity that would not have these losses, lies below the original supply curve, as depicted by Supply' in Figure 1; given the original price, P0, more can actually be produced and supplied to the market (Q2 at point B), or the original quantity, Q0, can actually be produced at a much lower cost (P3 at point C) if losses were to be absent. Note that the 'optimal' supply curve does not necessarily have to be parallel to the original supply curve, as the extent of losses may vary with the scale of production (and price).

What happens if food losses in supply for the food commodity in question are tackled? Suppliers may, for example, be induced to tackle the losses because of the emergence of a new technology, which makes this possible and worthwhile, or new policies (regulations, taxes and subsidies) that penalize and stimulate reductions in food losses. The action of avoiding the losses, given the original demand curve and given the underlying motivation of doing so, would result in a lower price, P1, and a higher equilibrium quantity, Q1, in the market, as given by

point D. At this new equilibrium consumers can buy more food at a lower price, resulting in a welfare gain to consumers as measured by the change in the consumer's surplus of P0ADP1. Similarly, producers can sell more, but at a lower price, resulting in a change in the producer surplus of P^1D0 - $P0AP^3$, which is also positive. The overall welfare gain equals the sum of the change in the producer and the consumer surplus, which amounts to the area P^3AD0, the blue shaded area between the new and old supply curve and under the demand curve.

These impacts - lower equilibrium price, higher quantity of food produced and consumed, and welfare gains for both producers and consumers - seem to be in line with the qualitative literature on impacts and are encouraging from the perspective of low-income countries, where food losses on the supply side dominate. From Figure 1, it can also be seen that the size of the impacts will depend, amongst others, on how big the losses are relative to the size of the market, which as shown, varies by type of food and country or region. Whatever the extent of the losses, in terms of quantity the size of the impact, Q^0Q^1, however, is much smaller than the original size of the problem, Q^0Q^2, which is due to the change in the price. The impacts of tackling food losses and waste differ from the size of food losses and waste and depend, in addition, on the extent to which they are avoidable, factors that cause them to arise and the costs associated with measures to reduce them. Interactions within the value supply chain and the broader economy also affect the impacts (Rutten, 2013).

2.6 Research gaps

Demand for milk and dairy products in COMESA and EAC countries is predicted to grow at 3.5 % annually until 2020 hence the need for interventions to support growth and exploit the opportunity. Postharvest innovations to mitigate the losses were minimally documented and mostly their impact on reducing the losses was not evaluated comprehensively (Ndaka *et al*., 2012). Aulakh *et al*. (2013) further noted that most of the available postharvest loss and food waste estimates are based on the anecdotal stories with few actual measured or estimated numbers. Moreover these numbers, in turn, feed into estimates of food availability which are widely used in food security assessments and policy analyses. Limited work has been conducted in the estimation of Post-Harvest Losses (PHLs). Most of the published works available on PHL estimation are FAO initiatives, based on surveys in the developing countries. The study further

notes that consistent measurement of food losses is a necessary first step toward reaching the goal of reducing PHL's. Not much progress has been made in this direction due to 'measurement problems'. Amentae *et al*. (2016) notes that there is no universally agreed method for food loss assessments methodology that fits to measuring food losses for all types of food commodities in all situations.

A lot of post-harvest loss studies have been done mostly on cereals like rice, wheat and maize. There are limited studies on post-harvest losses for perishable products including milk. This study was also informed by the information which is in the public domain as a result of milk being poured by farmers in Nyandarua due to lack of adequate marketing channels and this resulted in public outcry as to why such an eventuality could have occurred when other parts of the country lack sufficient quantities of milk. This study seeks to strengthen PHLs database which will help improve other estimations and projections which rely on food balance sheets.

2.7 Conceptual framework

In a value chain, the actors are faced with a variety of intertwined factors which influence their participation and decisions which are mostly aimed at maximizing economic returns from their respective contributions in the milk value chain. However, post-harvest milk losses at the various stages of the value chain are perceived to reduce the expected net economic returns of these actors in their respective levels. There is a host of socio economic, and farmer characteristics of milk producers such as gender, age, education level, household size among others that influence dairy production especially at farm level. This by extension affects the handling of post-harvest losses at farm level which is an important and key level in the dairy value chain. This also affects the other levels of the value chain because milk produced at farm level flows progressively within the chain with value being added at the various stages. Cumulatively, post-harvest milk losses are caused by a variety of factors at different levels of the milk value chain and in this case, focus will be on the two levels of the value chain where post-harvest milk losses are perceived to occur. These are the farm level and transportation level.

Government policies and socio economics characteristics have an indirect impact on the performance of the dairy sector which also influence the management of post-harvest losses. The conceptual framework shows the interaction between the two levels of the milk value chain and how each level contributes to the perceived precedence of milk post-harvest losses and the variables of interest under each.

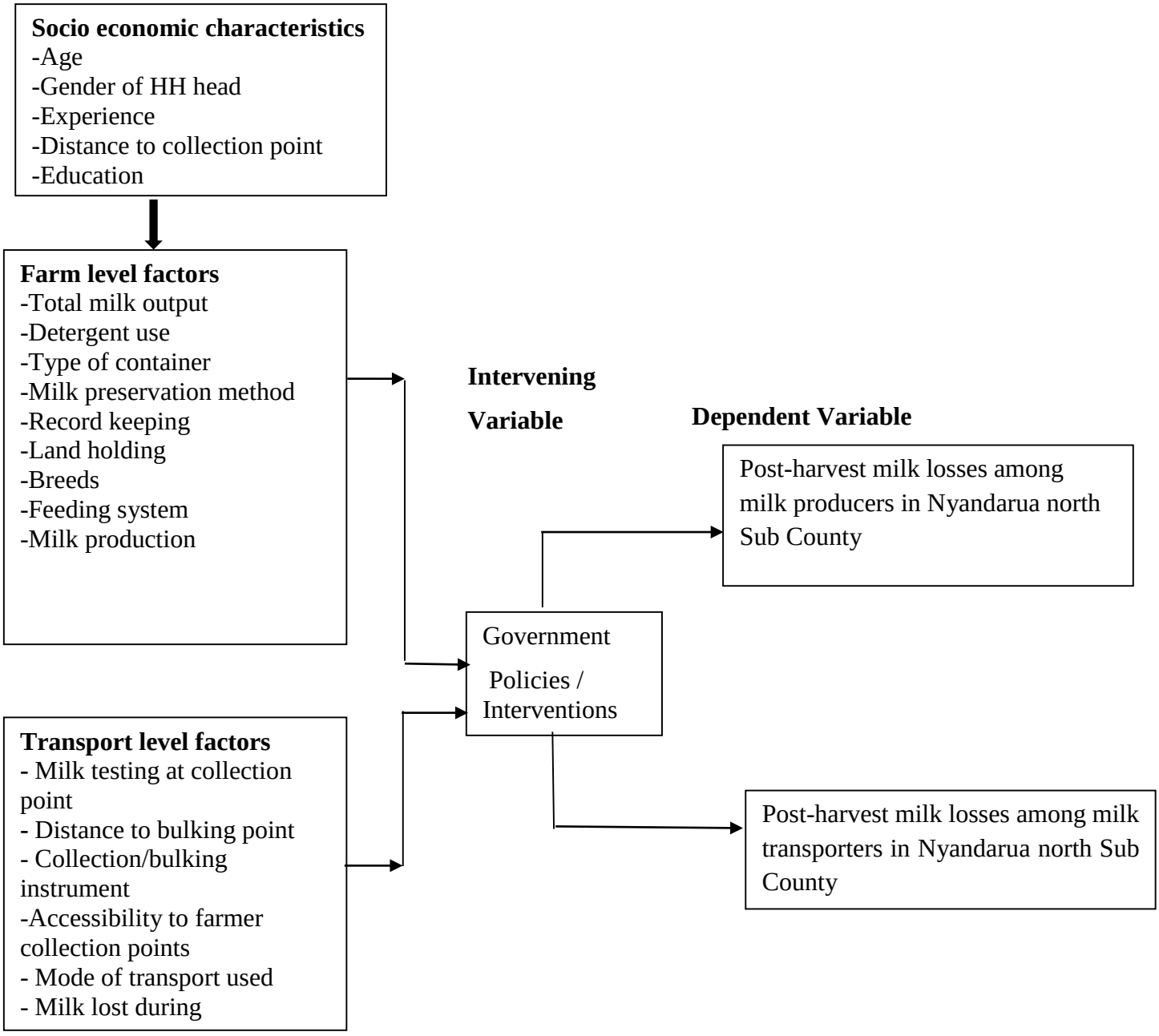

Figure 2: Conceptual framework

CHAPTER THREE
METHODOLOGY

3.1 Study area

Nyandarua County covers an area of 3,245.2 Square Km and is located in the North-Western part of former Central province of Kenya. It lies between latitude 0°8' North and 0°50' South and between Longitude 35° 13' East and 36°42' West. Nyandarua North Sub-County is one of the five sub-counties in Nyandarua County. However for agricultural extension purposes, the Sub-County has two divisions: Ndaragwa and Mutanga. The district covers an area of 683.6 Km^2; the forest area being 139.25 Km^2 while 544.35 Km^2 is arable land. The estimated population of the sub county is 92,626 people according to the 2009 population census. The livestock enterprises include dairy, sheep, goats, poultry, beekeeping, rabbit, beef and pig production. (Department of Livestock Production, 2012). The Sub-County has the highest population of dairy animals in the whole of Nyandarua county estimated at around 69,220 animals in the year 2012 (County Government of Nyandarua, 2013).There are two major milk processors serving dairy farmers namely Nyala dairy and Umoja dairy.

3.2 Sampling design and sampling procedure

The sampling frame included smallholder dairy farmers and milk transporters. Random sampling of smallholder farmers within formal and informal value chain setup was undertaken. The required sample size for milk producers was determined by Anderson *et al*. (2007).

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

where n = sample size, p = proportion of the population containing the major interest, q = 1-p, z= confidence level (α = 0.05), e = acceptable/allowable error. Since the proportion of the population is not known, p=0.5, q = 1-0.5= 0.5, Z = 1.96 and e = 0.07. This results in a sample size of 196 respondents as shown below.

$n = \frac{1.96^2 * 0.5 * 0.5}{0.07^2} = 196$ Milk producers

The processing factories in the sub county provided the names of milk producers in the formal channel while the rest in the informal channel were referred through Ministry of Livestock and Fisheries Development (MoLFD) field extension staff. 80% of the producers were selected from the formal channels and 20% from the informal channels. In the formal chain, 144 respondents were selected from Nyala and 13 from Umoja processors while in the informal, 36 respondents were selected from Ndaragwa and 3 from Mutanga. Further a census of all milk transporters to the formal channels was done to provide information regarding milk losses during transportation. The list and contacts of 43 transporters were provided by the main processing factories. There were different categories of transporters who moved milk from farms to collection points, processing points, milk bars, or hotels and who dealt with varying quantities and used different modes of transport.

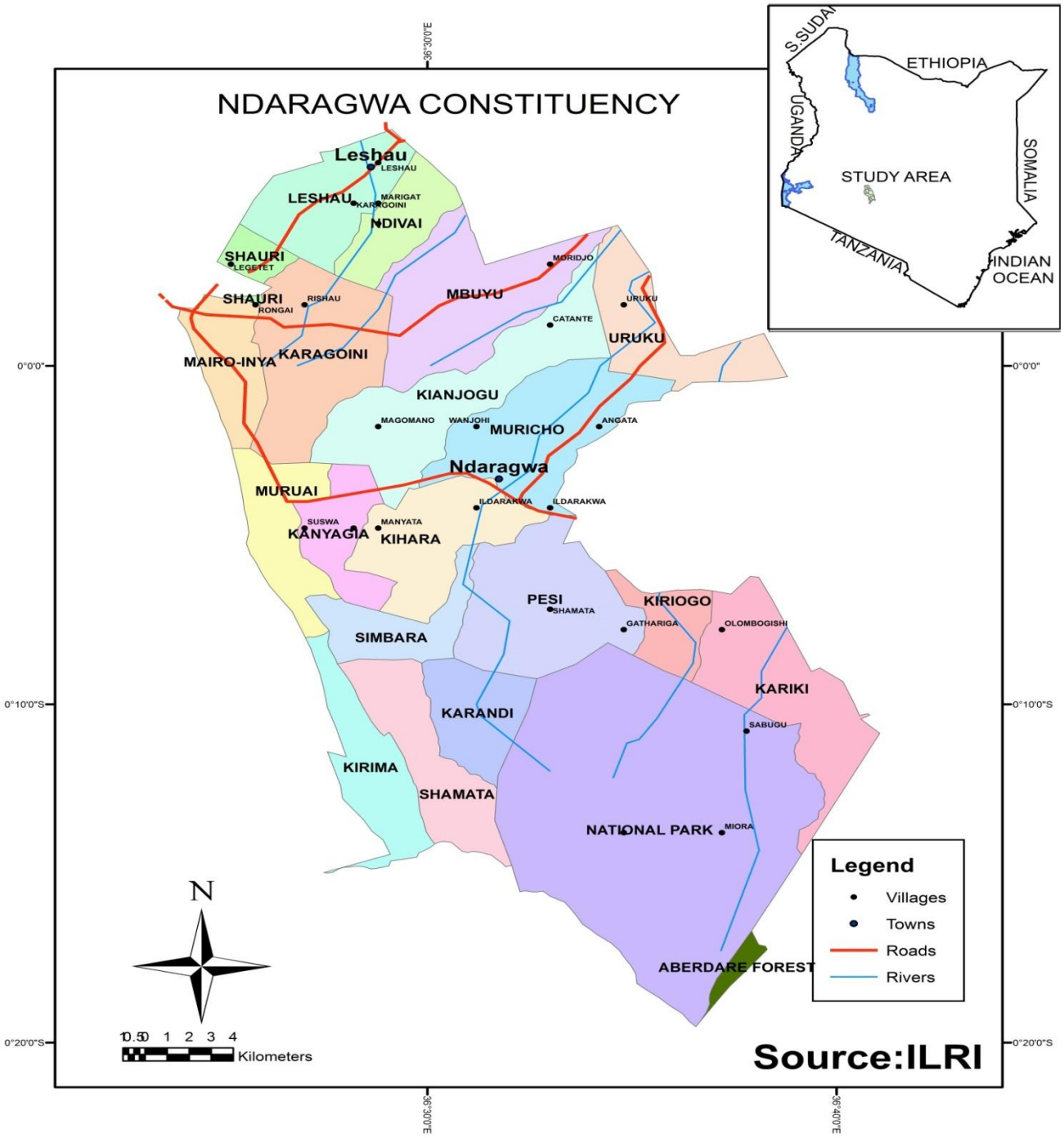

Figure 3: Map of study area

Source: International Livestock Research Institute (ILRI) 2015

3.3 Data collection

Primary data and secondary data were used for this study. Primary data were collected through questionnaires administered to the farmers and transporters. The questionnaire was designed to collect information on demographic characteristics and variables such as age of farmers, sex, major occupation, marital status, and education level among others while the non-demographic variable including average monthly income, losses incurred due to post-harvest losses, problem faced by the farmers in the course of production and postharvest handling of milk and its by-products. Secondary data was gotten from Nyandarua county government database, processors' records and from the Ministry of Agriculture and Livestock Development.

3.4 Data analysis

Quantitative techniques were used to analyze the data collected. The data was analyzed using Microsoft Excel, SPSS and STATA computer packages.

Objective 1. To characterize the socio economic and milk handling attributes of milk producers in Nyandarua north sub county. Statistical analysis was used to obtain descriptive statistics for the first objective. Descriptive statistics refer to the use of percentages, means, standard deviations, t-test, and frequency distribution in the process of characterizing the socio economic and milk handling attributes of milk producers who are important actors in the dairy value chain. Socio economic characteristics and milk handling attributes of milk producers was done as well as further grouping of milk producers based on those who incurred milk losses versus those who did not.

Objective 2: To estimate the mean milk losses among milk producers and milk transporters in Nyandarua north sub county.

Descriptive statistics, t-tests and chi-square tests were used to explain this objective, in the process of determining the mean milk losses among milk producers and milk transporters using different modes of transport as well as those undertaking milk tests at collection points.

Objective 3: To determine the factors influencing choice of a milk marketing channel among milk producers in Nyandarua North Sub County.

Objective 4: To determine the causes of milk losses among milk producers in Nyandarua North Sub County.

Objective 3 and 4 were analysed using the Heckman model. This model applies a two stage approach. The selection equation (first step) shows whether farmers participate in the either the formal or informal milk marketing channels. In the first step, the dependent variable was modelled as a binary variable equal to 1 if a milk producer participates in the formal milk channel or 0 if they participate in the informal channel. The outcome equation (second step) examines the causes of milk losses among milk producers.

Empirical model specification

Given that the focus of this study is to identify the factors influencing choice of a milk marketing channel and causes/effects on milk losses, we state the relationship as below,

$$Ml = Xi'\beta + \delta C_i + e_i \quad (1)$$

where;

Ml= milk losses in litres (total)

e_i= random normal distribution term (error term)

C_i = Dummy variable (0 = informal channel, 1 = formal channel) showing the channel selected by the farmer.

X_i = Vector of explanatory variables

The decision to dispose milk through a particular channel depends on choice of participation or not and can be estimated with the help of index function expressed as follows:

Index function

$$L_i = X_i\alpha + u_i \quad (2)$$

L_i is a latent variable showing the difference between utility obtained from participation in the formal channel and utility from participation in the informal channel. The condition for the farmer to participate in the milk channel requires the following condition to be met.

$L_i^* = U_f - U_{in} > 0$

where,

L_i = difference between utility through formal milk channel U_f and utility from informal milk channel U_{in}

X_i = shows the explanatory variables which affect market participation, where e_i is an error term.

The probit model predicts the probability of choice and also obtains the inverse Mill's ratio (IMR) as shown below:

$$X = \varphi (p+axi) / \Phi (p+axi)$$

where φ and Φ are, respectively the standard normal density function and standard normal distribution functions.

The two-step Heckman's approach has the selection equation (first step) which shows whether milk producers choose to participate either in the formal or informal channel and is specified below.

$$C = b_0 + b_1\, Age + b_2 Gender + b_3 Secondary\ dummy + b_4 Tertiary\ dummy + b_5 Total\ output\ of\ milk + b_6 Records + b_7 Aluminium\ milk\ containers\ dummy + b_8 Plastic\ milk\ containers\ dummy + b_9 detergent + e_i.$$

The outcome equation (second step) which examines the determinants of milk losses among milk producers, the equation is estimated by employing an ordinary least squares regression as follows:

$$D = y_0 + y_1 gender + y_2 Dairy\ farming\ exp + y_3 Dist + y_4 Secondary\ education\ dummy + y_5 Tertiary\ education\ dummy + y_6 Total\ milk\ output + y_7 detergent + y_8 Aluminium\ container\ dummy + y_9 Plastic\ container\ dummy + y_{10} Boiling\ dummy + y_{11} Chemical\ preservation\ dummy + y_{12} records$$

Table 1: Definition of variables that are used in the study

Variable	Description	Coding of variable/unit of Measurement	Expected sign
Dependent variables			
C	Decision to participate in a milk marketing channel or not	1=formal channel,0=informal	
D	Milk losses among milk producers	Milk losses in litres (continuous)	
Independent variables			
Age	Age of household head	Years (Continuous)	+/-
Gender	Gender of household head (Dummy)	1=male,0=female	+/-
Education	Education level attained by household head (categorical)	Primary, Secondary and tertiary	+
Distance	Distance from farm to milk collection point	kilometres(Continuous)	-
Total output	Amount of milk produced	Litres (continuous)	+/-
Detergent use	Use of detergent to clean milk container	Dummy (1=use,0=otherwise)	+/-

Container type	Type of milk container	Dummy (1= aluminium, 0=plastic)	+/-
Milk preservation	Milk preservation method	Categorical (1=Cooling, 2=Boiling, 3=chemical use)	+/-
Record keeping	Keeping of milk records	Dummy (1=yes,0=no)	+/-
Dairy farming experience	No of years in dairy farming	Continuous (Years)	+

CHAPTER FOUR
RESULTS AND DISCUSSION

This chapter presents results of post-harvest milk losses in the dairy value chain in Nyandarua North Sub County. The results and discussions have been outlined with reference to the study objectives. The results are presented in descriptive, inferential statistics, Pearson's chi-square and through a Heckman regression analysis.

4.1 Socioeconomic characteristics of milk producers

The socioeconomic characteristics and milk handling attributes of farmers along with milk handling methods are presented in Table 2. Focus was on variables including value chain, age, gender, education, landholding, breeds, feeding system and milk handling among other characteristics and attributes. According to Ogola *et al*. (2015), socio economic status of farmers influences decision making on a number of issues at farm level. Factors, such as, income from off-farm jobs, availability of capital, milk prices, price of land, farmer education and training and availability of family labour, influence a dairy farmers' decision on dairy operations .Results in Table 1 show that mean landholding size was 4.0 acres indicating they are small scale farmers but the mean land size for dairy production was 1.7 acres. This suggests that dairy production is not yet the main enterprise since substantial area is still being allocated to other farm activities.

With regard to dairy farmers' age, the mean age was 47.0 years with the youngest being 20.0 years and the oldest being 84.0 years. The results further indicate that 24.0% of the milk producers were below the age of 35 years while 76.0 % were above. It is apparent that fewer youths are engaged in dairy production. This is due to the fact that in many cases, resources particularly land, is culturally under the ownership of parents. In Kenya, youth are categorized as persons below 35 years and from these results, there is need to remove the barriers that limit their involvement in dairy farming. Farmers had a mean dairy farming experience of 12.2 years.

Table 2: Socio-economic characteristics of milk producers (n=188)

Description of variables	**Mean±SE**
Continuous variables	
Landholding size (acres)	3.97±0.35
Age of household head (years)	46.66±1.035
Dairy farming experience (years)	12.17±0.76
Distance from HH to milk collection point (km)	2.49±0.31
Milk prices offered through various channels (KES.)	
Cooperative society	32.45±0.13
Itinerant hawkers/brokers	30.86±0.46
Local sales/sales to neighbours	37.26±0.82
Direct delivery to processor	33.19±0.18
Monthly milk output	
Milk output (High season) in litres	18.44±1.36
Milk output (Low season) in litres	9.19±0.72
Categorical variables	**Percent**
Gender of household head	
Male	69.7
Female	30.3
Education level	
Lower primary	8.5
Upper primary	37.8
Secondary	42.0
Tertiary	11.7
Dependence on dairy income	
Yes	45.2
Don’t depend	54.8

The mean distance from households to milk collection point was 2.5 kilometres (Table 2). Milk producers have specific points where milk is delivered and collected by processors on a daily

basis: some at their gates while others have to transport to designated points. Brar *et al.* (2018) found that distance to market influenced market participation in that the more the distance to market from dairy farms, the less likely it would be the for farmer to participate in that milk market channel choice due to the perishable nature of milk and increased transportation charges. Olwade and Mathenge, (2011) also found that distance to tarmac road, which is an indicator of travel time and cost to the market, shows mixed results both in the model for decision to participate in the markets and in the extent of participation. It is significantly and negatively associated with the decision to participate in the milk markets. This puzzling result can be explained by the characteristics of the commodities, where perishability may possibly be influencing farmers to specialize depending on the relative advantages of their location. According to Omiti *et al*. (2009) distance to the market significantly reduces the percentage of milk sold particularly in the rural areas. The use of informal market information channels also contributes to increased output sale in the rural areas.

Prices per litre of milk varied among the various disposal outlets available to farmers. The mean prices offered were KES. 37, 33, 32, and 30 from local sales to neighbours, direct delivery to processing plant, cooperative society, brokers, and itinerant hawkers respectively (Table 2). The highest prices fetched were through local sales to neighbours mainly due to convenience of purchase, assurance of quality and the fact that the sellers and buyers have developed a close relationship through knowing and engaging each other over time. However, Ayenew *et al*. (2009) notes that milk co-operatives have an advantage as they are able to market larger volumes and sufficiently reduce transaction costs. Mburu *et al*. (2007) noted that cooperatives were not competitive in milk pricing and lower highlands farmers should utilize the other available milk marketing channels. For example in Kiambu district, the cooperatives experience shortage and surplus of milk in the dry (January- April) and wet (rest of the year) seasons respectively, hence, policies to improve the operational and pricing efficiencies of dairy cooperatives would have a self-accelerating effect on productivity. His further advice is that dairy farmers should visit their local extension agents and have their break-even costs of production computed based on prevailing milk price per kilogram. Once calculated, policy makers and planners when making decisions related to design of appropriate policies and investment respectively to support smallholder dairy development can use these estimates.

According to Morton and Miheso (2000), the advantages of cooperatives that consistently emerged are that they offer lump-sum monthly payment, which allows farmers to budget, they buy all milk offered to them, they offer credit on livestock feed, AI services, offer loans among others. Farmers also cited their sense of ownership in the cooperative and its assets, and the fact it generated employment, as advantages.

The least price was offered by milk brokers most of whom buy milk that has been rejected at the collection point or that has failed to be collected. Since there are limited options, farmers desperately dispose off their milk in a bid to avoid losses. Furthermore, the hawkers do not have stringent quality requirements making the price go even lower. A study by Sikawa and Mugisha (2011), indicated that low prices for the milk was a serious constraint of the formal milk marketing channel. It also noted that payments majorly influenced the channel farmers selected to dispose their milk. Farmers in the study further reported that delayed payments are intolerable to them as they need cash on sale so as to meet daily financial obligations. Morton and Miheso, (2000) noted that the major competitors to the cooperatives are the hawkers. Their clear advantage is price, and their clear disadvantage is their unreliability. They normally pay for milk in cash and create competition in the milk market. The practice of selling some milk to the cooperative and some to hawkers is known to be widespread, and some groups were explicit about this as a strategy for meeting short-term and medium-term budgeting needs. The main advantage of selling to neighbours is improved nutrition in the community while non-payment creates enmity among locals.

In regard to household milk production, the mean milk production per household was about 18 and 9 litres during the high season and low season respectively. The difference of about 50% between the seasons is significant and suggests the need to train farmers on how to bridge this gap and one way is how to conserve feed to ensure consistency in production through the seasons.

Muia *et al.* (2011) report that in Nyandarua, only about 35% total milk production was marketed through the formal sector which is considered by farmers to be more reliable in terms of milk prices and payments for milk delivered as compared to the informal sector. The formal sector which is involved in milk processing, value-addition, increasing shelf-life, and packaging to

ensure safety of milk and dairy products is mainly in the hands of public and private milk processors. The sector has the capacity to increase milk intake, processing and packaging to cope with large volumes of milk during the wet season. The high operational costs associated with the formal milk sector are therefore likely to decline as the processors operate at full capacity thus enhancing its efficiency and competitiveness both locally and internationally.

The informal channels comprise hawkers, itinerant traders and local sales mostly to neighbours. The collapse of KCC in 1997 resulted in serious milk marketing problems and a sudden influx of informal milk traders with studies conducted by the Smallholder Dairy Project (SDP) in the mid to late nineties showing that the informal milk market accounted for over 70% of the marketed milk. This was a clear indication that the government could no longer ignore these actors prompting the government to review the dairy act in order to accommodate the informal milk traders who according to the act were illegal (Sinja *et al*., 2006). Farmers using this channel prefer it because of the short distance involved during distribution. The terms of payment are strictly cash which also ensures that the farmers have continuous source of income to be used on regular household needs. The informal chain does not have stringent quality standards as compared to the formal chain where milk is subjected to a number of quality verification tests. Comparatively, the prices offered through the informal chain are higher than the formal chain making it attractive to those who wish to dispose their milk at the convenience of their locality. The use of informal market information channels also contributes to increased output sale in the rural areas (Omiti *et al*., 2009).

According to Sinja *et al.* (2006), small scale (mobile) milk traders are majority in the informal milk marketing because of ease of entry and exit. This is because milk collected from the farmers is paid for in the evening making the trade a favourite for school leavers and others who have no capital. It also causes the traders to play hide and seek with regulatory bodies for some time before they accumulate enough savings to pay for the licences. Omore *et al*. (2005) notes that lack of formal training, use of plastic containers and the absence of cold chains are the main factors that contribute to the low quality of raw milk sold by small-scale informal milk traders and hawkers. However, training in milk hygiene and quality testing, combined with the

use of more hygienic metal containers can significantly improve the quality of milk sold by informal small-scale traders.

The gender of households indicated that 69.7% were male while the rest were female (Table 2). This shows that more males were involved in dairy production activities than females. This is consistent with the fact that dairy production is labour intensive and may involving feeding, herding and caring of the dairy animals, a task better handled by men. With respect to level of education, 8.5% had at least lower primary education, 37.8% upper primary education, 42.0% secondary education and 11.7% had post-secondary education. Farmers who are educated could appreciate modern and beneficial technologies and practices which can lower milk losses. Sikawa and Mugisha, (2011) reported that the less educated farmers are likely to associate with informal marketing channel. This may mean that less educated farmers are not well informed of the benefits they could possibly accrue from the formal milk marketing channel.

Majority of farmers (54.8%) did not exclusively depend on dairy income for livelihood while 45.2% did (Table 2). The good number solely dependent on dairy income might be indicative of the need to have the dairy sector in the sub county revamped for improved incomes and sustainability. This will not only ensure that more farmers take dairy production as a serious economic venture but one that can fully sustain their livelihoods as well. Improved incomes will also encourage self-employment and youth involvement in the dairy sector hence reducing overdependence on white collar jobs after education. According to Karanja, (2003), most households identified the availability of milk for home consumption, mainly for their children, availability of manure as the main reasons for keeping dairy animals. Income from milk sales was nevertheless considered very critical especially due to the poor performance of other farm enterprises.

4.1.1 Milk handling attributes of milk producers

The milk handling attributes of farmers along with milk handling methods are presented in Table 3. Focus was on variables including type of cows kept, feeding systems and other milk handling methods and attributes.

Table 3: Milk production and handling attributes (n=188)

Description of variables (Categorical)	Percent
Type of cow breeds	
Ayrshire	22.9
Friesian	32.4
Guernsey	2.7
Jersey	1.6
Indigenous	3.2
Crossbreeds	34.6
Feeding system	
Zero grazing	16.9
Natural pastures and zero	22.1
Pastures only	61.0
Production records	
Yes	41.7
No Records	58.3
Hand washing when milking	
Yes	97.8
Don’t wash	2.2
Water source for household use	
River	14.5
Pond	5.9
Well	14.0
Tap water	52.2
Rain water	13.4
Frequency of milking parlour cleaning	
Daily	52.7
Weekly	22.0
Fortnightly	12.9
Monthly	2.2

Cleaned longer than a month	10.2
Cows udder cleaning	
Use of cold water	1.1
Use of warm water	97.8
No washing	1.1
Use of towel to wipe and dry cows udder	
Yes	98.9
Not used	1.1
Milk preservation method	
Cooling	85.4
Boiling	8.2
Other means	6.4

Results in Table 3 present the attributes that relate to milk production and handling. The type of dairy breeds kept showed that crossbreeds and indigenous dairy animals combined were common with about 38.0% of farmers keeping them while 32.4%, 22.9%, 2.7% and 1.6% of the farmers kept Friesian, Ayrshire, Guernsey and Jersey breeds respectively.

Feeding is a critical component of dairy farming and 22.1 % of the farmers depended on natural pastures with supplemental feeding with napier grass during milking; 61.0% depended on pastures only while the rest (16.9%) confined their animals in a zero grazing unit. Feeding has an implication on the quality and quantity of milk produced as well as subsequent milk losses realized.

About 42.0% of farmers kept dairy production records while the rest did not. Record keeping has an implication on estimation of both the production quantities and any losses that may arise. Most farmers (58.0%) did not have production records and depended on memory recall for estimating their production and losses.

The available sources of water used to wash hands were as follows: The highest was tap water (52.2%) of milkers followed by river water (14.5%), well water (14%), rain water (13.4%), and pond water (5.9%), respectively, (Table 3). Katuku (2009) noted that water used from wells and

streams is of doubtful hygienic quality. This could also lead to milk contamination as this is the same water used to clean the udder and milk utensils. Sreedhar *et al*. (2017) further notes that hygienic milking plays a crucial role in profitable dairy enterprise.

Cleaning of containers is important and 93.0% of milk producers used warm water to wash milk containers, 6.5 % used cold water while less than 1% smoked the containers. Hot or warm water is preferred since it is more effective in dissolving accumulated fats that may harbour harmful bacteria that can compromise on milk quality. The cleanliness of a container used to handle milk has an implication on whether the milk meets the required quality standards. This also goes hand in hand with use of soap or detergent to wash the containers. The results in this regard indicated that 98.4% used detergent or soap to wash the milk containers. Odongo *et al.* (2016) noted that delay in cleaning milk handling containers is a risk factor as it presents adequate time for microorganisms to multiply and increase microbial load to levels that are difficult to reduce to acceptable level during cleaning. This could result into high microbial counts in milk handled in these containers and hence accelerated microbial spoilage leading to post-harvest losses of the milk. Ayenew *et al*. (2009) further notes that smallholder dairy farmers who have no access to well organized milk storing and processing technologies rely on traditional measures of cleaning their milking and milk processing equipment and the addition of certain plant materials to their products which shall increase the shelf life. However, such techniques may contain health risks and the recommendation given was that basic handling and health education for producers is likely to help in improving milk quality on the markets.

Majority of milk producers used plastic containers (65.2%) while stainless steel (2.17%) containers were less common. Unlike metal containers, plastic containers are less expensive hence easily affordable by majority of farmers. They are also easy to replace when confiscated by regulatory bodies, in this case the Kenya Dairy Board. Plastic containers were linked to poor milk quality due to the inability to fully clean and sterilise them. Most of the milk marketed by small-scale farmers in Kenya has been reported to be of poor quality and does not meet national and international standards due to high bacterial load as well as and chemical residues (Omore *et al*., 2005).

The frequency of cleaning the milking parlour indicated that 52.7% of the farmers cleaned their parlours daily and 22.0%, 12.9%, 2.2% cleaned on weekly, fortnightly, monthly basis respectively with about 10.2% extending to more than a month (Table 3). Barn and parlour cleanliness reduces the instances of mastitis prevalence in the cows. Mastitis infection comes about when cows lie down in barns that are not clean leading to udder infection and subsequently milk produced is not fit for consumption. Reduction of such infections therefore calls for frequent cleaning of barns and parlours. Results on how the cow's udder was cleaned indicated that majority of farmers (97.8%) washed cows udder with warm water while 1.1% used cold water, and 1.1% did not wash the cows' udder. Apart from minimizing contamination, warm water stimulates the udder to release milk. In regard to use of a towel to wipe and dry cows' udder before milking, 98.9% used a towel, while 1.1% did not.

Processors and transporters collected only morning milk and so farmers were forced to either consume evening milk (forced consumption) or preserve for sale the following morning. The most common method of preservation was cooling where 85.4% of farmers cooled through dipping in a bucket of cold water, 8.2% boiled the milk and 6.4% used other means of preservation (Table 3). Traditional preservation methods are common among farmers mainly due to lack of adequate coolers and electricity to power modern equipment's like freezers. Preservation of milk is particularly important for evening milk to ensure it is still fresh to qualify for sale in the morning. Ayenew *et al*. (2009) notes in a study in Ethiopia that according to the local understanding, the practice of smoking milk vessels by burning wooden chips of specific trees and shrubs has an advantage of imparting special taste and odour to the product, and to disinfect the vessels, thus reducing the numbers of micro-organisms and thereby extending the shelf life of the product. However, this compromises on the quality of milk.

4.2 Mean milk losses among milk producers and milk transporters

4.2.1 Milk losses among milk producers

The quantification of milk losses among milk producers are as presented in Table 4.

Table 4: Mean post-harvest Milk losses resulting from different Quantifiable parameters. (n=188)

Description of variables	Morning	Evening
Monthly Milk losses by source (litres)		
Spillage (morning)	23.66±9.87	4.00±1.00
Forced consumption(morning)	4.20±1.28	6.58±2.03
Non-collection (morning)	42.00±39.33	3.00±0.00
Spoilage(morning)	21.95±5.14	15.22±4.32
Diseased cow(morning)	31.18±13.33	8.55±2.54
Contamination(morning)	52.17±31.32	0.00±0.00

The specific sources of loss is instructive. Farmers experience most milk loss through contamination of morning milk ($\overline{X} = 52.17$ litres) and non-collection of milk in the morning ($\overline{X} = 42.00$ litres) (Table 3). In the morning, milk gets contaminated especially when morning milk is mixed with the previous evening milk and this is the main source of contamination. Non-collection of milk mainly occurs since there are designated routes which transporters follow and when those routes are not accessible, the milk cannot be collected and this is a loss to farmers. Other sources of losses in order of prevalence were: loss through rejection of milk from a diseased or dewormed cow ($\overline{X} = 31.18$ litres); spillage of milk in the morning ($\overline{X} = 23.66$ litres); spoilage in the morning ($\overline{X} = 21.95$ litres) and evening ($\overline{X} = 15.22$ litres), in that order; forced consumption in the evening ($\overline{X} = 6.58$ litres) and morning ($\overline{X} = 4.20$ litres).

When milk losses are caused by sick or dewormed cows, there is a period within which any diseased or dewormed cow should be left to fully recover before milk can be used for consumption. The common cause of spillage is due to cows knocking over buckets during milking. Some animals are easily irritated while others experience pain in the udder especially due to mastitis. Forced consumption occurs when farmers are made to consume the milk they produce for lack of an alternative economically viable option like sale to traders or processors. This is mainly as a result of lack of a reliable market or even a reliable disposal mechanism. In a study by Aytaged and Tolesa (2004) in Ethiopia, it emerged that wastage of milk at collecting

centres was attributed to spillages, poor handling and spoilage resulting in contamination of milk while still at the farm. Further, pooling of milk from different sources and delays also contribute to milk spoilage at the primary collecting and processing units, with losses due to spillage and over consumption increasing with rising number of milking cows and handlers along marketing channels.

Table 5: Gender of household head and record keeping in relation to milk losses

Variable	Description	Percent No Loss	Percent with Loss	$\chi 2$
	Female	38	21.6	
Gender	Male	62	78.4	5.9657**
	No records	66	49.5	
Record Keeping	Kept records	34	50.5	5.2569**
Total		100	100	

**indicates $p<0.05$

Chi square test results further indicate that loss through gender is significantly different at 5% significance level (Table 5). The number of male milk producers who incurred milk losses was significantly more than female milk producers. Results indicate that fewer females (22%) lost milk compared to 78% males (Table 5). This is because dairy projects are the responsibility of men in terms of decisions relating to dairy management, milk production, and handling.

Chi square test results with respect to record keeping show that milk producers who kept records and lost milk were significantly more (50.5%) than those who did not keep records (49.5%) at 5% significance level. Records are emphasized for those farmers in the formal chain since they are used to compute periodic payments. In most cases, each farmer has two cards that show dates of delivery and quantities delivered. One is kept by the cooperative and the other remains in the custody of the farmer for ease of reconciliation. Without records, some of the losses may not be captured and would appear to be lower. On the other hand, rejection is higher in the formal chain than the informal chain since there are more stringent standards in regard to milk quality. These results are as shown in Table 6.

Table 6: Milk losses across milk marketing channels (Formal and informal)

Farmers milk value chain	no loss (No.)	Lost (No.)	Total (No.)
Formal	58	74 (84%)	132 (70.2%)
Informal	42	14 (16%)	56 (29.8%)
Total	100	88	188

$\chi 2 = 15.2355$ Pr = 0.000***

***indicates $p<0.001$

There were significantly more losses in the formal channel as compared to the informal channel at 1% significance level. This could be due to the stringent quality checks under this particular channel with any milk that does not meet quality standards rejected.

Milk losses across the channels varied but the formal chain registered the highest loss represented by 84% of milk producers sampled compared to 16% from the informal channel. The reason for such difference can be explained by the stringent quality standards in the formal chain. Further, producers in the formal chain sold more milk which could contribute to increased losses.

The general perception on choice of channel is that where farmers used the formal chain, they had access to cooling facilities and fewer losses whereas those using informal channel relied on traditional methods of milk preservation which more often resulted in milk spoilage. Most farmers (70%) in the study area used the formal channel. Omiti *et al*. (2009) established that market information plays a significant role in farmers' decision on how much output to make available to the market depending on the prevailing price and nearness of the specific market outlet.

4.2.2 Milk losses among transporters

This section provides results relating to losses among transporters. The parameters analyzed were monthly mean cumulative loss per transporter, milk losses by source during transport as well as other categorical variables related to milk transportation as shown in Table 7.

Table 7: Quantifiable parameters related to milk post-harvest losses among milk transporters. (n=43)

Continuous variables	**Mean±SE**
Monthly mean cumulative loss of milk per transporter	104.95±18.38
Quantity of milk losses during transportation by source (litres)	
Spillage	
(Morning)	56.82±25.85
(Evening)	50.00±21.21
Spoilage	
(Morning)	62.50±12.50
(Evening)	86.42±22.16
Contamination	
(Morning)	0.00±0.00
(Evening)	46.16±12.45
Categorical variables	**Percent**
Transport losses due to either spillage or spoilage	
Yes	82.5
No losses	17.5
Mode of transport used	
Bicycle	7.1
Motor bike	52.4
Donkey cart	19.0
Pick up vehicle	14.3
Truck	4.8
Physical delivery by walking	2.4
Type of milk bulking equipment	
Plastic containers	52.4
Aluminium can	47.6
Size of milk bulking equipment	
50 litres	51.2

40 litres	9.8
30 litres	31.7
20 litres	7.3
Time of milk collection	
4 a.m.	4.8
5 a.m.	26.2
6 a.m.	45.2
7 a.m.	19.0
8 a.m.	2.4
10 a.m.	2.4
State of road linking farm to milk collection point	
All weather road	73.8
Murram road	21.4
Tarmac road	4.8
Farm accessibility during rainy seasons	
Yes	31.0
Not accessible	69.0
Farm accessibility during dry seasons	
Yes	97.6
Not accessible	2.4

Sources of milk loss during transportation included spoilage in the evening which was the most prevalent ($\overline{X}$= 86.42 litres) and in the morning ($\overline{X} = 62.50$ litres) indicating that milk preservation and storage was a challenge among transporters as well (Table 7). When transporters collect and bulk milk in the evening, the milk is from different farmers' and raises the probability of spoilage especially where some of that milk is contaminated or adulterated. This is a loss to transporters since they buy the milk from different farmers and dispose it to processors at a premium. The mean for spillage in the morning was 56.82 litres and 50.00 litres in the evening. Spillage is a common loss and this occurs due to the transport logistics

employed. Some transporters use motor cycles (52.4%) and when roads are muddy and sometimes they overturn leading to spillage of milk.

Contamination, which most farmers attributed to wayward transporters out to make illegal gains, was experienced. Some transporters collected fresh milk from farmers and in order to make some extra money, they added water to gain quantities. Once water is added, they would add butter or margarine to maintain butterfat and use hydrogen peroxide to increase shelf life. However, transporters carry out some quality verification tests including use of lactometer, organoleptic tests involving taste and/or smell and use of ethanol gun. The mean quantity of milk lost in the evening through contamination was 46.16 litres. Majority of milk transporters (82.5%) admitted experiencing milk losses during transportation. Most of the transporters used motor bikes (52.4%) with only 2.4% of them managing to deliver their milk directly to the processor. The rest of the transporters used bicycles (7.1%), donkey cart (19.0%), pick up vehicles (14.3%), and trucks (4.8%) for transporting the milk (Table 7).

The type of milk bulking equipment mostly used was made of plastic with 52.4% of transporters using them. The rest (47.6%) used aluminium containers which are highly recommended by the Kenya Dairy Board (KDB) due to their ease of cleaning and ability to cool and maintain milk hygiene. The main reason reported for using plastic containers was the ease of bulking and mobility. For example a transporter was able to tie six 30-litre containers on a motor bike which enabled transportation and delivery of about 150 litres at once. Karanja, (2003) further notes that at the milk collection stage, both aluminium and plastic containers are used. Smallholder farmers prefer to use plastic containers citing their low cost and convenience. However, in large-scale areas, where large quantities of milk are handled, most farmers use the aluminium cans

According to Omore *et al*. (2005) most unlicensed milk hawkers used plastic jerry cans because of the risks of confiscation of containers used in unlicensed sale of milk. The lack of licensing may contribute to the continued poor quality of milk sold by informal traders. In order to improve milk quality, informal traders should be trained, certified and licensed to sell milk. This would gradually incorporate them into the formal milk market and allow for greater

monitoring and control of their activities, which should include insistence on use of more hygienic/easily sterilisable metal or other food-grade containers. Ndaka *et al*. (2012) further adds that spillage and spoilage losses incurred during transportation of milk from the farm to milk collection centres may be minimized by the use of well-designed appropriate milk churns.

Time of milk collection among transporters varied from 4 am to 10 am with 45.2% of them collecting milk at 6 am. The rest collect milk at 4am (4.8%), 5am (26.2%), 7am (19.0%), 8am (2.4%) and 10am (2.4%) respectively. The earlier the collection time the better since the milk could be delivered in an acceptable state. The challenge to early delivery was security concerns. Milk transporters preferred to operate at 6 a.m. which they considered safer not only for themselves but also for their vehicles and motorcycles as cases of thuggery, carjarkings and theft have been previously reported.

Most of the milk transporters (73.8%) used all weather roads to access households and milk collection points with 21.4% and 4.8% of the milk transporters using murram and tarmac roads respectively. However, 69.0% of them faced difficulty accessing the households and milk collection points during the rainy season in comparison to 2.4% during the dry season. The state of roads affected transportation of milk especially because most of the roads are all weather and during wet periods, most transporters could not access some farmers and collection points resulting in higher milk losses.

Melesse *et al*. (2014) noted that milk rejection problem from cooperatives or collectors due to milk spoilage which was the major reason. This was attributed to improper cleaning of milk handling equipment ,use of inappropriate containers ,poor milk handling practices such as storage of milk in a hot place for long time, inappropriate transportation system, and inappropriate cleaning of milk containers among other reasons revealed in the study in Ada'a and Lume districts of east Shoa Zone, Central Ethiopia

Table 8: Milk testing and transport mode in relation to milk losses among transporters

Group	Observations	Mean	Std. Err.	t value
Milk testing				
No Farm test	3	195.667	144.573	
Farm test	39	97.974	17.037	
Combined	42	104.952	18.387	1.384*
Mode of transport				
Low speed transporters	12	58.500	10.316	
High speed transporters	30	123.533	24.725	
Combined	42	104.952	18.387	-1.63**

*indicates $p<0.1$, **indicates $p<0.05$

Mean losses for transporters who did milk tests against those who did not are shown in Table 8 and indicate that those transporters who did not undertake milk testing experienced significantly more losses (195.67 litres) than those who undertook milk testing (97.97 litres) at collection points. The t-test results indicate that there is a significant difference in milk losses among transporters who performed milk tests and those who did not at 10% significance. This is indicative of the need for milk tests at collection points by milk transporters which would significantly reduce the resultant milk losses. Omore *et al*. (2005) noted that bulking of milk from many sources increases the risk of infection with milk-borne zoonosis. This is especially so among transporters who bulk milk from different sources for sale to processors.

Mean losses for transporters who used low speed against those using high speed transportation are presented in Table 8. The transporters who used low speed modes which include walking, bicycles and donkey carts experienced significantly lower losses than those who use high speed means like use of motorbikes and vehicles. The high speed transporters bulk more milk to enable them recover the costs associated with transportation. Since the high speed transporters handle more volumes of milk (123.5 litres), there is a likelihood of them losing more as shown in the results which are significant at 5% (Table 8).

Low speed transporters on the other hand may not handle large volumes of milk and so the losses incurred are less (58.5 litres). Ndaka *et al*. (2012) state that providing some form of cooling and proper sanitation and transportation procedures is very effective at reducing spillage and spoilage losses. Cooling Equipment at farm level, fitting transportation with cooling equipment, collecting milk from farmers twice in a day are suggested as possible ways of reducing the losses. Exploring value addition options like fermentation of evening milk, which forms a large part of forced consumption losses, is one feasible option to reduce fresh milk losses.

4.3 Determinants of choice of milk marketing channel and the causes of milk losses among milk producers

In establishing the determinants of choice of channel and the causes of milk losses among milk producers in Nyandarua north Sub-County, a Heckman Two-stage regression model was used.

4.3.1 Determinants of choice of milk marketing channel among milk producers

The estimated results indicate that gender of household head, total milk output, keeping of records and type of milk container significantly influenced the choice of milk marketing channel. Experience from countries like Uganda and Kenya pointed to marketing outlet being a key initiator of milk production by smallholders (Ayenew *et al*., 2009). The results are presented in Table 9.

Table 9: Factors influencing choice of milk marketing channel

Variable	Coefficient	SE	p-values
Age of household head	-0.005	0.005	0.359
Gender of household head	0.437**	0.192	0.023
Secondary education	-0.121	0.181	0.502
Tertiary education	-0.327	0.283	0.247
Total milk output	0.014**	0.005	0.002
Records	0.418**	0.177	0.019
Detergent use	-0.537	0.361	0.137
Container type	0.411**	0.195	0.035
/athrho	17.410	147.993	0.906
/lnsigma	3.975***	0.077	0.000

*indicates $p<0.1$; **indicates $p<0.05$; *** indicates $p<0.01$

Male farmers had a higher probability of using the formal milk channel at 10% significance level. Male heads of household are attracted to the kind of additional services available in the formal channel which include availability of loan facilities, input provision and lump sum payments among others. More males (69.7%) were involved in dairy production activities than females (30.3%) due to the fact that dairy production is labour intensive. The formal channel is preferred mainly because of regular monthly payments for milk delivered and well organized milk collection with transport provided. In addition, farmers are able to get inputs, payment of advances and loans based on delivered volumes of milk.

Total milk output was significant at 1%. Farmers with higher milk output were more likely to use the formal chain to dispose their milk because of rapid delivery to the processing point. The informal channel actors may not have the capability to transact large quantities. Farmers who practised free grazing had a higher probability of using the formal channel as it was significant at 5%. These are farmers who have larger pieces of land and likely to produce more quantities of milk

Farmers in the formal channel are more likely to keep records since the copy of the deliveries will be used for reconciliation and subsequent agreed payments. Farmers who keep records are able to identify and quantify the milk losses they incur through the different channels, while those who don't keep records may not realise that they are incurring losses as a result of failure to keep elaborate and up to date milk records.

Choice of plastic containers was significant at 1% and most farmers preferred it because of the convenience in terms of mobility of milk from farms to collection points, they are relatively cheaper than stainless steel containers, and are readily and locally available. From the results, a majority of milk producers and transporters used plastic container to handle milk. However, plastic milk containers are highly discouraged by the Kenya dairy board among other regulatory bodies as they are associated with milk spoilage and rejection according to a study by Katuku (2009). Handling containers determine the choice of channel a farmer is to pick for marketing milk. Notably, most farmers as well as transporters preferred to use cheaper plastic containers mainly to reduce losses incurred when the containers get confiscated by regulators like Kenya

Dairy Board, who often move round collection points to ensure laid down regulations are followed.

A study by Mutura *et al*. (2015) found that land size, number of dairy cows owned by a household, access to training, total milk output, access to market information, and household head education level were found to significantly influence choice of household dairy market outlet. He further states that choice of appropriate milk marketing channel ensures high gross margins. Consequently provision of education and services to the farmers on different milking marketing channels will be key in accessing the best marketing channel.

4.3.2 Determinants of milk post-harvest losses

The results from the second step of the Heckman model (OLS) suggest that gender, total milk output, use of detergent to clean milk containers and keeping of production records were significant as far as causes of milk losses among milk producers was concerned. The results are presented in Table 10.

Table 10: Determinants of milk post-harvest losses among milk producers

Variable	Coefficient	Std Errors	P-value
Gender of household head	20.613**	9.906	0.037
Dairy farming experience	-0.083	0.090	0.356
Distance to milk collection point	0.693	0.751	0.356
Secondary education	-6.827	9.710	0.482
Tertiary education	-21.157	14.217	0.137
Total milk output	0.800***	0.245	0.001
Detergent use	-44.172***	10.986	0.000
Container type	19.503**	9.448	0.039
Cooling	5.102	5.526	0.356
Boiling	-14.263	38.968	0.714
Records	23.951**	9.408	0.011

*indicates $p<0.1$; **indicates $p<0.05$; *** indicates $p<0.01$

In regard to gender, male headed households are likely to experience less losses than female headed households. The results indicate that more males were involved in dairy production activities than females. This is consistent with the fact that dairy production is labour intensive and may involving feeding, herding and caring of the dairy animals, a task better handled by men. According to Rangnekar and Thorpe, (2001) women and school age children contribute greatly to labour for dairy activities, especially to milk production and marketing, which involve waking up very early in the morning to feed and milk cows, and to take the milk to market. This labour input has been viewed negatively, raising concern relating to gender imbalances in labour distribution at the farm level.

On total milk output, the higher the output, the higher the likelihood of experiencing more losses. The likelihood of losing more milk after bulking is higher for a milk producer who has larger volumes of milk than those handling smaller quantities. This is because a farmer who has more milk will incur more post-harvest losses than a farmer with smaller volumes.

Detergent use among milk producers was also significant ($p<0.001$) indicating that milk producers who used detergent to wash milk containers had a lower probability of experiencing milk losses per month (Table 10). Hygiene is paramount in milk handling and the higher the levels of hygiene, the less likely a farmer will lose as a result of especially contamination brought out by low levels of hygiene.

On milk container type, those milk producers using aluminium are likely to experience less milk losses than those using plastics. The Kenya Dairy Board recommends use of aluminium or stainless steel containers to store or transport milk. This is due to the fact that the recommended containers reduce milk losses since they are easier to clean and their ability to cool the milk making milk stay longer without spoiling unlike plastics.

Keeping of production records was significant ($p<0.001$) (Table 10). The results indicate that despite farmers in the formal channel keeping records, they experienced more losses than the ones in the informal chain. This is because the records expose the losses which cannot be captured in informal channels where record keeping is poor.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1. The result indicate that majority of milk producers in the study area preferred the formal value chain compared with the informal chain corroborating similar statistics at the livestock production office. However, milk losses across the channels varied but the formal chain registered the highest loss represented by 84% of milk producers sampled compared to 16% from the informal channel, with average milk production ranging from 9 to 18 litres during the low and high seasons respectively.

2. Farmers experience most milk loss through contamination of morning milk and non-collection of milk in the morning. Majority of milk transporters (82.5%) also admitted experiencing milk losses during transportation. Spillage and spoilage were the major sources of losses among transporters and they lost an average of 104 litres of milk monthly. Those milk transporters who used high speed means like use of motorbikes and vehicles experienced significantly higher losses than those using low speed means like walking, bicycles and donkey carts. It was noted that most of the roads in the study area are all weather which provides challenges in movement especially in wet weather when accessibility to collection points is hampered. Further, transporters who did not undertake milk testing at milk collection points experienced significantly more losses than those who undertook milk testing.

3. The main factors influencing choice of a milk marketing channel among milk producers were gender of household head, total milk output, keeping of records and type of milk container used.

4. The major contributors of milk losses were gender of household head, total milk output, use of detergent to clean milk containers, type of milk container and keeping of production records.

Anteneh *et al*. (2010) notes that lack of market information reduces the efficiency of the marketing system. Producers do not maximize their returns as they do not get optimum prices. They also do not respond to price changes resulting from supply and demand variations. The lack of market transparency restricts the development of the livestock economy through

hampering planning and policymaking. The availability of market information would thus help producers, traders and exporters to plan production operations and marketing decisions. Brar *et al*. (2018), identified age of the household head, distance to selling point, price of milk sold, availability of advances among others as the important variables which influence the adoption process of marketing channels by small and medium dairy farmers hence these variables can be used as policy instruments to enhance the producers' likelihood towards the organized milk markets.

5.2 Recommendations

1. Milk marketing channels, both formal and informal, need to be re-evaluated based on returns and convenience with emphasis on proper post-harvest milk management and handling. Farmer education should be enhanced through frequent trainings, seminars and field demonstrations by concerned stake holders. Farmers should also be sensitized to seek extension services from extension service providers so as to get requisite knowledge on milk production, handling and management of post-harvest milk losses.

2. The study has clearly demonstrated that smallholder farmers and milk transporters require capacity building training aimed at addressing some of the challenges they experience in order to address post-harvest milk losses. The losses experienced are indicative that milk handling and preservation remains a challenge and sufficient training on the same needs to be undertaken. Some of the challenges experienced by smallholder milk producers and milk transporters and which policy makers can address include compliance with cleanliness and hygiene requirements, use of recommended containers to store and carry milk, testing of milk before bulking among others. Milk processing should be expanded to enhance value addition to ensure reduction of losses through longevity of value added products.

3. On channel choice and causes of milk losses among milk producers, the factors of interest to policyholders and dairy stakeholders include training on how to maximise production which directly affects the total milk output, training on keeping of records and awareness creation on the type of milk container that is suitable and recommended for handling milk. Other focus points will be training on hygiene on milk production and especially using detergents to clean milk containers. Policy implementers and dairy stakeholders should prioritise efforts to

minimise post-harvest milk losses considering that the implications of these losses directly affect the economic wellbeing and livelihood of farmers and other chain actors. This will reduce on the losses and additional cost incurred by milk producers and transporters ultimately resulting to higher economic returns for the respective chain actors in the dairy value chain. Additionally, the regulations governing the quality of marketed milk need urgent review to keep pace with the current conditions of milk marketing in Kenya as well as harmonizing the policies and laws affecting the dairy industry

Borrowing from Muia *et al.* (2011) it is recommended that in Nyandarua, milk marketing would be improved through reduction in cost of transportation, increased quality and safety for the informal sector, increased capacity and value addition for the formal sector, taking advantage of high population in urban and milk deficit rural areas, and the full exploitation of existing and emerging national, regional and international markets. Further, milk production would be enhanced through the improvements in marketing, use of appropriate dairy production and marketing technologies, sustainable natural resource management, and the increased accessibility to dairy production inputs and support services. Moturi *et al*. (2014) also recommends the need for further expansion of the modern milk marketing channels in Nyandarua, which can be facilitated by the establishment of milk collection infrastructural facilities at the farm gate, incentive pricing and rewards for quality produce. Sreedhar *et al*. (2017) further notes that suitable training programmes on improved milking management practices will help the farmers in clean milk production and increase the production performance of the dairy animal as well as generate more additional income to the farming community. He further recommends the need to organize extension activities through conducting demonstrations and training, on a limited scale but forceful enough to have a catalytic influence on the improvement in the knowledge of the farmers on recommended milking management practices. In addition, closer interaction between researchers, extension workers and farmers through participatory approaches has assumed greater mechanism for improvement of extension system by strengthening vertical linkages among components resulting in an effective extension setup, well equipped with technical know-how and solid infrastructural back up required to cater for the local needs of the dairy farmers. Anteneh *et al*. (2010) adds that frequent extension services on improved milk production to enhance the

knowledge and skills of farmers and other actors in the value chain is essential and critical. Market linkage, market promotion and provision of up-to-date market information at different market sites would also be an important component to enhance dairy production. Installation of milk chilling points in every ward in Nyandarua North Sub County would greatly reduce milk losses as milk would be chilled on delivery thereby eliminating traditional preservation currently used. Hodges, (2011) notes that the postharvest systems of LDCs, which includes Nyandarua, need considerable investment to create more formal markets and improve their performance to a point where PHLs can be substantially reduced. This, he suggests, can be through provision of public 'goods' including infrastructure such as the development of networks of all-weather feeder roads among others. The expected results from such investments include better educated farmers, better infrastructure to connect smallholders to markets; more effective value chains that provide sufficient financial incentives at the producer level; opportunities to adopt collective marketing and better technologies supported by access to microcredit; and the public and private sectors sharing the investment costs and risks in market-orientated interventions. Ayenew *et al*. (2009) further recommends that the development of innovative organizational structures such as cooperatives and other forms of producer groups, and the improvement of infrastructure such as transport, milk collection and milk processing units of a suitable capacity will help to increase the number of marketing options available to smallholder milk producers. It is suggested that improvements be made in infrastructural development especially a good road network. This will ensure that dairy products reach markets at the right time. A study by Omiti *et al*. (2009) suggested however that improved infrastructure is a necessary but not sufficient condition for enhancing agricultural commercialization. The sufficient condition would be simultaneous efforts to improve integration, through institutional reforms, and access, by building sustainable and predictable linkages to urban markets. Efforts towards this end would include group marketing arrangements to bring down transaction costs, bargain for better prices, enforce farmer-trader contracts and explore other opportunities inherent in economies of scale and scope. According to Lore *et al.* (2005), recommendations for interventions including training, technology, policy/legislation and information, aimed at reducing milk losses have been targeted at the farm level and small-scale milk transporters where losses in value were found to be most significant.

Omiti *et al*. (2009) further states that transaction costs often decline with increased urbanization, improvements in market access and the degree of market integration, while enterprise competition intensifies. This leads to a transition from low value crops such as maize, to more profitable enterprises such as dairy and tomatoes.

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APPENDICES

APPENDIX 1: Milk producer questionnaire

Greetings, I am Mathai M. Ndungu, a student at Egerton University pursuing a master of Science Degree in Agribusiness Management, conducting a research study on **"Determinants of post-harvest milk losses in the dairy value chain Nyandarua North Sub-County"**. As a milk producer you have been selected to participate in the study. You are therefore requested to provide accurate information being sought in this questionnaire. Your participation is voluntary and you are also assured that the information you provide will be treated with confidentiality and used solely for the purpose of research. Your support to the research is highly appreciated in advance. For more information or clarification, you can contact the project manager through 020 2318567 / 0736436466.

Identification

1. Division _____ Location _____

2. Name of enumerator _____

3. Milk producers Name and contact_____

4. Date of interview _____ Starting time _____Ending time_____

5. Milk producers milk value chain ☐ (1- Formal VC, 2 – Informal VC)

SECTION A: CHARACTERIZATION OF THE SOCIOECONOMIC AND MILK HANDLING ATTRIBUTES OF MILK PRODUCERS

6. Who is the head of household _____Sex (Male -1, Female - 0)

7. Age of Household head (Years)_____

8. Education level_____ (1 - lower primary, 2 - upper primary, 3 - secondary, 4 - Tertiary)

9. Dairy farming experience (Years) _____

10. Do you depend solely on income from dairy farming?

Yes ☐ No ☐

If no, what percentage of your total income is dairy income……

11. How many acres of land do you own and what acreage is used for dairy production?

Total acreage (Acres)_____ Area under dairy production (acres)_____

12. Herd composition details

Details	**Number**	**Type of breeds**
Cows (In milk)		
Cows (dry)		
Heifers		
Calves		
Bulls		

1-Ayshire, 2-Fresian, 3-Guernsey, 4-Crossbreeds, 5-Indeginious, 6-Jersey

13. Feeding system_____ (1- Zero grazing, 2- Natural pasture and zero, 3-pasture only)

14. Do you keep dairy production records? Yes ☐ No ☐

15. If yes, which records do you keep?

- Financial records ☐
- General records ☐
- Production records ☐
- Others (Specify)_____

16. Do you wash your hands with soap and clean water before milking?

Yes ☐ No ☐

17. What is the source of water you use for use and cleaning in your household? (1- River water, 2- Pond water, 3- Deep Well water, 4 – Tap water, 5 – Rain water)

18. Washing of milk containers (1 – use of cold water, 2 – use of warm water, 3 – No washing practice, 4 – Smoking the containers)

19. Do you use detergents or soap to wash your milk containers Yes ☐ No ☐

20. Milking parlour cleaning frequency (1 - Cleaned daily, 2 – cleaned weekly, 3 – cleaned fortnightly, 4 – cleaned monthly, 5 – cleaned after more than a month)

21. Udder cleaning (1- washed using cold water, 2 - washed using warm water, 3 - No washing)

22. Do you use a towel to clean and dry cows' udder? Yes ☐ No ☐

23. Do you use a different towel for each cow milked? Yes ☐ No ☐

24. How do you preserve your milk ? ……

(1 - cooling , 2 - boiling ,3 - chemical preservation, 4 - other)

Briefly explain……

SECTION B: QUANTIFICATION OF MILK POST-HARVEST LOSSES ALONG THE MILK VALUE CHAIN

25. Distance from household to milk collection point in Kms …….

26. Daily Milk Production and distribution (High Season)

No of cows milked	**Total Amount produced (Lts)**		**Total output**	**Amount consumed (Lts)**	**Amount fed to Calves (Lts)**	**Amount sold (Lts)**	**Other use ……**
	Morning	**Evening**					

27. Daily Milk Production and distribution (Low Season)

No of cows milked	**Total Amount produced (Lts)**		**Total output**	**Amount consumed (Lts)**	**Amount fed to Calves (Lts)**	**Amount sold (Lts)**	**Other use …**
	Morning	**Evening**					

28. Choose any cause of milk post-harvest losses you might have experienced and actual quantities of milk losses

	Cause of milk PHL/Month	**Quantities lost (Monthly)**		
		Morning	**Evening**	**Total (Lts)**
A	Spillage			
B	Forced consumption			
C	Non-collection of milk			
D	Spoilage			
E	Contamination			

F	Milk thrown away due to diseased cow e.g. mastitis or effect of deworming drugs			
G	Other			

SECTION C – DETERMINATION OF FACTORS THAT CONTRIBUTE TO POST-HARVEST MILK LOSSES ALONG THE MILK VALUE CHAIN

29. Please provide information of milk marketing channels available in your locality, offered price and advantages /disadvantages of each?

Milk marketing channel	**Offered price per litre (Kes)**	**Advantage(s)**	**Disadvantage(s)**	**Channel used by ; (tick)**
Cooperative society				
Milk brokers / hawkers				
Sale to neighbours / local sales				
Direct to processor				
Other (Please specify)				

……

……

30. Among the many farm based decisions, do you mix evening and morning milk for sale to the processor? (Tick one)

☐ Yes No ☐

If yes do you experience any spoilage or contamination? If no, what measures have you put in place to ensure milk quality is not compromised with? Please explain.

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31. What type of milk containers, milking churn and milking items do you use?

☐ Aluminum ☐ Plastic containers ☐ Stainless steel ☐ other (Please specify)……..…….

32. Have you mechanized dairy production activities at your farm (Milk coolers, milking machines etc.)?

Yes ☐ No ☐

If yes, please explain…….....

(General information by all respondents – milk producers / transporters / processors / other stakeholders e.g. livestock extension officers). This information will also facilitate the focus group discussion – FGD)

33. What factors contribute to post-harvest milk losses in Nyandarua North Sub-County?

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34. What suggestions can you give for these losses to be reduced in Nyandarua North Sub-County?

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35. What interventions in your own opinion can be initiated to reduce milk post-harvest losses and ultimately result in a better performing milk value chain for all chain actors in Nyandarua North Sub-County?

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36. Any other comments / suggestions / or ideas that can be of use to this research?

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THANK YOU!

APPENDIX 2: Milk transporter questionnaire

Greetings, I am Mathai M. Ndungu, a student at Egerton University pursuing a master of Science Degree in Agribusiness Management, conducting a study on **"Determinants of post-harvest milk losses in the dairy value chain Nyandarua North Sub-County"**. As a milk transporter, you have been selected to participate in the study. You are therefore requested to provide accurate information being sought in this questionnaire. Your participation is voluntary and you are also assured that the information you provide will be treated with confidentiality and used solely for the purpose of research. Your support to the research is highly appreciated in advance. For more information or clarification, you can contact the project manager through 020 2318567 / 0736436466.

Identification

1. Division _____ Location _____

2. Name of enumerator _____

3. Transporter Name and contact_____

4. Date of interview _____ Starting time _____Ending time_____

QUANTIFICATION OF MILK POST-HARVEST LOSSES AMONG TRANSPORTERS ALONG THE MILK VALUE CHAIN.

4. During bulking at farmer collection point, are there instances where collection equipment quantity is inadequate and resulting in rejection of excess milk?

Yes ☐ No ☐

If yes please provide estimates of quantities rejected per every 50 litres bulked.

……

……

……

5. Do you experience any loss of milk due to either spillage or spoilage? Yes ☐ No ☐

If yes please provide actual milk loss quantities per every 50 litres bulked.

	Cause of milk PHL during transportation	**Quantities lost (Per every 50 litres bulked)**		
		Morning (lts)	**Evening (lts)**	**Total (lts)**
A	Spillage			
B	Spoilage			
C	Contamination			
D	Other			

DETERMINATION OF FACTORS THAT CONTRIBUTE TO POST-HARVEST MILK LOSSES AMONG TRANSPORTERS ALONG THE MILK VALUE CHAIN

6. State of road linking farm to collection point (Tick appropriately)

Road state	**All weather**	**Murram**	**Tarmac**	**Other (Please specify)**
Tick appropriately				

7. How accessible are the farms that you collect milk from?

	Season	**Accessibility to farmer collection points (Tick)**			
1.	Rainy season	Yes		No	
2.	Dry season	Yes		No	

8. What is the mode of transport you use for transporting milk to the processors?

Transport mode	**Tick appropriately**
Bicycle	
Motor bike	
Donkey cart	
Pick up	
Truck	
Physical delivery by walking	
Other (please specify)	

9. Which kind of equipment do you use to bulk milk during collection from farmers?

Equipment(s)	Size of equipment in litres	Reason(s)

1 - Plastic containers, 2 - Aluminium can, 3 - Paper bag

10. Do you undertake any type of milk quality verification test at collection points?

Yes ☐ No ☐

If yes, please specify……

11. What happens to milk that has failed the quality test at the collection point?

(1 – Reject and give back to farmer , 2 – Collect conditionally 3 – Colour the milk to prevent resale , 4 – Other (Please explain)

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12. Who bears the cost for spoilt milk during transportation between the collection point and the processing plant?

	Cause of milk PHL during transportation	**Bearer of milk loss Burden (Tick appropriately)**		
		Farmer	Transporter	Processor
A	Spillage			
B	Spoilage			
C	Contamination			
D	Other ……			

13. What time do you collect milk on a daily basis and does this have an implication on milk quality?

Time (morning.)……Time (evening)……..

Implication(s)……

……

14. Approximately how long does it take you to deliver milk collected to the processing point?

Time taken to deliver milk to processing point in hours	**< 1hour**	**1**	**2**	**3**	**4**	**Above 5 hours**
Tick appropriately						

(General information by all respondents – farmers / transporters / processors / other stakeholders e.g. livestock extension officers). This information will also facilitate the focus group discussion – FGD)

15. What factors contribute to post-harvest milk losses in Nyandarua North Sub-County?

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16. What suggestions can you give for these losses to be reduced in Nyandarua North Sub-County?

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17. What interventions in your own opinion can be initiated to reduce milk post-harvest losses and ultimately result in a better performing milk value chain for all chain actors in Nyandarua North Sub-County?

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18. Any other comments / suggestions / or ideas that can be of use to this research?

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THANK YOU!

APPENDIX 3: Milk processor questionnaire

Greetings, I am Mathai M. Ndungu, a student at Egerton University pursuing a master of Science Degree in Agribusiness Management, conducting a study on **"Determinants of post-harvest milk losses in the dairy value chain Nyandarua North Sub-County"**. As a milk processor, you have been selected to participate in the study. You are therefore requested to provide accurate information being sought in this questionnaire. Your participation is voluntary and you are also assured that the information you provide will be treated with confidentiality and used solely for the purpose of research. Your support to the research is highly appreciated in advance. For more information or clarification, you can contact the project manager through 020 2318567 / 0736436466.

Identification

1. Division _____ Location _____

2. Name of enumerator _____

3. Processors name and contact_____

4. Date of interview _____ Starting time _____Ending time_____

QUANTIFICATION OF MILK POST-HARVEST LOSSES AMONG MILK PROCESSORS

5. What are the actual milk losses that you experience per every 100 litres of received milk at your plant?

	Cause of milk PHL at processing point	**Quantity of loss per every 100 lts of milk received**		
		Qty (Lts)	**Approximate value (KES)**	**Who bears this cost?**
A	Spillage			
B	Spoilage			
C	Contamination			

D	Power failure/equipment breakdown			
E	Rejection due to substandard quality of milk			
F	Non collection of milk at farmer collection points			
G	Inadequate bulking equipment			
H	Other e.g. Accident leading to spillage……..			

6. Do you discard milk that is not fit for processing?

☐ Yes No ☐

If yes, please specify method of disposal and if possible daily averages, if no, please explain what happens to this milk

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7. Do you experience a reduction in quantity of milk during processing and /or conversion as a post-harvest loss?

	Cause of milk reduction at processing point	**Reduced quantity per every 100 lts of milk received**		
		Qty (Lts)	Approximate value (Kes)	Who bears this cost?
A	Spillage			
B	Spoilage			
C	Contamination			
D	Other ……			

DETERMINATION OF FACTORS THAT CONTRIBUTE TO POST-HARVEST MILK LOSSES ALONG THE MILK VALUE CHAIN

8. Does your plant experience post-harvest losses of milk after collection by transporters or delivery at processing plant?

☐ Yes No ☐

If yes, please specify the main causes of such losses. (1 – Spillage, 2 – spoilage, 3 – Contamination, 4 – Other (please explain)

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(General information by all respondents – farmers / transporters / processors / other stakeholders e.g. livestock extension officers). This information will also facilitate the focus group discussion – FGD)

9. What factors contribute to post-harvest milk losses in Nyandarua North Sub-County?

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10. What suggestions can you give for these losses to be reduced in Nyandarua North Sub-County?

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11. What interventions in your own opinion can be initiated to reduce milk post-harvest losses and ultimately result in a better performing milk value chain for all chain actors in Nyandarua North Sub-County?

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12. Any other comments / suggestions / or ideas that can be of use to this research?

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THANK YOU!