

**INFLUENCE OF INNOVATION PLATFORM-BASED CAPACITY BUILDING ON
FARM-LEVEL MILK LOSSES AMONG SMALLHOLDER DAIRY FARMERS IN
MOGOTIO SUB-COUNTY, BARINGO COUNTY, KENYA**

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**A Thesis Submitted to the Graduate School in Partial Fulfillment of the Doctor of
Philosophy Degree in Agricultural and Rural Innovations Studies
of Egerton University**

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented or submitted for examination in any institution.

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Recommendation

This thesis has been submitted for examination with our approval as supervisors, in accordance with Egerton University regulations.

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DEDICATION

This work is dedicated to my parents for their unwavering support and prayers throughout my studies, as well as to my wife and children for their encouragement.

ACKNOWLEDGMENTS

All glory goes to the Almighty God for his sufficient grace and favor upon my life throughout my academic journey. It is He who granted me energy and good mental health to begin and to complete this task successfully. To Him be the glory and honour. Sincere gratitude goes to my supervisors, Dr. Agnes O. Nkurumwa and Dr. Stephen W. Maina, for their great guidance, supervision, and steadfast support that have ensured this thesis is successful. I am also indebted to acknowledge the support from the Kenya Climate Smart Agriculture project for financing the project. My special thanks go to the County Government of Baringo, Mogotio Sub-County, for giving me an opportunity to conduct my research. I also gratefully acknowledge the support given to me by smallholder dairy farmers, whom I interviewed for their honest and enormous contributions during data collection. To my colleagues, I am grateful for their enthusiasm to share great ideas and knowledge throughout the study. God bless you all!

ABSTRACT

Smallholder farmers constitute 80 percent of dairy producers and 56 percent of the milk production in Kenya. The income generated from milk for many smallholder farmers is their only income. Furthermore, many farmers experience significant farm-level losses of milk, which negatively impacts their income. Decreasing farm-level milk loss through the use of an interactive innovation platform is important in increasing the income of smallholder dairy farmers and actors along the dairy milk value chain. This study aimed to help decrease farm-level milk loss through an innovation capacity development and platform-based approach of smallholder dairy farmers in the Mogotio Sub-County of Baringo County. A mixed-methods research design was employed. The target population was 2500 smallholder dairy farmers, and the accessible population was 840 members of the Mogotio Dairy Cooling Plan. A sample of 120 farmers was selected from a baseline survey, and probability sampling was employed to select the sample of farmers. Capacity building was rendered to dairy farmers by the researcher and KALRO staff in 8 weeks. At the end of the project, 120 farmers were sampled in an end-of-project survey to measure the effect of the capacity-building intervention. Thirty of the farmers selected were purposefully sampled for focus group discussions. Data were collected from smallholder dairy farmers via a questionnaire and focus group discussion guides. Stakeholder data were collected via a key informant study guide. To maintain reliability, instruments were piloted at Marigat Ward. The Cronbach's alpha coefficient was used to measure the reliability of the data; a reliability of 0.781 was found, which is above the acceptable limit of 0.7. SPSS and NVivo were used for data analysis. For study hypothesis testing, bivariate statistics were used; Pearson chi-square and t-test were conducted at the $\alpha = 0.05$ level of significance. Descriptive statistics used measures of central tendency, dispersion, and proportions analysis. The study surfaced high levels of farm-level loss of milk, low levels of milk production, and high spillage, spoilage, and contamination of milk for smallholder dairy farmers in Mogotio Sub-County. The capacity-building intervention positively affected the reduction in farm-level loss of milk for smallholder dairy farmers in Mogotio Sub-County. The use of the platform provided farm-level handling practice innovation for smallholder dairy farmers. The intervention also added to the traditional government extension service with changes in their agricultural extension services. Based on this study, I recommend that the Ministry of Agriculture and Livestock Development help with the advocacy to integrate innovation platforms, digital platforms, smallholder dairy farmers, and dairy value chain actors into the traditional extension

programs.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATIONS	ii
COPYRIGHT	iii
DEDICATION.....	iv
ACKNOWLEDGMENTS.....	v
ABSTRACT	vi
LIST OF TABLES	xi
LIST OF FIGURES	xiii
LIST OF ABBREVIATIONS AND ACRONYMS	xiv
CHAPTER ONE.....	16
INTRODUCTION.....	16
1.1 Background of the Study	16
1.2 Statement of the Problem	20
1.3 Purpose of the Study	20
1.4 Objectives of the Study	20
1.5 Research Questions	21
1.6 Research Hypothesis	21
1.7 Significance of the Study	21
1.8 Scope of the Study.....	22
1.9 Limitations of the Study	22
1.10 Assumptions of the Study	22
1.11 Definition of Terms	23
CHAPTER TWO	25
LITERATURE REVIEW.....	25
2.1 Introduction.....	25
2.2 Milk Production and Farm-Level Milk Losses	25
2.3 Dairy Farming in Baringo County, Kenya	29
2.4 Status of Dairy Production Response to Environmental Shocks in Baringo County	35
2.5 Status of Livestock Advisory Services in Kenya	36
2.6 Dairy Farming Capacity Building Through Innovation Platforms.....	39
2.7 Factors Affecting Milk Production in Baringo County, Kenya	57

2.8 Market Status for Milk in Kenya	59
2.9 Milk Cooling Centers	63
2.10 Theoretical Framework.....	66
2.11 Conceptual Framework.....	69
CHAPTER THREE	72
RESEARCH METHODOLOGY.....	72
3.1 Introduction.....	72
3.2 Research Design	72
3.3 Location of the Study	73
3.4 Target Population	75
3.5 Sampling Procedure and Sample Size	75
3.6 Instrumentation	77
3.6.1 Baseline Survey Questionnaire	77
3.6.2 Focus Group Discussion Guide	78
3.6.3 Key Informant Interview Schedule.....	78
3.6.4 Endline Questionnaire	79
3.6.5 Farmers Training Guide.....	79
3.7 Validity	80
3.8 Reliability	80
3.9 Data Collection Procedure.....	81
3.10 Data Analysis.....	84
3.11 Analysis for Objective One	86
3.13 Analysis for Objective Three	86
3.11 Ethical Considerations	87
CHAPTER FOUR.....	88
RESULTS AND DISCUSSIONS	88
4.1 Introduction.....	88
4.2 Socio-Economic Characteristics of Smallholder Dairy Farmers.....	88
4.3 Status of Farm Level Milk Losses Among Smallholder Farmers in Mogotio Sub- county	91
4.3.1 Feeding Systems	92
4.3.2 Dairy Production Record Keeping	93
4.3.3 Type of Cattle Breeds Kept	94

4.3.4 Average Milk Production by Smallholder Farmers in Mogotio Sub-county	97
4.3.5 Market Outlet for Milk	99
4.3.6 Influence of Variable Costs on Clean Milk Production	100
4.3.7 Milk Handling Attributes of Smallholder Dairy Farmers	102
4.3.8 Level of Farm-Level Milk Losses Experienced by Smallholder Farmers.....	103
4.3.9 Findings from Focus Group Discussions on Farm-level Milk Losses	104
4.3.10 Focus Group Discussion and Dairy Advisory at IP Intervention in Mogotio Sub-County	107
4.4 Opportunities for the Utilization of Innovation Platform-based Programme to Build Capacity in Proper Milking Practices.....	108
4.4.1 Nutritional Management Technologies	108
4.4.2 Opportunities to Improve Access to Advisory Services Through Innovation Platform	112
4.4.3 Opportunities in Maintaining the Mogotio Innovation Platform.....	114
4.4.4 Attendance of Trainings on Reduction of Farm Level Milk Losses	115
4.4.6 Training Mode and Training Aids Used by Mogotio in the Innovation Platform.	117
4.5 Influence of Innovation Platform-based Capacity Building Programme on Farm Level Milk Losses	119
4.5.1 Influence of the Dairy Innovation Platform-based Capacity Building on Milking Techniques.....	119
4.5.2 Influence of Innovation Platform-based Capacity Building on Use of Home-made Milking Structures	120
4.5.3 Influence of Innovation Platform-based Capacity on Daily Milk Yields.....	121
4.5.4 Challenges Addressed by Mogotio Innovation Platform	125
CHAPTER FIVE.....	128
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.....	128
5.2 Summary of the Findings	128
5.3 Conclusions.....	129
5.4 Recommendations.....	129
5.5 Suggestions for Further Research.....	130
REFERENCES	131
APPENDICES	169
Appendix A: Baseline Survey Questionnaire	169

Appendix B: Focus Group Discussion Guide For Smallholder Dairy Farmers	177
Appendix C: Key Informant Schedule	178
Appendix D: End-line Survey Questionnaire.....	179
Appendix E: Farmer Training Guide.....	183
Appendix F: Map of the Study Area	188
Appendix G: Research Permit.....	189
Appendix H: Abstracts of Published Papers	191
Appendix I: Selected Data Analysis Outputs	193

LIST OF TABLES

Table 3.1: Target Population and Sample Size	77
Table 3.2: Summary of Data Analysis	85
Table 4.1: Social Characteristics of Smallholder Dairy Farmers in Mogotio Sub-county (n=120).....	89
Table 4.2: Land Ownership and Sources of Household Income of Smallholder Dairy Farmers (n=120).....	90
Table 4.3: Feeding Systems Used by Dairy Farmers (n=120).....	92
Table 4.4: Dairy Production Records of Smallholder Farmers (n=120).....	93
Table 4.5: Type of Breeds and Stock of Smallholder Farmers (n=120).....	96
Table 4.6: One-Way ANOVA Results for the Test of Differences in Milk Values per Breed (n=120).....	96
Table 4.7: Amount of Milk Realized Before Implementation of Innovation Platform-based Capacity Building Programme (n=120).....	97
Table 4.8: Mean Milk Production of Smallholder Farmers After the Intervention (n=120) ..	98
Table 4.9: The Chi-square Results for the Milk Yield Before Farmers' Acquired Knowledge on Milking Techniques (n=120)	99
Table 4.10: Market Outlets for Milk Among Smallholder Dairy Farmers (n=120)	100
Table 4.11: Status of Variable Costs Incurred by Smallholder Dairy Farmers (n=120)	101
Table 4.12: Milk Handling Attributes of Smallholder Farmers (n=120).....	102
Table 4.13: Types of Milk Losses on Farms of Smallholder Farmers (n=120).....	104
Table 4.14: Smallholder Farmers' Nutritional Management Practices (n=120).....	110
Table 4.15: Milking Area Management by Smallholder Farmers (n=120)	111
Table 4.16: Opportunities to Improve Breeding Strategies by Smallholder Dairy Farmers (n=120).....	112
Table 4.17: Sources of Information Opportunities on Proper Milking Techniques Before Innovation Platform- based Programme (n=120)	113
Table 4.18: Mean Value for Level of Knowledge on Milking Techniques Before Training (n=120).....	114
Table 4.19: Training Modes Preference Assessment After the Innovation Platform Capacity Programme (n=120).....	118
Table 4.20: Mean Values for Level of Knowledge of ilkMing Techniques After Training (n=120).....	120

Table 4.21: One-way ANOVA for the Differences in Mean Milk Values Across the Milking Methods (n=120).....	120
Table 4.22: Use of Home-made Milking Structures (n=120).....	121
Table 4.23: Amount of Milk Realized After Implementation of Innovation Platform-based Capacity Building Programme (n=120).....	121
Table 4.24: Chi-square Results for the Milk Yield After Farmers Acquire Knowledge on Milking Techniques (n=120)	123
Table 4.25: Accessibility of Dairy Advisory Services Through Innovation Platform Capacity Building (n=120).....	123
Table 4.26: Gender Distribution of Farmers Requesting Enlisting on the Innovation Platform-based Programme	124

LIST OF FIGURES

Figure 2.1: The Value Chain of Dairy Milk in Baringo County	34
Figure 2.2: Agricultural Innovation System Approach.....	66
Figure 2.3: Kurt Lewin's Model of Organizational Change.....	67
Figure 2.4: Factors that Influence Knowledge Construction, Actions, Behaviours, and Agricultural Outcomes	68
Figure 2.5: Conceptual Framework	70
Figure 4.1: Level of Farm-Level Milk Losses Experienced by Smallholder Farmers.....	104
Figure 4.2: Sources of Milk Losses (n=120)	106
Figure 4.3: Dairy Training at Innovation Platform Intervention (n=120).....	107
Figure 4.4: Promotion of Participation (n=120)	108
Figure 4.5: Opportunities in Maintaining the Mogotio Innovation Platform (n=120).....	115
Figure 4.6: Attendance of Training on Reduction of Farm-level Milk Losses (n=120)	116
Figure 4.7: Calves Early Weaning Practice (n=120)	117
Figure 4.8: Challenges Addressed by Mogotio Innovation Platform (n=120).....	126

LIST OF ABBREVIATIONS AND ACRONYMS

AAS	Agricultural Advisory Service
AfDB	African Development Bank
AI	Artificial Insemination
ASAL	Arid and Semi-Arid Land
CIDP	County Integrated Development Plan
CMO	Context-Mechanism -Outcome Theory
CPF	Country Programming Framework
EADD	East Africa Dairy Development
EDE	Ending Drought Emergencies
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
FHH	Female-Headed Household
GoK	Government of Kenya
HH	Household Head
ICTs	Information and Communication Technologies
IE	Impact Evaluation
IGAD	Inter-Governmental Authority on Development
IP	Innovation Platform
KAVES	Kenya Agricultural Value Chain Enterprises
KCC	Kenya Cooperative Creameries
KDB	Kenya Dairy Board
KES	Kenya Shillings
KNBS	Kenya National Bureau of Statistics
KPHC	Kenya Population and Housing Census
MCC	Milk Cooling Centers
MHH	Male-Headed Household
MoALF	Ministry of Agriculture, Livestock and Fisheries
NDMA	National Drought Management Authority
NGOs	Non-Governmental Organizations
NKCC	New Kenya Cooperative Creameries
PAR	Participatory Action Research
SCC	Somatic Cell Count
SDG	Sustainable Development Goal
SRA	Strategy to Revitalize Agriculture

SSA	Sub-Saharan Africa
SSMV s	Small-Scale Milk Vendors
TC	Training and Certification
TCA	Thematic content analysis
UHT	Ultra-High Temperature
USA	United States of America
WB	World Bank
YHH	Youth-Headed Household

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The global dairy industry encompasses diverse countries, each with unique production methods and consumer markets. It is experiencing rapid growth, with global milk production projected to rise by 178 million tons by 2030 (Bojovic, 2023). This expansion is largely driven by population growth, urbanization, and rising incomes in developing markets, which continue to fuel demand for dairy products. The industry produces a wide range of commodities, including milk, cheese, butter, cream, curd, and kefir, with milk remaining the most widely produced product worldwide (Eskola et al., 2020). Several animal species contribute to milk production, such as cows, goats, camels, and buffalo; however, cows are the dominant source, accounting for the majority of global output.

In 2023, global milk production was estimated to be approximately 911 million metric tonnes. This amount represents a modest growth from the years before, and it is consistent with the growth of the global dairy industry (FAO, 2024). Livestock production is a good source of food in the world, and there has been a rapid increase in milk and dairy consumption in several developing countries. It is estimated that globally over 118 million farms are registered as dairy farms (Spielman *et al.*, 2019). About 65% of these farms are located in Sub-Saharan Africa (SSA), South Asia, Eastern Europe, and Central Asia. Over the last thirty years, the world's milk production has increased by over 50% (FAO, 2018). This trend will most likely continue in emerging economies, due to rapid population growth and increasing incomes. The need for fresh milk and related products has been connected to ongoing issues related to food safety issues in established and new dairy chains within both emerging and developed economies (Van Bokhorst-van den Veen & Groot, 2017).

In 2023, Africa's milk production was estimated at approximately 40–45 million metric tons, reflecting steady growth in the continent's dairy sector. Despite this progress, Africa's contribution remains relatively small compared to leading producers such as the European Union, the United States, and India (FAO, 2024). Cow milk accounts for nearly 75% of total output, while camels and goats contribute the remaining 25% (FAO, 2021a). In Sub-Saharan Africa alone, about 88% of the 31.3 million metric tons produced in 2023 originated from cattle, underscoring the central role of dairy cattle in the region. Advances in selective breeding, feeding, and management practices have significantly enhanced productivity

(Wahyono et al., 2023). This growth has substantial economic and social implications, as milk production—dominated by smallholder farmers—provides both income and employment opportunities, particularly in rural areas (Prayitno et al., 2022). Consequently, the dairy industry holds considerable potential to drive poverty alleviation, improve food security, and enhance nutrition across Sub-Saharan Africa. However, challenges such as climate change continue to hinder the sector's effectiveness. Because production is predominantly rain-fed, milk yields are subject to marked seasonal fluctuations, which threaten the reliability of supply (Tadesse & Dereje, 2018).

Mekuriaw and Harris-Coble (2021) note that Eastern African countries (Ethiopia, Kenya, Uganda, and Tanzania) represent the largest share of cow milk produced in sub-Saharan Africa, and Kenya is the leading producer in the sub-region. In sub-Saharan Africa, Eastern Africa is a relevant producer of cow milk. Kenya, Ethiopia, and Uganda are key countries in the region. In a report by FAO (2021a), Eastern African countries contributed approximately 63% of the cow milk produced in sub-Saharan Africa. Kenya, as an example, produced approximately 3.43 billion litres of milk per annum, which represents approximately 18% of the total cow milk produced in sub-Saharan Africa. There were approximately 22 million tonnes of milk produced in the sub-region in 2019, signifying a good performance of the sector. Even though we are on top in milk production in Sub-Saharan Africa, on the globe, Eastern African countries represent a weak 3.5% of the world's total milk production, despite consisting of about 21% of the world's milking cows (FAO, 2021b; Wilkes *et al.*, 2020).

The dairy sector is the largest agricultural sub-sector in Kenya, contributing approximately 14% to the national GDP (Wangu et al., 2021). It directly supports the livelihoods of around four million people (Kyule & Nguli, 2020), with an estimated 1.3 million households engaged in dairy cattle farming. Annual per capita milk consumption stands at about 117 litres (FAO, 2021a), highlighting the sector's critical role in ensuring food and nutritional security. Smallholder farmers account for nearly 80% of total milk production, most of which is sold through informal markets that dominate roughly 80% of raw milk distribution in the country. These informal markets are largely controlled by brokers, who are often perceived negatively due to their role in distorting prices (Wangu et al., 2021). Consequently, only about 20% of smallholder farmers supply milk to cooperatives and processors, despite the latter's processing capacity increasing at a rate of 7% annually. These dynamics underscore the structural challenges confronting Kenya's dairy sector (Omondi *et al.*, 2017).

The stagnation of production is a major concern for Kenya's dairy sector. In 2016, it had around 6.5 million dairy cows. This dropped considerably to 4.61 million before recovering somewhat back to around 5 to 6 million dairy cows starting in 2022 (Ministry of Agriculture, Livestock, Fisheries and Cooperatives, 2022). Milk output decreased from 4.1 million tonnes in 2016 to 3.98 million tonnes in 2019. As the head count of dairy cows decreased, milk output also decreased (FAO, 2021b). Despite this, there was a slight rise in productivity per cow. The yield of cow milk, for instance, in 2016 was 0.63 and 0.86 tonnes in 2019, but still way below the global average of 2.2 tonnes per cow and the potential based on recent sector developments (Anwar, 2017). Limited milk production in the Country is generally due to decreased land size, poor husbandry, high input costs, poor quality feed, and climate change impact (Bingi *et al.*, 2015). Other issues confronting the dairy industry are policy and regulatory issues, low producer milk prices that discourage investment in milking, loss of milk from the farm to market and processing, and high production costs.

In Kenya, there is little literature on milk losses, and those that do exist often deal with post-harvesting loss of milk (Kashongwe *et al.*, 2017a). The studies generally indicate that the milking techniques affect the quality of the milk, with a notable focus on the cleanliness in milking, where dirty conditions can affect the microbial quality of the milk. Kashongwe *et al.* (2017a) indicated a significant loss of quality and safety of milk as a result of suckling calves on the cows before milking. Even though this stage reduces the quantity of milk allowed for collection, not much has been done on this issue related to dairy research in Kenya.

According to March *et al.* (2019), the significant milk loss problem at the farm has not received sufficient attention, and therefore, insufficient attention has been paid to primary production losses in Kenya. Nevertheless, loss of milk production as a result of suckling before milking is generating more attention from stakeholders because it has not received enough attention to address the issues to eliminate the milk loss. Milk losses at the farm depend on research on milking practices, which provide not only cow milk hygiene but also ensure the loss of optimal milk quantity.

Innovation platforms are collaborative structures used to facilitate and promote innovation amongst stakeholders (Chilundo *et al.*, 2020). An innovation platform could be an excellent channel to tackle farm-level milk losses through skill-building of farmers. Innovation platforms provide a structured setting where partners can exchange knowledge, ideas, and resources in order to address complex issues and create innovations, technological or socially

based (Brown *et al.*, 2022). Innovation platforms typically include processes for dialogue, coordination, and group problem-solving, allowing collective response to tackle challenges and leveraging their unique attributes to create innovations and accelerate the rate of innovation (Brown *et al.*, 2022).

There are multiple forms of structured entities meant to improve human or organizational skill, knowledge, and competence using a collective and innovative manner (UNFCCC, 2024). An Innovation Platform-Based Capacity Building Programme in Dairy is a collaborative space or network where relevant stakeholders, including researchers, practitioners, policy-makers, or communities, come together to dialogue, share knowledge, and pool ideas and resources (Dadfar *et al.*, 2013) to create innovations or address specific challenges or opportunities.

Dairy cooperative societies have become essential in enhancing milk production among smallholder farmers. Beyond marketing, these cooperatives address members' technical needs by providing education, extension services, feed supplies, and credit facilities to support investments in dairy infrastructure. They also play a key role in facilitating the adoption of improved dairy management practices, thereby serving as formal platforms for innovation (Wangu *et al.*, 2021). One critical area of support expected from cooperatives is raising awareness and promoting the implementation of improved calf-rearing systems, which can enhance milk yield, quality, and safety while reducing post-harvest losses (Asheim *et al.*, 2016). Nonetheless, limited research exists on the economic impact of practices such as preventing suckling on milk production in Kenya, particularly in semi-arid counties that hold significant potential for livestock development.

Mogotio farmers' cooperatives in Mogotio sub-county, Baringo county, our project site, despite the high milk volumes it receives, its dairy product portfolio is less diverse compared to other cooperative societies due to low milk cooling capacity. The dairy farmers of Mogotio still depend on open field grazing and depend on calves to assist with milk let-down stimulation before they milk, which results in milk losses. At the time of milking, it is considered suitable to use suckling of the calf and tether the calf near the dam to stimulate milk let-down (Johanssen *et al.*, 2023).

It has been known that restricted suckling is labour-intensive; as such, they have moved from restricted suckling to artificial rearing, particularly where milk is an expensive supplement to their diet and no affordable substitutes are available (De la Cruz-Cruz *et al.*, 2019). However,

it was found that the amount of time needed to milk with the calf alongside the dam was no different than the time required to feed calves.

This study was conducted in Mogotio sub-county, Baringo county, Kenya. While the promotion of preventing suckling during milking has been supported by other cooperatives in the county, the adoption of this dairy management system by farmers in Mogotio remains low, leading to decreased milk performance, quality, and higher milk losses (Kumar, 2023). A dairy innovation platform could transform Baringo's dairy industry, especially the Mogotio Sub-County dairy cooperative societies and agricultural entrepreneurship innovators, by modernizing their dairy equipment and fostering an industry that reduces farm-level milk losses and boosts income for small-scale dairy farmers. Therefore, this study examined the effect of the innovation platform on reducing pre-harvest milk losses among smallholder livestock farmers in Mogotio sub-County, Baringo County, Kenya.

1.2 Statement of the Problem

Milk losses represent a significant economic issue for the smallholder dairy farmers of Mogotio Sub-County. This is mainly attributed to improper milking practices such as limited suckling, late weaning, and concurrent milking and suckling. These procedures expose an overage calf to approximately 20% of the total milk in the udder, resulting in loss of milk. Late weaning of calves also contributes to farm-level milk losses by dairy farmers. Besides significant milk losses, suckling as a pre-milking palpation routine is a major impediment to assured milk quality, quantity, and safety, which further causes post-harvest milk losses, contamination, and rejection by processors. Through the innovation platform approach, smallholder farmers can acquire and receive new knowledge through training and the sharing of technical information on milk loss reduction. This study assessed the influence of innovation platform-based capacity building on farm-level milk losses among smallholder dairy farmers in Mogotio Sub-County, Baringo County, Kenya.

1.3 Purpose of the Study

The purpose of this study was to examine the influence of innovation platform-based capacity building on the reduction of farm-level milk losses among smallholder dairy farmers in Mogotio Sub-County, Baringo County, Kenya.

1.4 Objectives of the Study

The objectives of the study were:

- i. To assess the status of farm-level milk losses among smallholder dairy farmers in Mogotio Sub-County, Baringo County, Kenya.
- ii. To determine opportunities for the utilization of innovation platform-based programme to build capacity in proper milking practices among smallholder dairy farmers in Mogotio Sub-County, Baringo County, Kenya.
- iii. To determine the influence of an innovation platform-based capacity-building programme on farm-level milk losses among smallholder dairy farmers in Mogotio sub-county, Kenya.

1.5 Research Questions

The study sought to answer the following questions:

- i. What is the status of farm-level milk losses among smallholder dairy farmers in Mogotio Sub-County, Baringo County, Kenya?
- ii. What are the opportunities for the utilization of innovation platform-based programmes to build capacity in proper milking practices among smallholder dairy farmers in Mogotio Sub-County, Baringo County, Kenya?

1.6 Research Hypothesis

The following hypothesis was tested in the study:

H0₁: Innovation platform-based capacity building programme does not have a statistically significant influence on farm-level milk losses among smallholder dairy farmers in Mogotio sub-County, Kenya.

1.7 Significance of the Study

The study has come up with a dairy Farmer Training manual, which may be useful to smallholder dairy farmers in helping reduce farm-level milk losses. The study sheds more light on how innovation platforms facilitate interactive learning, which is useful to

policymakers, smallholder farmers, and development partners. In addition, dairy farmers have received advice on proper milking and hence may be able to reduce milk losses. Through the provision of advisory services at the innovation platform, this study complements the services offered by the ever-reducing livestock extension staff deployed by the government. This may directly benefit over 800 smallholder farmers who supply milk to the Mogotio cooling plant. In addition, over 2500 households may benefit directly or indirectly as secondary and tertiary beneficiaries through enhanced knowledge sharing and application.

1.8 Scope of the Study

This study focused on smallholder dairy farmers engaged with the Mogotio innovation platform. Although the platform offers a wide range of services, the present research considered only its role in building the capacity of smallholder farmers. Within this scope, attention was further narrowed to two specific areas of capacity building: the adoption of proper milking practices and the application of techniques aimed at reducing milk losses at the farm level.

1.9 Limitations of the Study

Limitations of the study were as follows:

- i. There was a limitation on the accuracy of Government statistics. Some of the reported data may have been inaccurate. This was addressed by triangulating all the statistics from the government with other data sources.
- ii. There were inherent biases or weaknesses associated with data from study participants as collected through the researcher-administered questionnaires. This was resolved through methodological triangulation as a participatory action research (PAR) study utilizing multiple procedures of data collection.
- iii. The study was undertaken in the Mogotio Sub-County of Baringo County, and thus, the results can only be generalized to other regions of Kenya with caution due to differences in context and characteristics.

1.10 Assumptions of the Study

The study presumed that the smallholder dairy farmers in the Mogotio would actively engage

in innovation platform-based learning to improve milking practices.

1.11 Definition of Terms

The key terms of this study are defined as follows:

Capacity building: Capacity building is the strengthening and maintenance of people, organizations, and society's ability to conduct core functions and sustain their ability to continuously improve (Kusters *et al.*, 2017). In this study, capacity building refers to training of dairy farmers in Mogotio Sub-County using an innovation platform to reduce milk losses and connecting them to agricultural advisory services.

Farm level milk losses: It is the economic consequence of spoilage, spillage, and forced home consumption of milk commodity (Bebe *et al.*, 2002). In this study, it means milk that is lost (measured in litres) as a result of poor milking practices.

Forced home milk consumption: According to the FAO (2003), forced home consumption of milk is when milk is consumed by humans or calves in excess of normal household consumption, due to a milk glut. In this study, it refers to the excess intake of milk, which can be termed as milk loss due to the revenue anticipated from it.

Innovation platform: Innovation platform is a learning space, either physically (or virtually), and therefore a vehicle for change and action (Homann-Kee Tui *et al.*, 2013). The innovation platform happened to be the Mogotio dairy innovation platform, in which farmers learn, share, and create new knowledge and ideas for successfully establishing, capturing, and sharing value chain activities.

Innovation platform-based capacity building programme: An innovation platform-based capacity building programme is a stakeholder network—farmers, researchers, NGOs, and industry informers starting to share knowledge and innovations and advancement leading to sustainability (Fu *et al.*, 2023). In this study, it is a planned activity designed to enhance the capacity, knowledge, and ability of people or organizations towards capacity building using collaborative and innovative learning.

Innovation-capacity: The behavioural capacity to have alignment and transformational behaviours simultaneously (Brouwers *et al.*, 2013). In this study, it was delineated as initiatives and dialogues designed to develop farmers' understanding, knowledge, and

capacity for the adoption of milking processes to minimize milk losses during the milking process, whilst being mindful of ensuring quality and safe milk.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter briefly highlights smallholder dairy farmers' production practices and farm-level milk losses, presents a brief outline of the innovation platform capacity building avenue that they could adopt, and lists various adaptation practices that may have been used for minimizing farm-level milk losses. The chapter concludes with the theoretical and conceptual frameworks.

2.2 Milk Production and Farm-Level Milk Losses

In 2019, global milk production was estimated at 852 million tonnes, representing a 1.4% increase from the previous year. This growth was largely attributed to improvements in post-harvest handling, although milk losses remain a significant challenge that limits the potential benefits for dairy farmers worldwide (Paraschivu, 2021). According to the Dairy Market Review, livestock farming continues to serve as a vital source of food, with notable increases in the consumption of milk and dairy products, particularly in developing countries (Singh, 2021). Globally, there are about 118 million dairy cattle farms (Spielman *et al.*, 2019), of which approximately 65% are located in Sub-Saharan Africa, South Asia, Eastern Europe, and Central Asia. The majority of these are smallholder enterprises, which often encounter numerous management-related constraints (Nyokabi *et al.*, 2021).

The estimation for Africa's dairy production in 2018 did not differ appreciably from 2016 production (FAO, 2018). An analysis of data within the same duration, however, noted there was a decline of dairy production by 8.1% for Africa (Ronquest-Ross *et al.*, 2020). This depicted a steady decline of 0.74% per annum in Africa's dairy production. Furthermore, it was noted that the decreases were partially due to effects of climate change on animal feeds, as most of dairy farmers utilize rain fed feeding system (Dono *et al.*, 2016). Poor management of milk losses resulted in low dairy productivity in sub-Saharan Africa and ultimately increased importation of dairy products by several countries to fill the gap of domestic supplies (Linh *et al.*, 2019). A large portion of farmers face many high levels of milk losses from poor management and local breeds that have low milk-yielding potential, and typically make up the majority of the dairy sector (Groot & van't Hooft, 2016).

There is a growing demand for milk and dairy products in Kenya because of population growth, rising household incomes, and nutritional value. FAO and USAID (2017) estimated the demand to increase by roughly 175% between 2010 and 2050.

In Kenya, most milk production takes place in the Central and Rift Valley regions (FAO, 2011). The sector has been expanding steadily at an average annual rate of 5–7% and currently contributes about 14% to agricultural GDP, 40% to the livestock GDP, and 4% to the overall national GDP (KDB, 2015). The dairy industry also provides employment opportunities for more than 1.2 million people, both directly and indirectly. Smallholder farmers dominate the sector, owning more than 80% of the national dairy herd, which is estimated to range between 4.2 and 6.7 million cattle. According to Odero (2017), these smallholders are responsible for over 56% of total milk output, typically keeping between one and three dairy animals. Productivity levels vary significantly, with smallholder farms averaging 5–8 litres of milk per cow per day, compared to 17–19 litres per cow per day on large-scale farms (Kabunga, 2017).

The main constraints faced by the dairy industry in Kenya include the seasonality of milk production, low-quality animal feed supply, and limited use of supplement feeds (Karnatam *et al.*, 2023). Other constraints include little access to breeding, animal health, and financial conditions, as well as poor agricultural and advisory services with regard to husbandry techniques, and the high costs of artificial insemination (AI) services. (Moller *et al.*, 2023). The infrastructure for milk collection and marketing in dairy-producing areas is poor and includes poor roads and power. According to Bebe *et al.* (2017), the challenge of poor coordination or interplay of research, extension, and training, and the limitations of farmers' access in the output market, with 45 percent of the milk produced consumed by dairy farmers' households. In 2016, per capita dairy unit consumption was 115 litres annually.

According to projections, Kenya's per capita milk consumption was anticipated to increase by 6% annually from 2012 to 2022 (USAID, 2018). The anticipated per-capita consumption is 220 litres by the year 2030. About 2.8 billion litres of the remaining milk produced are consumed through unofficial and authorized market channels (USAID KAVES, 2014). According to USAID KAVES (2014), between 80 and 90 percent of milk sold originates via unofficial channels, while the remaining 10 to 20 percent comes from legitimate channels. Milk marketing involves producers, street vendors, and retailers. They provide the raw and semi-processed milk to milk bars, dispensers, and cooperatives. The unapproved channel gets

a small portion of their money (Nguyen, 2023).

Smallholder farmers constitute the majority of dairy farmers in Kenya. Thus, a smallholder farmer is an individual who only has access to a small amount of land, has limited or inadequate endowments of capital, labour, skills, and technology, is subsistence-oriented, and is extremely risk-sensitive. A smallholder, however, might not necessarily experience all these aspects of smallness at once (Hazell *et al.*, 2010).

Infectious diseases in dairy livestock significantly reduce productivity, contribute to food insecurity, and result in trade losses as well as diminished economic returns for farmers (Sharma & Baldock, 1999). Identifying the most prevalent and critical health challenges is therefore essential. Interactive innovation platforms that bring together dairy producers, veterinary specialists, and other stakeholders can facilitate the development of herd-level management strategies tailored to local needs. Such strategies may integrate scientific approaches with existing knowledge systems, including conventional practices, indigenous medicines, and modern health interventions (Damte, 2003; Benin *et al.*, 2002). Collectively, these measures have the potential to improve animal health and enhance milk yields globally.

Farmers in Kenya face inadequate storage facilities for their dairy products (Gracia, 2018). The most prevalent difficulty among Kenyan farmers is the shortage of proper storage facilities, which results in significant losses since the majority of the milk goes to waste. This is witnessed during peak seasons when the rains are falling, but still there is a shortage of milk in many areas where milk is produced. Most farmers experience the impact of a lack of storage facilities. Another obstacle for most milk producers in Kenya is delayed payments for milk products (Zainol *et al.*, 2023).

Farmers and milk processing companies have long had a squabble, especially when it comes to end-of-month pay-outs, which is a huge setback for the farmers who have put in the time and effort. As a result, many dairy producers are forced to take the initiative by hawking milk to make up for their losses (Rosa, 2023). Dairy milk payments delay in Kenya can have a substantial impact on farmers' finances since they must pay for feed and additives (Kilelu *et al.*, 2017). County Governments and the Ministry of Agriculture and Livestock Development have failed to advocate and mediate for dairy producers, resulting in the emergence of middlemen profiting from farmer shortcomings (Sultana, 2020). Rural roads in Kenya are in a state of disrepair, which makes transporting milk to faraway processors difficult (Mabharwana *et*

al., 2023). Rural farmers find it hard to transport milk to the market due to a lack of milk cooling facilities. Farmers have to invest in costly feeds and supplements in order to boost their milk production, and they often resort to low-quality feeds and supplements because they are cheap (Mukhovi *et al.*, 2020). The long-run consequences are reduced milk production associated with the low price of low-quality feed.

Moreover, the vast variations in altitudes in high-yielding milk zones in Kenya have also interfered largely with milk production in the country (Mhoro *et al.*, 2023). Forssell (2018) posits that such variations in altitudes have often resulted in different dairy management routines that have led to milk quality and yield interference. Other challenges that have been cited to affect dairy milk production at both the farm and dairy chain levels include feeding of dairy animals, poor handlers, and dairy animals' hygiene (udder health), milking routines, management factors on farms, breeding, and milk quality differences (Makoni *et al.*, 2014).

Many farmers prefer selling milk directly to local markets, restaurants, hotels, or even to neighbors rather than to processors (Goel *et al.*, 2023). This preference is driven by the assurance of immediate payment, reduced risk of milk spoilage, and the opportunity to earn higher prices (Häsler *et al.*, 2019). A smaller proportion of farmers, however, opt to supply milk to collection centers, as these provide more consistent buyer loyalty, particularly during periods of oversupply when local demand is insufficient. According to Häsler *et al.* (2018), farmers who avoid collection centers face several challenges, including lack of reliable markets during rainy seasons, limited access to essential inputs such as vaccines, artificial insemination services, veterinary drugs, animal feeds, and dairy advisory services. In addition, restricted access to affordable credit due to high loan interest rates, inadequate knowledge of livestock diseases, poor farm management experience, and the absence of milk testing equipment continue to hinder improvements in milk production among dairy farmers (Lodhi, 2023).

Häsler *et al.* (2018) further mentioned in their study that while milk producers were treating their animals, most producers were not discarding milk after treating their animals with veterinary drugs and administering vaccines. Less than five out of every ten cow-milk producers operated with sloppy hygiene and disease control measures, leading to substantial amounts of lost milk (Stoev, 2023). Nonetheless, something striking about consumers was that they did not dwell so much on the quality of the milk, but they purchased milk based on the trust they had in their farmers, safety practices, and colour of the milk (Bojovic, 2023).

Constraints to trade among producers of milk include cattle diseases, lack of technical skill, poor dairy cattle breeds, limited access to working capital, insecure market (unreliable or inaccessible), and limited round fodder/pasture (Häsler *et al.*, 2019). Lack of capital was due to the low income generated by households and high poverty levels among milk producers. On the other hand, most of the rural lands are communal lands and nobody has a right over it (Anaifo *et al.*, 2023). Hence, everyone in the community often grazes their cattle, leading to pasture competition. Also, it is often difficult to divide land for crop production and livestock keeping, with most farmers preferring allocating more land to crop production, leaving limited land for livestock keeping. All of this leads to pasture & feeding supply constraints in the long term (Wróbel *et al.*, 2023).

Animal diseases pose a diverse range of adverse effects with respect to cow-milk production and productivity, leading to some significant economic losses due to death, sickness, weight loss, low growth rate, poor conception rates, and reduced draft power in dairy cows (Buchan *et al.*, 2023). In Ethiopia, animal diseases cost an estimated 18,231 camels, 4.37 million sheep, 3.23 million cattle, 4.90 million goats, and 41,195 poultry were lost, solely from the 2014-2015 fiscal year (CSA, 2016). According to Grace *et al.* (2012), Ethiopia was ranked second to Nigeria in the burden of zoonotic diseases.

Reduced nutritional status, lack of livestock advisory services, livestock mobility, and climatic factors were all factors relating to the high prevalence of cattle diseases (Berhanu, 2002). When estimating prevalence, incidence, and profitability of a farm, identifying the production system is of paramount importance (Simianer *et al.*, 1991; Thrusfield, 1996). Animal diseases and mismanagement are reported to incur huge financial liabilities in the livestock sector. Poor hygiene on-farm and in the environment is ranked as one of the leading risk factors of infectious diseases in the production of cow milk (Bramley & McKinnon, 1990).

2.3 Dairy Farming in Baringo County, Kenya

In Kenya, smallholder dairy production systems are generally classified into three types: semi-zero grazing, zero-grazing, and grazing-only systems (Aguti, 2023). Zero-grazing is the most common system among smallholder farmers in central Kenya (Bebe *et al.*, 2003a), largely due to limited land availability and the system's efficiency in producing more milk per unit of land compared to semi-zero or open grazing. This system is typically associated

with improved dairy breeds such as *Bos taurus* (Bebe *et al.*, 2003b), which produce higher milk yields than indigenous breeds like *Bos indicus* (Abeygunawardena & Dematawewa, 2004). Improved breeds, such as Friesian and Ayrshire cattle, are characterized by larger body sizes, which translates into higher nutritional and caloric requirements (Habimana, 2023).

Farmers who rely on grazing systems often prefer indigenous cattle breeds; however, these systems face several limitations that reduce milk productivity. Challenges include the low energy digestibility and protein content of natural grasses, variations in forage types (grasses versus browse), and the influence of household labor availability and economic farming models (Archimède *et al.*, 2011; Walsh *et al.*, 2011). As a result, grazing is often carried out during cooler periods of the day or at night to reduce heat stress on the animals (Knox *et al.*, 2018). In regions such as Baringo County, where a semi-arid climate predominates, commercialization of value-added dairy products is particularly difficult. Across all feeding regimes, farmers encounter further constraints in realizing the genetic potential of improved breeds, primarily due to limited availability and poor quality of feed, especially during the critical periods before and shortly after calving when nutritional requirements are highest (Butler, 2000).

The availability and quality of feed, animal health and care and calf management have all been prioritized through promotion incorporating several strategies. The scope and depth of their adoption or their impact on milk production remain in doubt. Accordingly, feed systems or management strategies modifications are relevant to the dairy sector in the Baringo dairy farmers' context and Kenya in general (Carulla, 2023).

Yields in agriculture are the backbone and principal source of livelihoods in Baringo County, and dairy farming is among the primary economical activity thus contributing income and employment for most of the population (Raneri, 2023). Mixed farming and pastoralism are substantial in the highlands and lowlands, and other economic activities related to farming include beekeeping, aquaculture, and fishing from Lake Baringo, which contributes lower proportions of the County's income due to the non-formal marketing of farm products (Cuesta *et al.*, 2023).

In relation to livestock activities (youth, male, female-headed households' contributions) 27%, 51% and 19% of the livestock production animals, respectively (Akumu *et al.*, 2023).

Climate related hazards influencing agriculture included drought, flooding, high temperature, inconsistent rainfall, and uncertainty regarding the onset and duration of the rainfall season (KNBS-Baringo, 2013). The livestock population comprised about 180,529 dairy cattle and 45,242 beef cattle. Livestock production accounted for KES 2,810,409,526 in 2016 from sales of livestock products and KES 986,959,700 from sales of live animals (Yitbarek, 2019).

Milk is obtained from local cattle, crossbred cattle, and exotic cattle. Exotic cattle produced the most milk with an average of 6.2 litres/day, followed by cross-bred cattle (4.4 litres/ day), local cattle (2.6 litres/day) (Habimana, 2023). The highest milk production in the dry season, at 7.7 litres /day, was achieved by FHH with the exotic cattle breed. This usually lowers due to environmental shocks that caused changes in production practices by smallholder dairy farmers in the sub-county (Baringo CIDP, 2018).

According to the Food and Agriculture Organization of the United Nations (FAO), Kenya had an estimated 6 million milking cows in 2017 (FAOSTAT, 2019). The dairy sector is a vital component of the country's economy, supporting the livelihoods of numerous stakeholders across the value chain. Beyond its economic role, milk and dairy products are a key source of nutrition for many rural households. At the farm level, the industry generates approximately 841,000 full-time jobs, in addition to around 15,000 jobs in processing and 40,000 positions in both the formal and informal milk markets (Muriuki, 2011).

The dairy value chain in Baringo County involves multiple actors, ranging from farmers as primary producers to consumers at the final stage. This chain can be classified as either formal or informal, depending on whether the milk is processed (e.g., pasteurized) before reaching the market or sold in raw form. The number and type of actors involved vary across different stages of the chain, with greater integration often observed at the milk collection stage. Informal milk collectors, typically using bicycles or motorcycles, play a key role in transporting milk from farms to bulking or cooling centers (Kiambi *et al.*, 2018).

In many regions, milk trade and retail are highly dynamic and largely informal, involving a range of actors who can broadly be categorized into three groups based on their marketing practices: (1) milk bars or kiosks, (2) mobile traders, and (3) milk vendors. Some of these actors operate seasonally, becoming more active during periods of peak milk production, particularly in western Kenya (Kiambi *et al.*, 2022). Many participants in this informal market combine multiple functions, such as production, aggregation, transportation, and

sales. During peak production periods, traders often source 70–100% of their milk directly from local farmers, focusing on areas with surplus supply and extending their networks into other regions during the dry season. To expand their catchment areas, traders sometimes rely on transporters to deliver milk.

Distribution patterns vary: most traders sell directly to consumers in urban and peri-urban areas, while rural households tend to purchase directly from producers. Mobile traders and vendors may buy milk either from producers or from milk bars and kiosks, the latter of which procure milk directly from farmers. Typically, milk bars sell at a slightly higher price, with vendors purchasing at a discount of about KES 5 below the retail price. Milk bars also tend to operate on a larger scale, often equipped with small cooling facilities and handling between 50 and 350 litres daily, compared to mobile traders and vendors who manage smaller volumes ranging from 10 to 100 litres (Auma *et al.*, 2017).

Another form of integration occurs when products from the formal dairy value chain enter informal markets and vice versa. In practice, some processes overlap across both systems. For instance, milk destined for formal processing is sometimes transported to bulking stations in plastic containers—a method more common in informal markets—rather than in the recommended aluminum cans. Beyond this, the structure of dairy value chains also differs between urban, peri-urban, and rural contexts. In rural areas, milk typically passes through multiple channels, such as collection centers, bulking facilities, cooperatives, or processors, before reaching consumers. By contrast, milk produced in urban and peri-urban farms often moves directly from producers to consumers with minimal or no cold-chain infrastructure in place (Kiambi *et al.*, 2018).

Because of the informal and dynamic mode of marketing and trading of milk, and the undefined marketing role of market actors, estimating marketing margins at each node of the dairy value chain in Baringo County is quite complicated. Also, the unknowable specialization in marketing roles along the value chains due to low volumes means that it hardly happens that market actors directly reach the final consumer. In Baringo County, we can categorize market actors into eight categories with respect to market margin calculations: producers/collectors, collectors/mobile traders, collectors or milk vendors, vendors (retailers), mobile traders, bars and kiosks, cooperatives, and chilling plants (Auma *et al.*, 2017). Again as previously noted, milk collection and transportation processes are completed by the same people.

Kenya, is recognized for having some of Africa's greatest dairy research institutes, but it has hurdles in the customization, marketing, and acceptance of dairy productivity-enhancing technology. This is mostly due to inadequate extension services and inadequate private-sector distribution networks (USAID KAVES, 2013). KALRO, the State Department of Livestock, Kenya Livestock Breeders Organization, and Kenya Livestock Producers Association are the main players in the supply of extension services. Some big milk processors, such as Brookside, assist dairy producer groups with extension services. Even with the liberalization of dairy value chain components, the government retains regulatory power (Luseba & Rwambo, 2015).

The Directorate of Veterinary Services is primarily responsible for overseeing animal health, breeding, and input supply, with animal health service delivery largely devolved to the commercial sector (Luseba & Rwambo, 2015). In Kenya, milk reaches consumers through both formal and informal channels, with the informal sector accounting for approximately 86% of the total milk supply. Prior to a 2004 policy shift, small-scale dairy producers and traders often faced harassment from dominant market players seeking to consolidate control. The policy reform empowered the Kenya Dairy Board (KDB) to collaborate with small-scale milk vendors (SSMVs) by providing training, issuing licenses, and supporting milk marketing. This change resulted in significant welfare gains for consumers, producers, and vendors alike (Kaitibie *et al.*, 2009).

Improving the efficiency of the dairy value chain is a key theme of climate-compatible development. On-farm milk losses occur during milking. A reason for possible lower dairy cow production during restricted suckling and after calf weaning could be the dairy cow withholding any milk, ensuring the calf receives adequate nutrition. Thereby, the mean milk yield from the lactation period can be significantly reduced (Sellitto *et al.*, 2018).

Access to reliable information on production, marketing, breeds, animal health, feeding, husbandry practices, and price trends is essential for improving dairy production in Baringo County. With the advent of devolved governance, responsibility for extension services now lies with county governments (Auma *et al.*, 2017). However, this has resulted in inconsistencies in the delivery of government-supported extension services across counties. In the project area, most extension services are provided by private actors, while public livestock and veterinary staff, along with non-governmental organizations (NGOs), play a comparatively smaller role. Figure 2.1 shows the status of the dairy value chain in Baringo

County.

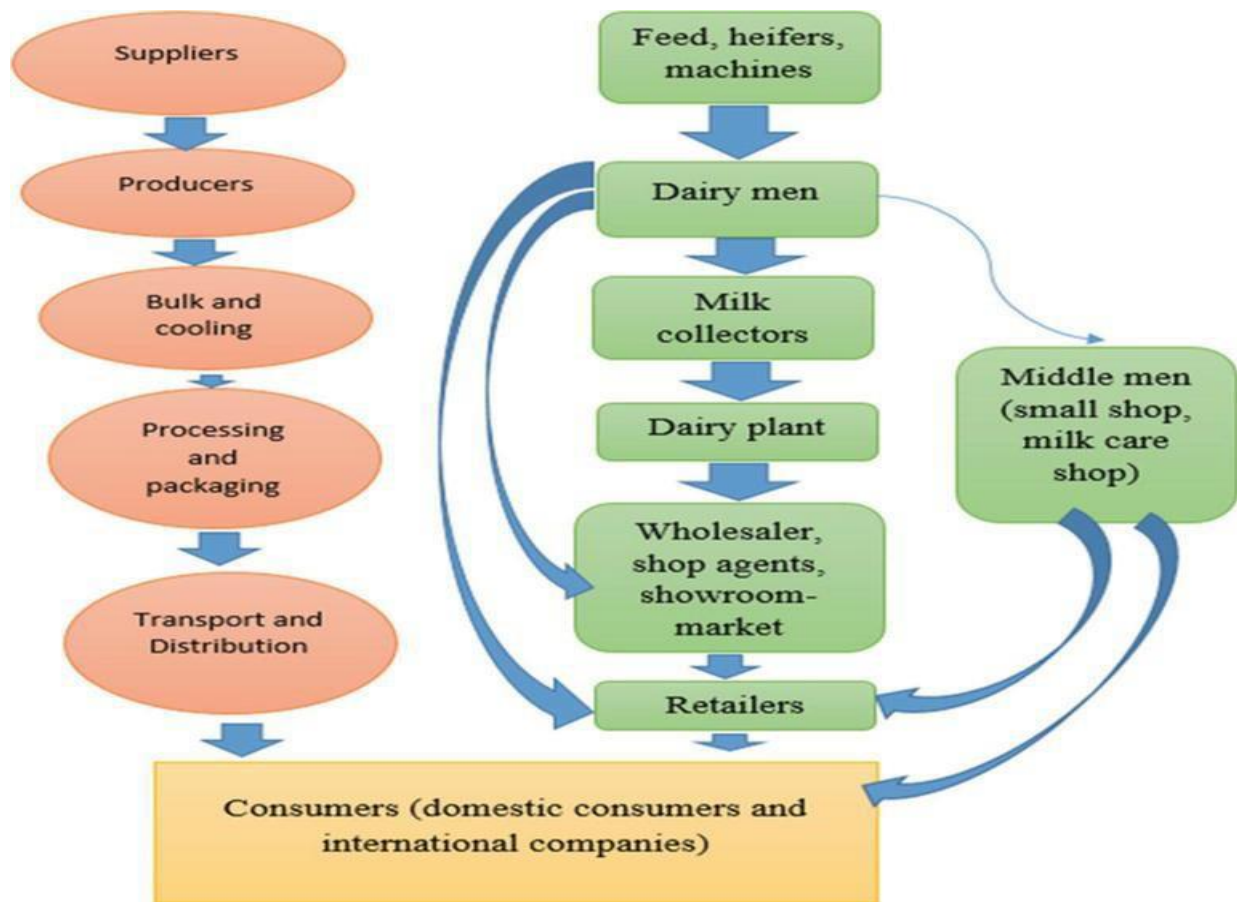


Figure 2.1: The value chain of dairy milk in Baringo County

Source: Adapted from Auma *et al.* (2018)

Increased productivity and the sustainability of dairy smallholder farms is necessary to globally secure food availability sustainably (Dolinska & d'Aquino, 2016). An interdisciplinary, systems-based and holistic approach to innovation is now recognised as being required after the linear technology transfer model has been unsuccessful in addressing this issue (McIntyre *et al.*, 2009). Such is the trend of the now popular Innovation Platform (IP) conceptualisation, with innovation viewed as a development in collaboration of a number of individuals who will have a stake in the generation, exchange and application of information.

According to several studies Klerkx and Proctor (2013), farmers participate in heterogeneous networks to learn new information. Lack of interaction with farmers and other stakeholders was given by farmers as an impediment to innovation, supposedly (Gonzalez *et al.*, 2019)

because farmers are isolated from those networks that have provided the innovation and resources (Spielman *et al.*, 2009), separated from the sources of creativity and relevant information or knowledge (Klerkx *et al.* 2010), or lacking the agency to initiate the changes necessary to enable the innovation to disseminate (D'Aquino *et al.*, 2021).

At the same time, Klerkx (2022) note those emphasizing farmers' connections to various information sources may result in underestimating the significance of peer networks. Several authors who have published studies that demonstrate peers were the source of information farmers used most often show the importance of farmer to farmer learning and networking. Farmers' ability to independently generate information and innovate has been acknowledged since the 1980s (Ortiz-Bobea *et al.*, 2021; Richards 2023). A significant body of research reveals that this knowledge is separate from that of extension workers.

2.4 Status of Dairy Production Response to Environmental Shocks in Baringo County

Climate change and variability represent significant threats to agriculture in Baringo County. Climate change heightens the intensity and frequency of climatic hazards such as floods, landslides, high temperatures, and drought (Laino *et al.*, 2024). The highlands are more susceptible to landslides compared to the lowlands, while floods frequently occur in the lowlands due to the terrain. The effects of these hazards are particularly pronounced on vulnerable community segments that lack the means to adapt or recover after such events (Mezei, 2023). Climatic shocks impact dairy farming, causing livestock losses, variations in productivity, and health challenges for the animals (Cartwright, 2023). In Baringo County, various stakeholders, including farmers, have identified rising temperatures (high temperatures) and decreasing rainfall during seasons as major obstacles to livestock production (KNBS, 2013).

According to McDowell *et al.* (2023), poor environmental management on dairy farms can lead to significant negative impacts, including milk contamination, water pollution from manure runoff, soil degradation due to overuse of fertilizers, and increased greenhouse gas emissions, particularly methane. Furthermore, poor waste management can exacerbate air pollution and health risks for both humans and animals, especially mastitis in lactating animals.

High temperatures cause dairy cows to decrease their feed intake, while also raising disease

incidences, thereby increasing the demand for veterinary services (Sáfár, 2023). Concurrently, the demand for Artificial Insemination (AI) declines as the health of the animals worsens due to reduced feeding (Galina, 2023). The demand for supplementary feeds also diminishes. The Veterinary Services Department offers veterinary services; however, private practitioners also provide these services, but their costs are prohibitively high for farmers (Baringo CIDP, 2018). At the farm level, decreased feed intake results in lower production. As a result, the volume of milk available for marketing is reduced, leading to increased costs for bulking and transporting each unit of milk. Milk spoilage rises due to high temperatures (Laino *et al.*, 2024). The severity of high temperature impacts varies from moderate to high throughout the value chain. Reduced rainfall in the first season presents a major challenge as it leads to less fodder availability, forcing farmers to resort to free-range practices and thus altering their milking strategies (Sotarauta & Pulkkinen, 2011).

2.5 Status of Livestock Advisory Services in Kenya

Traditional government-led livestock extension services have been declining globally, largely due to factors such as the rise of computer-based agricultural information systems and the increasing complexity of agricultural enterprises. Given this changing landscape, the sector must continuously embrace innovation to achieve sustainable socio-economic development. In response, the Agricultural Innovation Systems (AIS) approach has emerged as a framework for identifying bottlenecks and harnessing opportunities to enhance productivity in agricultural systems, particularly within sub-Saharan Africa (SSA)(Pigford *et al.*, 2018).

In Kenya, extension services are primarily delivered by public institutions, including central and county governments, parastatals, as well as research and training organizations (GoK, 2012). Additional support is provided by private actors and civil society, such as companies, NGOs, faith-based groups, cooperatives, and community-based organizations. However, a study conducted across 16 districts between 1996 and 1998 revealed that private sector extension services were largely concentrated in wealthier regions and focused mainly on high-value enterprises (Munyanga *et al.*, 2006).

Livestock advisory services framed within the agricultural innovation systems (AIS) perspective emphasize that innovation emerges from the collective efforts of multiple actors. These include farmers, researchers, extension agents, traders, service providers, processors, and development organizations, whose interactions are further shaped by factors such as

technology, infrastructure, markets, policies, regulations, and cultural norms (Haggblade, 2010). Therefore, innovation extends beyond the adoption of technology to encompass social and institutional transformations, evolving through a systemic and co-evolutionary process.(Kilelu *et al.*, 2013). Recent research suggests that multi-stakeholder platforms are fostering agricultural innovation due to increased interdependence among actors and building social capital (van Rijn *et al.*, 2012).

The East Africa Dairy Development (EADD) program in Kenya successfully brought together various actors representing different aspects of the innovation process. The initiative demonstrated effectiveness in coordinating innovation, largely due to the diverse and complementary skills and expertise contributed by intermediary actors within the platform (EADD Kenya, 2011). In contrast, the traditional government-led livestock extension services for smallholder dairy farmers in the sub-county have been declining. Recruitment of livestock extension officers has not kept pace with the growing demand for dairy production support. As a result, new strategies are being explored, including the use of innovation platforms to provide dairy advisory services. These platforms foster continuous collaboration and the exchange of technical knowledge among stakeholders, thereby strengthening advisory support for farmers (Baringo CIDP, 2018).

The role of the private sector in the provision of agricultural extension and advisory services is of interest in relation the transformation agrifood systems in most developing countries including Kenya (IDH, 2016). Transforming agrifood systems are related to global economic and demographic trends of increasing population and urbanization, more and more middle-class consumers, changing dietary and consumption patterns and increasing concern about quality and safety of food and how it was produced (McCullough *et al.*, 2008).

The trends in the Kenyan food system generate opportunities, challenges and risks not just for farmers but for an entire actor of the value chain around dairy farming in the food systems. The expected increasing demand for nutritious foods means increased demand for productivity at the same time fewer negative impact to the sustainability of the environment (IFC, 2014). This increasing demand is related to an increasing formalized market system that requires food which is safe, consistent and reliable for the supply of food high quality of production and post-harvest handling which adheres to good agricultural practices. As the agri-food systems are slowly turning to a knowledge intensive, technologically agile, and inclusive holistic model producers find that any value chain actor who wishes to stay

competitive has to continuously innovate to be able to address challenges and remap opportunities (Kabasa *et al.*, 2015; Kilelu *et al.*, 2011).

Producers, at production level, who want to transition for farm production with eventual hopes of making production sustainable and competitively viable for them are becoming increasingly entrepreneurial about their farming pursuits at production level, and are seeking through innovation platforms the technical and managerial support services to help make their corresponding farm enterprises to be sustainable and competitively viable. For aggregators and/or processing the case for good business is to elaborate knowledge, technology and utilize packaged services that will support their suppliers, complimenting the process of developing and obtaining responsible supply, that provide a sustainable high quality raw provision to produce. That opens up for agricultural extension and advisory services and the emergent role of the private sector for agricultural extension and advisory services and complementary services (IDH, 2016; IFC, 2014).

The Agricultural Sector Development Support Programme (ASDSP) (2015) of Kenya has brought it into the limelight that extension advisory services are important for skill and knowledge enhancement productivity gains. However, decline in the effectiveness of the public extension service is among factors disallowing agricultural growth in Kenya (Munyanga *et al.*, 2006). Therefore, Strategy to Revitalize Agriculture has indicated it would be necessary to improve the extension system by giving the linkages between research, extension and farmers more effectiveness. In essence, extension is one of the six SRA first-tracked areas in urgent need of a fix (Agwu *et al.*, 2023). The World Food Summit (WFS) in 2002, also pointed out the significance of extension services and called upon governments to design a new and extended policy in favour of extension and communication of agriculture, in order to facilitate development and improvement of food security in rural areas (Rivera *et al.*, 2003).

Extension services ultimately aim at conveying particular knowledge to farmers, such as the new technology, management strategies, or capacity building (Birkhaeuser *et al.*, 1991). Farmers, who clearly know the extension services, are more likely to achieve successful implementation of the extension, which will adequately meet their needs. A successful extension process through innovation platform is able to identify farmers' need and issues while facilitating for the best solutions to be agreed (Mattee *et al.*, 1994). Delivery of these services takes a variety of forms including training, demonstrations, field days, subject matter

for groups of farmers, and agricultural messaging through information and communication technologies. However, if farmers are not provided with appropriate incentives, the adoption of new technologies or management practices will happen but, the production levels will not be socially optimal (Feder *et al.*, 2003). These services (also called innovation support services) (Faure *et al.*, 2018; Kilelu *et al.*, 2011) aspire to provide need-driven, innovative, market-based solutions to entrepreneurial farmers.

The dynamic and evolving Kenyan agri-food system is also seeing new private sector Agricultural Extension and Advisory Services business models. These include those that focus on training and extension services—mostly training centers—and independent or value chain-embedded models. These private providers are emerging and experimenting with new institutional and organizational arrangements to provide demand-driven, market-oriented agricultural extension and advisory services.

Assessments on alternative agricultural extension and advisory services models in Kenya have shown varied histories. First, the innovation platform interactive model was advisable because the public sector models were largely seen as inadequate, and slow to respond timely to the demands of modern agriculture (Gautam & Anderson, 1999; Zhou, 2015), or have encountered systemic constraints in resource allocations, and coordination because of pluralism (Poulton & Kanyinga, 2014). However, the most recent pilots on publicly provided fund partnership have been shown to be feasible through completely strengthening farmer cooperatives (Bebe *et al.*, 2016). Second, this private sector through innovation platform provision satisfactorily fills the gaps in the public subsystem, albeit their services are sensed to be somewhat biased toward high-value agricultural enterprises. Third, the recognized usefulness of international non-governmental organizations (NGOs), and faith-based organizations, civil society models in reaching to impoverished, remote, and subsistence farmers, although the scope of work has been perceived to be low (Muyanga & Jayne, 2008). Overall, the major sector role being generated by IPs through private sector AEAS business models in Kenya is also recognized (DLEC, 2019). However, little about these private Agricultural Extension and Advisory services models being developed in developing countries including Kenya is known (Veldhuizen *et al.*, 2018; Zhou, 2015).

2.6 Dairy Farming Capacity Building Through Innovation Platforms

Capacity building is considered as an essential component for improvement of dairy farming.

It entails enhancing and sustaining people's, organizations', and society's capacity to carry out essential tasks sustainably and develop over time. Stakeholders in an innovation platform (IP) must have access to the necessary information and abilities to manage IPs and create collaborative activities (Kusters *et al.*, 2017). The necessity of an innovation platform, comprising problem identification, prioritizing, resource mobilization, risk-taking, cooperation, and connectivity, is emphasized by Leeuwis *et al.* (2014). Intellectual property (IP) capacity building is possible at both the individual and organizational levels (Pyburn & Mur, 2014).

Capacity building at the farmer level focuses primarily on promoting facilitation competence and enabling innovations by bringing a variety of stakeholders together on a platform (Lema, 2014). As noted in previous studies (Makini *et al.*, 2013), the success of IP is dependent on exceptional facilitation by the platform facilitators. A facilitator or organization provides mediation, enabling people to identify their common issues, opportunities and vision while taking them through the process of reaching fair compromises and enduring agreements. Nederlof *et al.* (2011) emphasizes that a diverse set of competencies are needed to facilitate processes considering that it is unusual to find a facilitator who has all these skills. Thus, facilitators need to be trained to enable them to acquire new facilitation skills (Mur *et al.*, 2014).

Key competencies for a successful facilitator were identified by Tukahirwa *et al.* (2013) and Lema (2014) as listening, respecting opinions, understanding audience dynamics, trusting people, flexibility, self-awareness, confidence, presentation, being positive and consistent, and good arrangement. These characteristics are necessary for building a supportive and productive atmosphere and successful stakeholder interaction (Mur *et al.*, 2014).

Convener, moderator, and facilitator are the three responsibilities that Brouwer *et al.* (2016) identified as essential for facilitators to improve interaction during training with farmers or among the stakeholders. The convener assembles the parties involved, promotes conversation, and inspires farmers by using patience and attentive listening. Participants get a sense of confidence and order because to this role (Mur *et al.*, 2014).

The second function of IP facilitation is to be a catalyst to spur farmers and other stakeholders to develop new ideas and innovative solutions to farming practices. The third function is the role of a mediator, where the facilitator manages farmer or stakeholder

conflicts, and promotes learning amongst each other to enhance collaboration. As Homann-Kee Tui (2015) and Akpo et al. (2016), state, the facilitation process is fluid, and once farmers, research entities or development agencies obtain intellectual property (IP), they should engage with other participants to ensure the continuation of the platform.

Platforms, according to Brouwer *et al.* (2016), ought to be initially enabled by outsiders and then handed over to insiders. The management and facilitation of IP should be taught to new members in order to maintain it. In India and Mozambique, for instance, initiators first facilitate IP to increase goat production, and then actors are taught in facilitation techniques. In six irrigation systems in Tanzania, Mozambique, and Zimbabwe, Van Rooney *et al.* (2017) demonstrate how local facilitators trained players to promote interaction and creativity.

As emphasized by Lema (2014) and Schut et al. (2017), the sharing of the facilitation function among IP actors is important for ownership and capacity development. In order to resolve problems and sustain the platform, Pyburn and Mur (2014) reinforce the importance of equipping actors with the training they need to enhance their development for creativity and problem-solving in IP activities.

Homann-KeeTui et al. (2015) indicated that farmers, traders, and input suppliers all require training in some type of communication regarding market requirements and cost-benefit analyses. Likewise, according to Dusengemungu et al. (2016), farmers, researchers, extension agents, processors, and input suppliers need training relating to value addition, business skills, post-harvest management, and financial and marketing credit services. Training on rules and regulations relating to agriculture should be given to local authorities and policy makers. Certainly, these training will assist these actors in putting new farming innovations into practice.

In order to resolve issues, Schut *et al.* (2017) stress the significance of building stakeholder capacity in platforms. This involves educating farmers about production methods, farmer groups about the marketing and organizing of their products, and research organizations on promoting communication across platform actors. The platform may more effectively assist farmers, organizations, and research institutes in overcoming their difficulties and improving their total output by attending to their demands.

According to Nyikahadzoi *et al.* (2012) IP was formed in Malawi to encourage farmers to

grow vegetables by training them about customer requirements, quality processes, and business management concepts. To learn more about demand, pricing, and payment options, farmers also went to supermarkets. Dairy smallholder farmers in Mogotio Sub-County may took part in training sessions to increase stakeholder capacity and lessen farm-level milk losses, ensuring sustainability.

Capacity building is aimed at enabling organizations such as cooperative or farmer group organizations to achieve their objectives. It builds on the formalization and institutionalization of intellectual property (IP), meaning they legally register with government agencies and create organizations, policies, and procedures that govern platform operation (Wennink & Ochola, 2011).

Formalization practices help platforms stay active, gain recognition from entities such as governments, and receive legitimacy as organizational representatives (Nederlof *et al.*, 2011b). For instance, Bungoma South farmers in Kenya registered their organization to recognize their organization, while Bubare IP within Uganda registered as a community organization to receive government support from the local government (Makini *et al.*, 2016).

Depending on the context of a given country, IP could be formal or informal, as noted by Nederlof and Pyburn (2012). Homann-Kee Tui *et al.* (2015) noted that formality can limit the flexibility of stakeholders on platforms because member roles are determined and must be changed over time. Instead of formal rules, Makini *et al.* (2016) identified the importance of establishing clear ground rules steering participant interactions on platforms.

The terms "decision-making," "stakeholder roles," "new stakeholder joining and leaving," and "conflict resolution among actors" should all be defined in the ground rules. While formality discourages member flexibility, it restricts stakeholder flexibility. Openness and reliability demand a governance structure with a coordinating entity, like a committee. Schut *et al.* (2017) suggest, that the governance structure, like Mogotio's milk plant innovation platform, should operate via an executive committee who is responsible for managing business on behalf of other members, an executive committee, with chairperson, vice-chairperson, secretary and treasurer, could work with the facilitator to schedule meetings, manage venues, manage conflicts, take minutes, and monitor financial costs, (Dusengemungu *et al.*, 2016).

To ensure the survival and advancement of IP meetings, Brouwer *et al.* (2015) note their

importance. Members should be directed by a recommended number of times to have these meetings, and a specific agenda to follow. Actors should be involved in the planning, implementation, and reflection of the successful stories, as cited by Posthumus and Wongtschowski (2014). The executive committee and facilitator must ensure that meetings happen frequently and according to the timeline established by platform members. The Mogotio innovation platform should also adopt this approach.

An innovation platform refers to a collaborative framework designed to foster and facilitate innovation by bringing together diverse stakeholders (Chilundo *et al.*, 2020). These platforms serve as organized settings where participants collaborate by exchanging knowledge, resources, and ideas to tackle complex issues and advance technological or social progress. They typically offer tools for dialogue, coordination, and collaborative problem-solving, facilitating collective action and utilizing the distinct strengths of each participant to speed up innovation (Brown *et al.*, 2022).

An innovation platform (IP) is a framework that brings together key stakeholders in the value chain, along with other participants, to collectively reflect on lessons learned and engage in action-oriented research. The aim is to generate, disseminate, and adopt technologies that enhance specific commodities or systems, thereby contributing to the economic well-being of both participants and stakeholders. As noted by Sreedhar *et al.* (2017), innovation platforms provide a space for identifying challenges, analyzing opportunities, and developing practical solutions. Within the dairy sector, training programs that focus on improved milking management practices can help farmers produce cleaner milk, enhance animal productivity, and provide modest additional income to farming households. Sreedhar further highlights the importance of extension initiatives that incorporate small-scale demonstrations and training activities, designed with sufficient intensity to stimulate the adoption of new knowledge on improved milking practices (Kaouche *et al.*, 2015). Evidence indicates that strong collaboration between researchers, extension staff, and producers, facilitated through participatory approaches, enhances the development of effective extension systems. Such collaboration strengthens vertical linkages among stakeholders, creating a functional extension framework that addresses the specific conditions faced by rural dairy producers. According to Anteneh *et al.* (2010), repeated extension interventions focused on improved milk production are essential, as they build upon the existing knowledge and experiences of producers and other actors within the value chain.

Market connection, market support, and regular market information updates, within the existing markets are also a great accessory to dairy improvements and overall performance. Communication in IPs, allow system to share and use ideas, and knowledge within many people for proposals and solutions reaching towards new outcomes (Victor *et al.*, 2013). Communication in practice is so important to make the innovations take place, not only to share more information but to apply the process to build credibility and trust by evaluation and also strength of the platform, and even with other joint platforms producers and research proposed innovations (Dantas *et al.*, 2016).

Innovation platforms are being used more and more for research and development projects to unite stakeholders in a platform or coordinate actions of individual members to solve the problem of the adoption of new technologies (Homann-Kee *et al.*, 2013), applied to agriculture extension utilizing network architecture. An arena for growth and change; equitable, dynamic environments designed to bring together diverse people and interests to co-create knowledge and collaborate on problem-solving. With the group defined, the members discuss, plan, develop, implement, and monitor agricultural innovations to address specific agriculture challenges that are defined, analyzed, and prioritized (Francis *et al.*, 2016). In summary, the platform facilitates innovation in agriculture by enabling networks and stakeholder interests to connect and collaborate.

Characterizing dairy innovations is critical for improving their adoptability, identifying potential opportunities and barriers to adoption, providing avenues for learning and feedback, guiding the development of appropriate sector policies, and mapping existing production systems to support the effective introduction of improved technologies (Goswami *et al.*, 2014). Omondi *et al.* (2017) note that, although the adoption of promoted dairy innovations remains low, limited information exists on the innovations already adopted, particularly within the milk sheds of Mukurweini Wakulima Dairy Limited (MWDL), Happy Cow Limited (HCL), and NKCC Sotik Factory, representing farmer-owned, private, and state-owned processors, respectively. Innovation platforms can provide a structured space for learning, experimentation, and coordinated action, supporting both technological and organizational change within the dairy sector.

Smallholder farmers engaged in the innovation process will generate locally relevant solutions, framed by the farming system, and the trajectories of local aspirations – the community wants to progress towards. Adopting a holistic innovations systems perspective

will enable insights to be gained around innovations regarding food systems, markets, incentives and local dynamics, as well as, power structures around these innovations, that could provide smallholder farmers, with opportunities and pathways to advance towards ecologically and socially just societies where women's roles and agency are valued assets. A frequently employed strategy for engaging smallholder farmers are innovation platforms (IPs) (Davis *et al.*, 2016). Given the methodology or tools use in agricultural development and research, execution of the approach is necessary. While there has been some early work on challenges, best practices, and strategies for measuring IP effectiveness, greater perspectives on practice are lacking.

In Kenya, one of the innovation platforms set up to support policy development to the dairy sector has led to the licencing of small-scale milk vendors who were previously publicly maligned for being unregulated and operating outside of the formal economy. Other policy advantages have included improved milk quality, increased profit margins for small-scale milk vendors, increased milk access by low-income consumers, and the creation of new jobs in the sector and downstream industries (Cadilhon, 2013).

The ideal innovation platform size depends on the innovation problem or opportunity being addressed. For farm-level testing of innovations, 20–40 stakeholders may be appropriate to have as members of the platform. The membership and size may change, as indicated by Lamers *et al.*, (2017) where new and existing farmer groups can be added, or those representing specific challenges invited to participate for the duration of the innovation, or members may lose interest or pull out of a collaboration where their needs have already been addressed. Innovation Platforms have become a popular way to improve multi-stakeholder collaboration in agricultural research for development (AR4D) programs. Innovation Platforms enable connections and collaboration within and between networks of farmers, governmental and non-governmental service providers, policymakers, researchers, the private sector, and the agricultural system (Schut *et al.*, 2016).

Innovation Platforms foster innovative processes and the willingness to learn (open to learning) and provide a safe operating space for multiple stakeholders to work together to experiment and collaboratively resolve their co-problems. The stage of the innovation cycle and who established it may influence whether an Innovation Platform seeks to resolve a specific technological, organizational or institutional issue that is embedded within a value chain (such as decreasing milk post-farm losses) or if it is a more systems-level issue to be

resolved across value chains (Schut *et al.*, 2016). When innovation platform achieves their purpose, its members can (or can choose not to) want to continue to work on new issues. Innovation Platforms may begin as informal networks and then become institutionalized, as through public-private partnerships where members are expected to be self-sustaining (Homann-Kee *et al.*, 2015).

Agricultural innovations may have direct and indirect consequences on beneficiaries' poverty and productivity. Therefore, technology transfer in agriculture must instead focus to specific interventions (entry points) along the trajectory of dairy milk production, including areas such as breeding, calf management, feeds and feeding, milking, herd health, post milking handling, and marketing. This includes building an innovation system in agricultural dairy milk productions that will enable more sustainable use of resources, for example animal health resistant vaccines, efficient calf management, milk storage systems, and milk marketing (Schut *et al.*, 2016).

In agriculture productivity increases will no longer be sustainably viable without developing, disseminating and providing access to cost effective yield enhancing agricultural dairy milk production techniques to dairy farmer stakeholders, as current demand no longer allows increased numbers of lactose consuming people (Awotide *et al.*, 2012). To develop innovate and relevant, appropriate, and attractive solutions for populations in local contexts, research on sustainable intensification of agricultural dairy milk production technologies must begin at local and national levels, with global support, where initial input was used primarily to yield mountain of agricultural milk. The first and earlier perspective is that research findings emerge from science and being a catalyst for innovation, creating new knowledge and technology to be adapted and transferred to any and all contexts. However, the process of innovation and productivity increase not only contains the generation of knowledge, but also the entire technological diffusion process, and adoption process, interactions and yet to be developed market. Markets, not production, are increasingly the main drivers of agricultural development of any economy, because in the end market for any produce is the driver of production. Lack of processing pathways, poor market linkages and weak links between producers and end users keeps production lower and profit margins thin (Michele *et al.*, 2012).

Innovation Platforms can be located at village/community level, district level, or even provincial or national level (Tucker *et al.*, 2013). The crucial question is: “At what level(s) can a challenge be effectively handled?” For example, a challenge with accessing quality planting materials could best be handled at the village/community level whilst exploring irrigation options may require stakeholder engagement at the watershed level. Local community level challenges are often tied to and have linkages to challenges at some higher level (e.g. lack of input certification which leads to poor quality fertilizer in market) so strategic engagement of national level policy actors can be beneficial further on. Once innovations take hold at local community level, the Innovation Platform could facilitate lessons learned and give a path for the innovation to be transferred/adopted into other domains. Again, this requires coordination mechanisms at other levels (Lamers *et al.*, 2017). Policy maker engagement is an opportunity to understand what potentials, limits, and policy support are needed to leverage for large scale success. Direct engagement of policy makers can also ease their timing and can be more compelling than typical policy briefs. Changing policy is generally more complicated and often takes longer. However, it may have a bigger influence when changed at the policy level. Agricultural policies may be quite difficult to move, however, when changed, the agricultural sector in some country experiences big momentum (Geels & Schot, 2007).

Innovation is the implementation of something new or upgraded (technologized, or not) in products (goods or services), processes, marketing, and organizational methods or procedures (Touzard *et al.* 2015). In other words, it means bringing new ideas, knowledge, or actions into a context, as is the case of the Mogotio platform, in order to generate good changes that lead to meeting needs, solving constraints or taking advantage of opportunities. This means when it comes to novelties and beneficial changes, they may be substantial (a major change or improvement) or additive (where small adjustments accumulate into major improvement). Technology transfer and best practice approaches have historically been more linear, with technologies developed by researchers and delivered to female and male farmers by extension staff (Geels & Schot, 2007). These approaches may have engaged stakeholders for the activities of delivery of inputs, or fresh market links, and they may have produced productive improvement in food security for the household, yet they did not develop the capacity of many disadvantaged smallholder farmers to sustainably upgrade their own livelihoods as a market entry dilemma for social and economic movement. They did, however, seek solutions to the contextual conditions that too often do not allow farmers to utilize their limited

resources to the best advantage (Swaans *et al.*, 2014).

Changes to systems towards sustainable futures for female and male farmers require deeper structural systems changes across space and time, and more effective integration and synergies within technical, institutional and policy options. This may at times mean intentional systemic transformation (Lachman, 2013). Research into innovation systems potential encourages that suppliers and users, engage in niche innovations, so that new Ecological regimes, emerge (Geels & Schot, 2007). Niche innovations are a type of space where small networks of actors create technical, institutional and organizational novelties from which their visions and expectations are linked. Learning processes connect the multi dimensional aspects into facets, and the push for change grows. IPs can be that niche, introduce the systems dynamics, and envelop the new solutions to be tested in a more secure place. They assist in finding the appropriate interventions, considering technical, social, economic and environmental factors, and suitable to the end users, that have a higher rate of adoption (Touzard *et al.*, 2015).

Historically, an innovation systems approach (World Bank, 2006) defined innovation in a system and interactive way. The Mogotio innovation platform is not a network of actors which transcend smoothly. It is a non linear social (and institutional) and technical process, of the participants are interacting to spark a common concern or impetus for change (Knierim *et al.*, 2015). So, with current rural and innovation policies, the innovation emergence from the Agricultural Knowledge Information System, constitutes many groups of actors are interactively operating during the phases of the innovation emergence (Wielinga, 2016) along the value chain, about a specific product or geographic region, or in an integrated manner to address a cross-cutting question or problem (EU- SCAR, 2013; World-Bank, 2006).

2.6.1 Influence of Innovation Platform Learning on Dairy Production

Mogotio Innovation platform was designed to address dairy innovation systems weaknesses by fostering engagement among the kinds of people and/or organizations, driving changes to practices, institutions and policies, and efficiently allocating existing human and financial resources to address challenges and seize opportunities (Davies *et al.*, 2018). Dairy Innovation platforms can be combined with participatory action research. Participatory action research is the interaction of doing research with key stakeholders and outcome-based research (Minh *et al.*, 2014).

The participation of key stakeholders in the Mogotio Innovation Platform during capacity-building initiatives was critical for three main reasons. First, stakeholder groups contributed complementary perspectives on the biophysical, technological, and institutional dimensions of dairy production, thereby strengthening the evidence base (Odame et al., 2009). Joint engagement within a social learning process enabled consensus on innovations that were technically feasible, economically viable, and socially and politically acceptable. Second, interaction among stakeholders fostered awareness of diverse interests and objectives, while emphasizing their interdependence and the need for coordinated action. Such collaboration allowed groups to overcome individual constraints and achieve collective outcomes.

Third, the process enhanced stakeholders' willingness to adopt and implement new ideas, while providing more effective pathways for scaling innovations through joint ideation and trial (Esparcia, 2014).

The absence of a common vision for the dairy industry means that the linkages between actors are typically weak (Makoni *et al.*, 2014). Beyond a few areas of coordinated action, there is not an integrated innovation system that can use problem solving and opportunity utilization to sustain innovation in the sector (Odame *et al.*, 2009). Supply-driven research that does not respond to sector needs, ineffective and irrelevant extension and advisory support systems, and education actors unable to respond to the needs of a highly skilled workforce characterize the current situation (Muriuki, 2011). Furthermore, the weak organizational capacity of many industry and sectoral associations limits the effective interaction, facilitation of investment, and lobbying in the dairy sector. Much donor-supported development interventions are not well-coordinated with existing ones resulting in duplication of interventions, and limited cross-learning and co-creation. These issues point to broader institutional concerns about trust and reliability between value chain actors (Kilelu *et al.*, 2013).

The Mogotio Innovation Platform has established networks that facilitate dialogue and co-learning, promoting innovation within the dairy sector. Such platforms require active support and nurturing from key dairy sector actors. While the Kenya Dairy Board has played a major role in initiating these platforms, their capacity to convene and coordinate stakeholders effectively remains limited (Kurwijila & Bennett, 2011). The Mogotio platform supports knowledge transfer and innovation in response to the evolving dairy sector, with a particular emphasis on demand-driven, market-oriented innovation support systems. Examples include

practical dairy training centers, business hubs, and private advisory services (Katothya & van der Lee, 2016). These systems, along with emerging inclusive business models and public-private partnerships, aim to build the capacity of smallholder dairy farmers by enhancing practical skills, fostering entrepreneurial mindsets, and linking smallholders with medium- and large-scale producers or international consultants. Investments by county governments further create opportunities for new partnerships and innovations. Nevertheless, it remains crucial to assess the effectiveness and operational outcomes of these models (Kilelu *et al.*, 2016).

2.6.2 Mechanisms and Arrangements to Broaden the Impact of Innovation Platform

It is urgent to redefine agriculture. The notion that agriculture and rural areas are for those who cannot make a living anywhere else needs to change. Agriculture needs to be marketed as the new untapped frontier of growth in business ventures (Njenga *et al.*, 2012). To the youth, agriculture is deemed as unattractive primarily to the time and input investments because the traditional staples are slow growing and high risk, and low yield returns. Agricultural incomes are seasonally linked to rainfall and plant cycles, which meant youth would have no income for long stretches of time. The lack of innovations in agricultural production generated resistance to the traditional and some very labor-intensive production methods, with continued cultivation going on in a tight set of narrow commodities, mainly staple crops.

The flow of agricultural production and marketing information available to youth has been stifled by limited use of information and communications technologies (ICTs) (International Institute for Communication and Development, 2013; Njenga *et al.*, 2012). It is critical to build and digitize agricultural production and marketing information into web-based mediums. This is necessary reach a broader audience, as there were few extension officers who would not reach many farmers and in different locations. Youth could benefit the agricultural sector by being knowledgeable in generating, posting, managing and utilizing the information.

A well-defined process and clear institutional mechanisms for collaboration ensure an

appropriate mix of research and development partners within innovation platforms. These platforms often originate with a narrow focus on specific issues (Opoola *et al.*, 2019). Initially, a flexible arrangement with clearly defined goals, roles, activities, expected outcomes, and resource requirements may suffice. However, as the platform expands and the initial objectives are achieved, there arises a need for more formalized and structured institutional arrangements to sustain and scale the innovation efforts.

The development of an innovation platform (IP) may include the formation of sub-groups with distinct institutional arrangements within and between groups. Over time, where capacity and need exist, pursuing legal recognition for the collective platform can enhance its sustainability, autonomy, and value propositions—both monetary and non-monetary—for members, as well as eligibility for funding or grants. Additionally, it may be beneficial to cultivate the interests of willing partners to advance platform activities through sub-groups or smaller social networks, thereby strengthening overall platform functionality.

Schut *et al.* (2017) recent review of mature Innovation platforms focused on the importance of Innovation platforms to be relatively embedded in private or public mechanisms and networks that allow platforms to go beyond the initial innovation platform attraction to reach target populations.

Innovation platforms are likely a valid scaling strategy that provides a solution beyond the uptake of innovations or impact and has longevity or systemic. Innovation platforms as seen in the agricultural innovation systems literature are intended to produce a change process in the conditions for systemic change by connecting participants towards effectiveness within groups (Hounkonnou *et al.*, 2018; Sartas *et al.*, 2018). In response to the production constraints farmers were facing, platform agendas started to shift from knowledge transfer ultimately developing towards focus on building the institutional capacity of platform members (1) connecting to market infrastructures, and (2) linking to inputs for production including accessing credit and quality milk, to enable scaling the innovations promoted to farmers. Most effective IPs led to scaling because focused on, the interactive and network development process, building identifies opportunities, facilitated collaborative, and ultimately scaling and the benefits it provided to farmers (Schut *et al.*, 2018).

The services offered vary widely in type (technical, economic, social, and legal) and by types (knowledge transfer, co-construction, participatory development) and delivered by (public,

private, NGO) (Mathe *et al.*, 2016). In the context of emergence of new actors, the role of AAS have shifted. AAS were once seen as the primary actors in innovating processes to by bringing technology and or information to the foreground, that idea is now obsolete. Additionally, some novel actors functionally engaged and developed innovation processes that provided new services that involved innovation-support activity and new delivery methods for those services. Some of the services required were: networking, access to finance, demand articulation support of innovation actors, then providing institutional support to niche innovators, to build capacity for new business skills, as well as general consultancy and backstopping (Mathe *et al.*, 2016).

The services required in an innovation process vary depending on the stage and may involve different actors at each point. Such involvement is central to transforming the “system” or addressing the identified problem (Beers *et al.*, 2014). Aligning or coordinating these services over time is challenging due to the diversity of actors, their interactions, and the dispersed demand and provision of services within the complex, non-linear innovation process.

Consequently, it is crucial to better understand what constitutes success for agricultural innovations and how public innovation policies can be strengthened to support multi-actor initiatives in rural contexts, particularly through targeted interventions and collaborative actions (Kilelu *et al.*, 2013).

Innovation support services are essential for enabling innovation by facilitating interactions and knowledge creation. Within a multi-actor framework, these services generate outputs aimed at addressing broader intervention objectives that are closely linked to the underlying problem (Edwards, 2013). While innovation support services can be viewed as either organizational entities or activities, this study adopts a process-oriented perspective, treating them primarily as activities (Labarthe *et al.*, 2013). Compared to traditional public sector systems, contemporary agricultural advisory service providers engage a wider diversity of actors, manage complex interactions among stakeholders, and maintain interdependencies with other services (Knierim *et al.*, 2015). Key services include facilitating networking, improving access to financial support, articulating innovation demands, providing institutional support for niche innovations, enhancing business skills, and offering consultancies and backstopping (Mathe *et al.*, 2016). The type of service required evolves as the innovation process progresses, often involving different actors at each stage to optimize the system or address the problematic situation (Beers *et al.*, 2014). Effective coordination

and alignment of services are critical due to the diversity of actors, their interactions, and the gradual co-construction of service demand and supply throughout the complex and non-linear innovation process (Kilelu et al., 2013; Le Coq et al., 2010).

Whether and to what extent such fragmentation of ASS potentially becomes an obstacle to innovation depends on the socio-technological level of complexity of the innovation and the flow between the elements of ASS: governance, funding mechanisms, competence and the advisory methods (Faure *et al.*, 2012). Fragmented ASS with many competing service providers can open up space for innovations to arise when coordination between ASS is not very important as innovations can more readily be steered by private or public entity sector. But when coordination is needed with respect to social systems such as farmer's organizations and rural communities then coordination with between service providers and other actors are critical for innovation to fully realize its potential (Beers *et al.*, 2014). Sometimes this coordination exists. The district experience highlights the pivotal administration of one association in coordinating a large number of diverse actors across multiple sectors (e.g., agriculture, tourism, national parks), while in other cases coordination is tenuous (Birner *et al.*, 2009).

2.6.3 Facilitating and Catalyzing Innovation Platform

Despite scientific recognition of innovation platforms (IPs) and their contribution to facilitation and catalysing agricultural innovation, they are still faced with substantial challenges for success. The platforms are most beneficial when analysis continues to develop possibilities and approaches for agricultural productivity, sustainability, and value chain improvements. In addition, the IPs are viewed as consisting of multiple actors forming a targeted alliance with a common objective of achieving change with respect to a specific sub-sector/sector. Due to this kind of action, it is easier for innovation platforms to find and address avenues of success by leveraging available opportunities.

Sustainability of the IP is one of the main challenges determining the development of an organization. The existence of a platform for innovation does not last long if it is not useful - it becomes useless. Change happens quickly in the commercial environment, changing a platform for development and use, creating differences that now must be mediated to meet immediate needs and new challenges. At the same time, while the platforms may build the innovative capacity of the sector, at the point they go away (Swaans *et al.*, 2013).

It should also be remembered that many of these platforms are run by non-government organizations (NGOs) whose original objective was to satisfy a particular need - say a need to be addressed. The project coordinators of these NGOs usually live in urbanized areas and therefore do not experience whether this platform is in fact achieving its objective and whether it is engaging the target audience at all. Moreover, after the project funding is finished, the NGOs are likely to drop their support, leading to the crucial dilemma of sustainability. Evidence suggests there is not any specific type of service provider for this sort of Innovation support service, of course, you may have specialists (Howells, 2006). However, specialists providing service for specific activity is rare. In fact, this sort of Innovation support service may be provided by other types of organization (farmers' organizations, private firms) who are motivated to trigger the innovation process, as well as different organizations which divide this role, one of them having a certain coordination component, or multiple organization carrying on independent of each other during different stages of the innovation process or lastly, a multi-stakeholder innovation platform with a facilitator (Klerkx & Leeuwis, 2008).

In general, many innovations platform appears complex in character, the actors and factors involved in such processes alter outcomes in unpredictable ways. In addition, as most innovation platforms are planned to terminated and not be successful, it is around unpredictable. On a daily basis, several activities aiming at tackling the same issue emerge, forcing the target groups to make a number of choices to sort through all their options. The dilemma is often augmented by the fact that the activities provide a conjunctive benefit, as even though independent activities for improving dairy cattle productivity, milk marketing, credit, and farmer cooperation might offer limited dairy farmers' benefit – as a whole they might actually be more compelling and persistent (Kilelu *et al.*, 2013). Instead of having various separate innovation platforms with different interventions, these should be bundled to ensure farmers get maximum benefit. Further to this, from the type of platforms available, it follows farmers would choose from one over the other based upon competing interest (Stür *et al.*, 2013). To build on this, innovation platforms are thought to be unequal benefit because the first people to join it, early adopters, tend to benefit much more than the second or later adopters. They are also believed to have benefits distributed by the farmers asset threshold, which could be low (minimum benefits), medium (benefited much) or high (less benefited due to already having market networks established in the area) (Totin *et al.*, 2020).

Most target participants, especially smallholder farmers, still don't even know anything about innovation platforms. There are a lot of uncertainties about what to do with the interviewed to ensure they get specific clarification of their meaning purpose – thus increasing acceptance among rural smallholder farmers (Totin *et al.*, 2020). While it appears that the innovation platforms have improved multiple businesses and farming communities, it seems recipients do believe that there are costs to the innovation platforms that they may or not be willing to pay. As Chilundo *et al.* (2020) shares, it takes audience to preference benefit of early adopters to become aware, meaning that their benefit and success of the innovation platforms is contingent upon the first adopters realizing that benefit. This indicates that more time, open discussion, and unique focus should be on internal and external stakeholder goals for agricultural innovations. A route to adoption of technological progress is through the verification that the technology has added value to farmers' livelihood goals (Eidt *et al.*, 2020).

Providing these Innovation support services indicate new responsibilities and to some extent unknown capacities for change agents (Koutsouris, 2014). In addition, to all the documented aspects of a change agent's 'skill set' like communication skills, active listening, and respect for farmers' knowledge (Ingram, 2008), these individuals would be able to work in collaboration with different types of actors, in order to build appropriate practices (Nettle *et al.*, 2017). Conventional advisors have trouble adopting new roles and have the mindset and the skills of a facilitator instead of acting as a professional broker. Klerkx and Jansen (2010) suggest it is partially due to a deficiency in will/attitude and competences, especially social competences, where advisors elect not to step out of their 'comfort zone' from their brokering roles.

Brokering functions have not been explicit, not adequately articulated, and not adequately evaluated in the literature (Labarthe *et al.*, 2013). More attention should be paid to the brokerage praxeology (theory behind practice; practice producing new theory) particularly their roles of innovation brokers in the stages of innovation process (with emphasis on specific competences needed to fulfill their roles). An agenda such as this will provide a stepping stone to understand the void in knowledge and means of filling voids and building a strong knowledge base for policymakers, academic and practitioners (Koutsouris, 2017).

Following Albert (2000) interactions between supply and demand actors of a service is regarded as functional relations of the service systems related to many components (such as

funding, input delivery, insurances, etc.). Ton et al. (2016) suggested that innovation brokers would importantly play a role in supporting such implementing of these services in an innovation system. This would specifically refer to offering guidance with and searching for resources and Legitimacy over them. Furthermore, in terms of resources mobilization, guidance towards accessing financial and human capital as a required input for the innovation system. Examples of such activity would help access finance to engage in long term research and development, industry (or government) initiated programs to develop and share more specific technological knowledge, and access to finance to allow to pilot innovative technologies in niche experiments. Hekkert et al. (2007), in their research of the functions of innovation systems framed these services under one name “resource mobilization function”, in this study of mapping ISS functions we refer to as “Enabling access to resources”.

Faure et al. While Carton (2014) describes service relation as an institutional arrangement, Gadrey (1994) uses institutional environment as a factor influencing the construction of service provision. Also, Kilelu et al. (2013), identifies “Institutional support” as institutional change and boundary spanning activities. Heemskerk et al. (2011) relate institutional support as “advocacy” seen as the buy in, and support of those that matter to host the innovation process, this includes informing policy and asking for policy change. Other authors like Edquist (2011) place institutional support for niche innovations (provision of incubators centers, experimental infrastructures), additionally, all administrative upgrades fall into this category. Despite the challenges, growth trends in the sector creates investment opportunity for entrepreneurs in dairy farming, service and input provisions, fodder production processed and milk retailing. Opportunities in dairy farming are more lucrative in pasture systems, because the costs of milk production is lower (Bebe *et al.*, 2002). Studies suggest that there’s an increasing need for fodder, which creates enterprise opportunities for fodder production (pastures, hay, silage) and processing of feed to be available in quality feed in larger volumes which gain from economies in scale. Opportunities are available in delivery services, so dairy enterprises can deliver milk in good conditions and minimize milk losses to the processing plants that are opening due to the demand for milk in both domestic and regional markets. The expanding middle class and urbanization are creating enterprise opportunities of milk processing, processing various dairy products. There is an expanding market demand for equipment’s and facilities for the handling, bulking, chilling, processing and dispensing of milk from commercially oriented farmers; GoK and county governments invest in local milk-chilling and processing capacities. Growth in the dairy sector creates demand for supportive

inputs and innovative platforms services on knowledge application, herd health and breeding, financing and insurance placements (Tegemeo, 2016).

2.7 Factors Affecting Milk Production in Baringo County, Kenya

The Rift Valley region in southwestern Kenya has the highest farm density in the country (Muriuki, 2011). Baringo County, one of Kenya's 47 counties, lies within this region, with elevations ranging from 700 to 3,000 meters. These variations in elevation create diverse climatic conditions, from humid highlands to arid and semi-arid lowlands, which in turn necessitate different management practices that can affect milk yield and quality. Major weaknesses in Kenya's dairy sector include milk losses at the farm or value-chain level, poor hygiene, and compromised milk quality. Milk yield is influenced by several farm management factors and udder health, including milking regimes, breeding practices, and hygiene standards, all of which also affect food safety (Hagnestam-Nielsen *et al.*, 2009). Optimizing farm protocols is therefore crucial for advancing the dairy sector. During the early to mid-1990s, the liberalization and de-control of dairy market prices reduced the market share of the Kenya Cooperative Creameries (KCC) and the Kenya Dairy Board (KDB).

While this shift benefited small-scale traders selling raw milk directly to consumers and dairy cooperatives, it also led to a withdrawal of government extension services, creating challenges for farmer training and knowledge transfer (Makoni *et al.*, 2014).

Following market liberalization, the number of dairy processors in Kenya increased from three to approximately thirty (Muriuki, 2011). Despite this growth, the majority of milk continues to be processed by five major companies, with Brookside Dairy Limited accounting for the largest share of national production (Ton *et al.*, 2016). This concentration affects milk pricing, as large processors can leverage their market position when negotiating with producers. Approximately 60–70% of milk is sold through informal markets without processing, raising significant food safety concerns. The high consumer demand in informal markets is largely driven by the lower prices and easy accessibility of milk. (Omore, *et al.*, 2000). Cooperatives that are mostly in the official market have trouble competing with milk marketed in the informal market when the milk is available from, for example itinerant vendors called hawkers.

Due to the projection of exorbitantly growing demand of dairy products in Kenya, production must increase to meet demand, using an average of 4.4 litres per cow and a production cycle of 305 days (Wambugu *et al.*, 2011). A number of management factors have an effect on milk production on dairy farms. Access to feed and water is critical issues regarding milk production. However, there are issues regarding feed that will be covered in another collateral study on the same farms (Möller, 2018).

Local control abscesses and somatic cell count (SCC) are indicators of leukocyte activity, which increases in milk when the udder is exposed to irritants, such as bacteria or tissue damage, leading to inflammation (Sandholm, 1995). Elevated SCC reduces milk yield by 0.7–3.7 kg per day, depending on parity and lactation stage (Hagnestam-Nielsen *et al.*, 2009). Higher SCC is also associated with decreased milk quality, as it lowers lactose content and alters fat and protein composition (Ali-Vehmas & Sandholm, 1995). In addition, increased proteolytic and lipolytic enzyme activity, linked to elevated SCC, reduces milk quality and shelf life (Barbano *et al.*, 2006). These changes make mastitic milk a more favorable medium for bacterial growth compared to healthy milk (Ali-Vehmas & Sandholm, 1995). Lactose being highly relevant for osmotic balance of milk while, the reduced lactose concentration allows sodium and chlorine to diffuse from the blood to the milk resulting in the increased levels of trace elements in mastitic vs healthy milk.

Somatic cell count (SCC) in milk can reflect the quality of milking procedures and farm management practices. SCC can be measured in the field using portable instruments, such as the DeLaval cell counter, which has been validated for on-site assessment of udder health (Lam *et al.*, 2011). Healthy milk typically has a pH between 6.6 and 6.8 at 20 °C, although it varies with temperature (Walstra *et al.*, 1999). Milk from cows with subclinical mastitis exhibits a higher pH due to the influx of blood bicarbonate (HCO_3^-) ions, making milk pH a potential indirect indicator of elevated SCC and compromised udder health (Batavani *et al.*, 2007).

Poor hygiene can lead to bacterial infections of the udder, resulting in a significant increase in somatic cell count (SCC). Milkers should wash their hands prior to milking and use clean water for udder wipes to prevent bacterial entry into the teats (FAO & IDF, 2011). Maintaining clean resting areas for cows is also essential, as bacteria can enter the teats while cows are lying down (Fröberg *et al.*, 2016). During milking, the cows' teat canals dilate and remain open for approximately two hours afterward. To minimize the risk of bacterial

infection during this period, it is recommended to apply a disinfecting teat dip and feed the cow after milking to discourage lying down. Additionally, allowing the calf to suckle briefly around milking can further support udder health (Fröberg *et al.*, 2016).

Most small farmers in Baringo still hand milk. The milk extraction method has been described in detail how it affects the condition of teats and the ability of the teat structure to stop pathogens from entering the udder in the literature on machine milking (Bruckmaier, 2010; Ferneborg & Svennersten-Sjaunja, 2010) and might be also relevant in handmilking systems (Millogo *et al.*, 2012). The recommendations of the Food and Agricultural Organization (FAO) and the International Dairy Federation (IDF) cite that the full-hand grip should preferably be used to avoid mammary damage.

Milk ejection is vital for milk removal efficiency (Bruckmaier & Wellnitz, 2008) and fat content during milking, and can be accomplished through tactile stimulation in the udder before milking. This alone reduces milk wastage at farm level through the right restraint of the animal in the milking parlor. Stimulation can be accomplished by massaging the udder or through molestation through the senses, smell, sound, visual stimulation. Tactile stimulation induces reflex ejection actions, during milking oxytocin is released in the pituitary into the blood. Oxytocin binds to myoepithelial (Ontsouka *et al.*, 2003).

Healthy cows shortly after milking have very low bacteria counts (2-6- <50 046), these counts remain for few hours after milking. After, bacteria numbers grow logarithmically in the milk if not stored properly at warm temperatures. So, it's important not mix milk collected on different occasions as mixing evening milk with morning milk will increase the change for bacteria numbers to enter logarithmic phase quicker than it should (Ton *et al.*, 2016). Paired with milking into a improperly clean vessels or mixing milk from different sources before delivery to the MCC, will only put you at further risk for proliferation of bacteria. pH is lowered by acidification through bacterial spoilage. It may take 24 hours of storage for this drop in pH to detect However, other issues such as udder health, cleanliness of storage vessel quality, or mixing milk can cause this pH drop sooner (Pesta *et al.*, 2007).

2.8 Market Status for Milk in Kenya

The dairy sector in Kenya has experienced substantial transformation over the past decades. Established in 1958, the Kenya Dairy Board (KDB) was tasked with providing cost-effective

dairy production and distribution networks (Muriuki, 2003). Many of KDB's functions were gradually assumed by the Kenya Cooperative Creameries (KCC), which eventually dominated dairy marketing and processing in the country. However, in the early 1990s, liberalization of the dairy sector and the decontrol of milk prices led to a loss of market control for both KCC and KDB. This shift benefited small-scale traders selling raw milk and strengthened dairy cooperative societies (Mbogoh, 1995), but it also resulted in the withdrawal of government extension services, creating challenges in training and knowledge transfer for dairy farmers (Makoni et al., 2014). Since liberalization, the number of dairy processors has increased from three to approximately thirty (Muriuki, 2011), yet the majority of milk continues to be processed by five major companies, with Brookside Dairy Ltd. maintaining the largest share of national production (Ton *et al.*, 2016).

Smallholder's farmers still have limited access to be able to acquire the innovations, technology, knowledge and information needed to improve productivity and livelihoods. It will be important to connect smallholder farmers to information and knowledge sources, input supply, and credit, and public investment in development and technology markets tailored towards smallholders' needs through the innovation platform. There is an apparent need to fill the gap left from the diminishing public extension model. Selective resource targeting and improved coordination with private advisers will place farmers in a better position to respond to changing demand. Investment will be required to strengthen producer organizations and leverage the tremendous potential of information and communication technologies (FAO & USAID, 2017). Wambugu et al. (2011) compiled data on geographic areas of milk productivity in Kenya from 2000 to 2010 and reported that the average annual productivity across the country was 1,344 litres per cow in Kenya.

Milk and dairy product prices are largely influenced by the bargaining power of processors, who often engage with larger producers and reduce their negotiating leverage. Approximately 60–70% of milk is sold through informal, unprocessed markets, posing significant food safety risks (Makoni et al., 2014). High consumer demand for milk in local markets is primarily driven by convenience and affordability (Omoro et al., 2000). Cooperatives operating within the formal sector face competition from these informal markets, where milk prices are substantially lower (Ton *et al.*, 2016), e.g., by itinerant hawkers.

Population growth, income, and urbanization will create demand for animal products like meat, eggs, and dairy products (FAO & USAID, 2017). The processing capacity of registered

milk processors has been described as 2 times what is being currently utilized, which presents an opportunity to increase the milk supply to processors (Makoni *et al.*, 2014). Nonetheless, milk supply exhibits significant variability between the dry and wet seasons, as production levels vary with spatial availability of animal feeds (Muriuki, 2003). Following the previously mentioned notion of providing dairy cattle with sufficient good quality feed 365 days a year is one strategy to reduce seasonal variability in milk supply. Another option is to engage in processing technologies that are used to turn fresh/raw milk into durable milk products such as milk granules and ultra-high temperature (UHT) milk (Muriuki, 2003).

The value chain of the milk industry provides additional formidable contributions towards food security, job and income development, and it raises living standards of dairy consumers, producers, processors, and all other participants in the milk value chain. The proposed 3.4 million head dairy population produces 3.1 billion liters of milk per year according to Muia *et al.* (2011). Smallholder dairy farmers that maintain 1 to 3 dairy cattle make up the most significant portion of the milk production in national production with milk production accounts for 80% of the total national production, these farmers practice mixed farming (food, fodder, a cash crop) employing the by-products as fodder (Wambugu *et al.*, 2011). The Strategic and Value Chain and Strategic Value Chain Study (2012) in Central Kenya estimated the value of milk production in the region of Kenya to generate approximately 30 billion KES in value which smallholder dairy producers receive 70% of this value (Muia *et al.*, 2011).

Despite the significant contributions to the Kenyan economy and households, postharvest losses were documented as a major problem for country economy (Lore *et al.*, 2005). In the dairy industry, postharvest losses refer the unsold milk that has been produced and generally follows the trajectory of from production on farm, to processing, marketing, and ultimately to consumer consumption. Losses may occur because of food spoiling and spills. Sometimes another form of loss occurs when there is scarcity of market options, which we call "forced consumption" (Muriuki 2003). Kenya, for example, wastes far more than 95 million liters of milk per year, which adds up to roughly US\$22.4 million in losses (Food and Agriculture Organization, 2014). Most impactful losses are at the on-farm or production level. Farmers and cooperative enterprises lose between 5% to 10% of the milk sold via cooperative channels. During the wet seasons, extension agents noted as high as 45% loss by some societies (Otieno *et al.*, 2020).

Such great loss of milk occurs when processors impose quotas or unilaterally reduced the quantity of milk received at their processing plants. Muia et al. (2011) state that an inadequate road network or the distance-to-market unfortunately resulted in not selling most of the milk produced during the wet season. Due the highly perishable nature of milk as well as farmers limited financial capacity to invest in milk chilling machines, most milk produced during wet season coincided with high levels of postharvest loss. Kiaya (2014) states that marketing can take place at many points in the agro-food supply chain and is strongly connected with transport, but ultimately, it is the final and most important aspect of the postharvest system.

Interventions in postharvest loss reduction are an important focus area for many organizations looking to alleviate food poverty, and more recently interventions are aimed at utilizing agriculture's full potential to supply the world's growing food and energy demands (Kiaya, 2014). Postharvest milk and dairy product losses can result in lower returns to the farmer, ineffectiveness of marketing, and lost employment; therefore, postharvest loss is significant in its implications. It is apparent that the extent of postharvest milk and dairy product losses in Kenya is not well documented; the numbers that currently exist for losses in this area are based on speculation, not fact (Muriuki, 2003).

Intervention is necessary to support the growth of the dairy market, monitor losses, and to take advantages of the potential growth as milk and dairy consumption in COMESA and EAC countries is projected to increased at rate of 3.5% per year up to 2020 The postharvest loss interventions that have been documented are the few postharvest interventions that have been proposed to reduce milk losses and most of these interventions on reducing postharvest losses have gone unassessed. The transition to a market-focused smallholder production has stemmed from major changes in the traditional dairy economy over time, in part due to favorable climatic conditions, advanced fodder technology, a large population of dairy animals, the incomes of consumers, and the accessibility of milk and dairy products (Ndaka *et al.*, 2012). As with other agricultural commodities, milk losses predominantly occur between production and consumption. By analyzing the underlying causes of these losses and the factors influencing the choice of milk-marketing channels, this study aims to address existing knowledge gaps while integrating interactive learning through the innovation platform. Such an approach can inform policies and programs designed to create a more efficient and effective dairy value chain, recognizing the milk farmer as a critical link in the

system (Muia *et al.*, 2011).

2.9 Milk Cooling Centers

Smallholder dairy farmers in Kenya often deliver their milk to milk cooling centers (MCCs), from which processors collect it. MCCs are primarily operated by dairy cooperatives, with approximately 13,000 cooperatives serving 1.5 million dairy farmers nationwide. These cooperatives provide essential services to members, including milk marketing, bulking, and temperature control. Processors collect milk from the cooperatives and transport it to their processing facilities (Ton *et al.*, 2016). Establishing an effective cold chain prior to collection has historically been challenging. Typically, morning milk is marketed, while evening milk is retained for household consumption, feeding children, or calves. “Involuntary consumption” occurs when milk that cannot be collected promptly exceeds household needs and is wasted (Muriuki, 2003). Community cooling centers function as satellite systems to MCCs, facilitating collection for processors. However, challenges remain, including high transportation costs due to limited infrastructure, emphasizing the need for innovation platform models around milk collection hubs (Makoni *et al.*, 2014).

Michelle Foreman (2013) mentions that the dilution of milk with water to increase income is a tried-and-true practice as it has been shown to increase volume. Milk cooling centers commonly have lactometers to test milk diluting, which to potentially provide an indirect indication of water diluting concentration. Milk pH is often tested at the milk cooling facilities, which demonstrates milk quality because pH decreases when bacteria convert the lactose in milk to lactate (Lu *et al.*, 2013).

There have been efforts to implement quality-based milk payment (De Leeuw, 2013), but extensive work is still needed to establish this (Ton *et al.*, 2016).

The total quantitative losses in the Kenya dairy milk supply chain due to seasonal milk gluts were reported at approximately 7.3%. Enhancing the key points listed above in the milk supply chain can go a long way to reduce milk loss and improve quality; (i) farm level (ii) collecting sites/centres, (iii) vendor outlets, i.e., milk bars. Based on a complete marketing chain analysis reported by Kimiywe (2015), the main causes of milk loss were spillage and spoiling – attributed to limited market access, market rejection, ineffective milk handling methods, and inconsistent power supply in milk processing plants.

This study acknowledges that innovation arises from collaborative interactions among multiple actors, including farmers, researchers, extension officers, traders, service providers, processors, and development organizations, and is shaped by technology, infrastructure, markets, policies, regulations, and cultural practices (actors' values and norms). Consequently, innovation is not limited to technological advancements; it also encompasses social and institutional changes and exhibits systemic and co-evolutionary characteristics (Kilelu *et al.*, 2013).

Mogotio innovation platforms since inception has been an interactive system which incorporated milk marketing and sourcing of feeds (Richards *et al.*, 2015). Interaction of the actors connected by the Innovation Platform took place bi-monthly. As was useful to present studies focused on three types of dairy innovations (technical, organizational, and institutional), previous work in these milk cooling plants innovation platforms identified the contribution of a single dairy innovation aimed at increasing milk production, and reducing seasonality effects. Richard *et al.* (2019) studies focused on the effect of high protein fodder tree feeding and other nutritional management factors on the amount of milk sold by smallholder dairy farmers or the impact of mineral feeding on reproductive efficiency of smallholder dairy farmers(s).

Kenduiwa *et al.* (2016) interactions in the Bomet county of NKCC Sotik milk shed studied the relationships between smallholder dairy farmers' participation in terms of microfinance on breed improvement, and studies in the milk shed catchment area of HCL provided the evidence of how engaging smallholder dairy farmer groups were able transforming new knowledge into action resulting in collaboration between researchers, farmers, and field assistants (Restrepo *et al.*, 2018) and the importance of better crop residue use such as kernel treat wheat with urea to keep milk production up during the dry season (Kashongwe *et al.*, 2017).

The dairy milk cooling plant hub is an innovative model developed in order to resolve some of the dairy value chain issues. Dairy milk cooling plant hub is a collective farmer- managed and/or owned milk bulking and/or chilling and value adding business where farmers can also obtain access to/or the other services they need for their subsistence enterprises (Mutinda *et al.*, 2015). Heifer International and other development partners have implemented multi-million dairy hubs across Kenya with the East African Dairy Development project which aims to increase characteristics of high yield and net returns of farmers in Africa (Kenya,

Uganda and Tanzania) (Pyburn & Eerdewijk 2016). The dairy milk cooling plant hubs have proven to be potentially rich platforms for improving access to markets, inputs and services for both male and female smallholder dairy farmers (Rademaker *et al.*, 2016). Indeed, they are changing rural communities (Kilelu *et al.*, 2016). In spite of dairy hubs yielding a number of benefits, dairy hubs have only marginal participation thus far (Omondi *et al.*, 2016). There is scant evidence of determinants of participation in either the dairy hubs by smallholder dairy farmers and outcomes in terms of dairy milk losses.

2.9.1 Agricultural System Approach Interaction Adopted at Mogotio Innovation Platform

This applied the agricultural innovation systems approach which leveraged the interactive character of agriculture (Figure 2.2). The generation and utilization of new knowledge is significant for all enterprises, including agriculture, but often the new knowledge that will improve productivity, profitability, and sustainability in agriculture is not widely adopted at scale. Lack of innovation in agriculture is prompting the search for new paradigms like ‘innovation systems’ that elucidate the process of agricultural innovation and ways to improve its relevance and value. The Mogotio cooling plant platform provides an enabling platform to share new knowledge on modelling the reduction of farm level milk losses to niche markets between the smallholder dairy farmers. Ongoing interaction between the farmers also simplifies the monitoring of feedback and progress consistency. The interactive system consists of humans and organizations demanding and supplying knowledge, and the policies and processes that enable and constrain the ways in which different agents interact to share access and exchange knowledge.

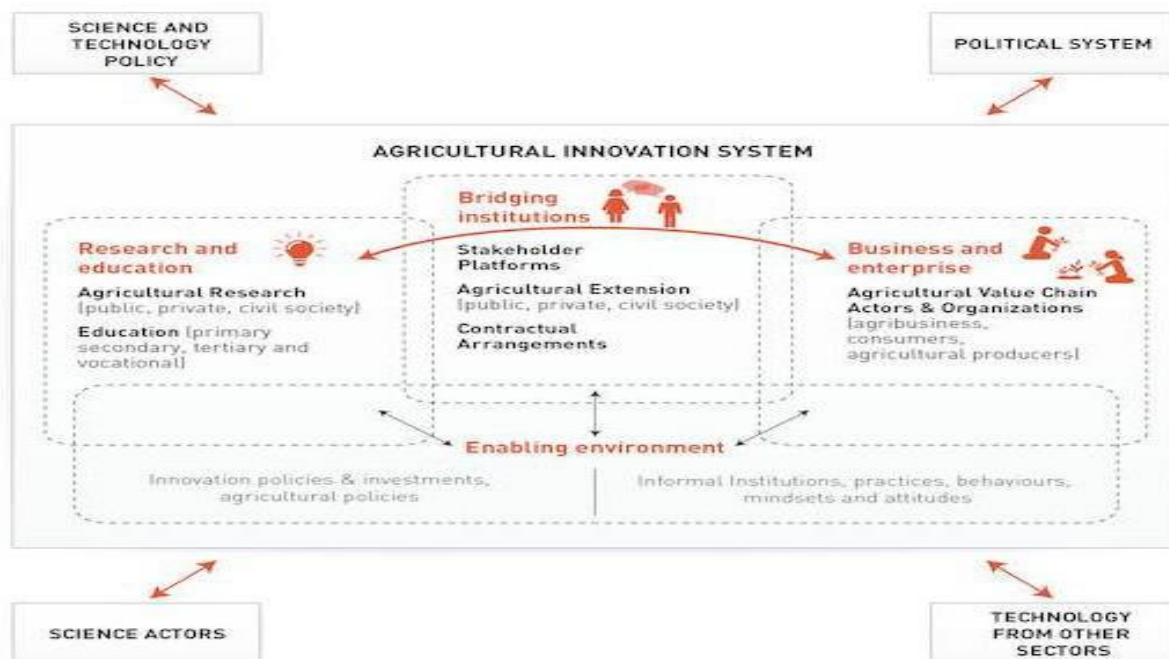


Figure 2.2: Agricultural innovation system approach

Source: Adapted from Leeuwis & van den Ban (2004)

2.10 Theoretical Framework

This study was guided by two theoretical frameworks: Lewin’s Model of Change and the Context-Mechanism-Outcome (CMO) Theory. Lewin’s Model of Change emphasizes behavioral transformation and is represented by the three-stage “unfreeze-change-refreeze” process, in which prior learning must be unlearned and replaced with new behaviors (Kurt, 1958). The first stage, unfreeze, prepares individuals and organizations for the desired change; the second stage, change, implements the intended transformation; and the third stage, refreeze, consolidates the new behavior to prevent regression. This model is particularly relevant to this study as it illustrates the process of introducing, adopting, and stabilizing individual and organizational behaviors related to novel technologies or institutional innovations within the dairy sector. Smallholder dairy farmer groups, for example, must undergo behavioral changes as part of institutional strengthening within the innovation platform framework (Sarayreh *et al.*, 2013).

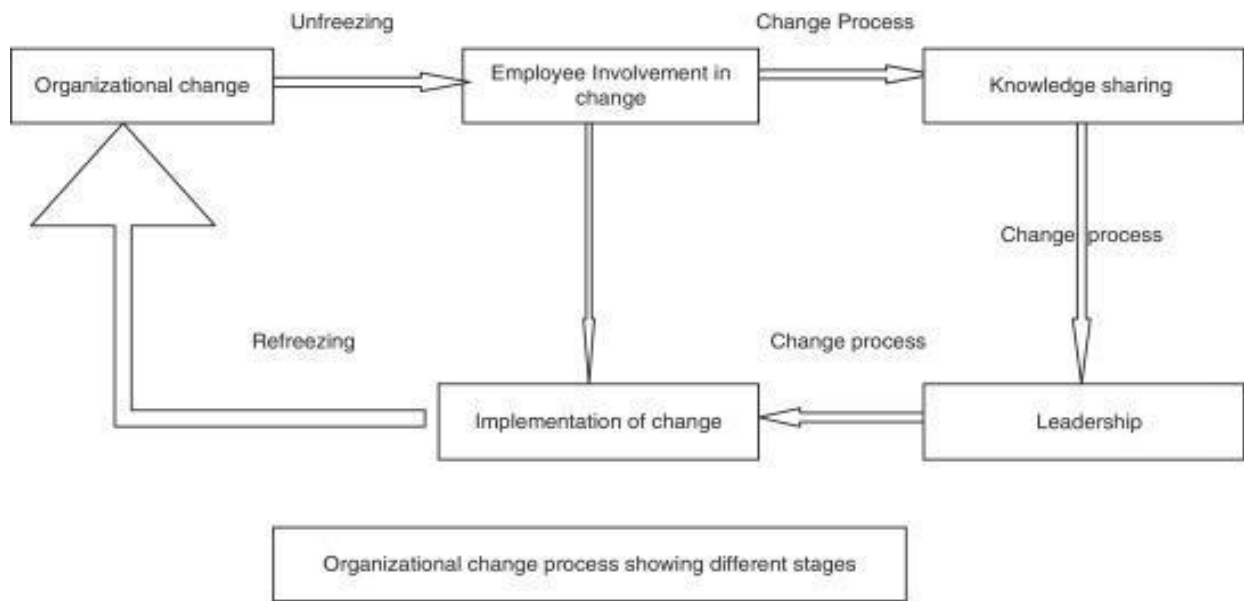


Figure 2.2: Kurt Lewin's model of organizational change

Source: Adopted from Sarayreh *et al.* (2013)

Lewin believed that the best way for an organization to go through change was to first, unfreeze or prepare the organization to accept the change. In this study, this step includes the unfreezing of existing behaviors of smallholder dairy farmers to come up with a new way to reduce milk losses in their farms. This stage of change is grounded in the consideration that human behavior is constituted through past observational learning and cultural influences, which we achieved through training in a varieties methods of milk loss on their farm. Change requires the facilitation of new change forces, or eliminating some of the existing forces that contribute to the behaviors of current practice that leads to farm level milk losses. From a Lewin's perspective, farm level milk losses of dairy farmers were essentially based on a quasi-stationary equilibrium sustained by a complex farm practice or forces. This means that the quasi-stationary equilibrium must be destabilized (unfrozen), and then brought through a change process (learning) and, finally re-stabilized (Refreeze), to facilitate new practices that do not produce farm level milk loss.

This suggests that relying on technical experts such as advisors, which are largely outside the rural dairy communities they are implemented, generally do not address whether local ecologically and culturally based skills experience by smallholder dairy farmers in Mogotio sub-county are aligned with the ecologically and culturally based technologies being advocated for adoption to overcome farm-level milk losses. It appears this can be attributed

to different ‘mental models’ of science experts and communities can differ in understandings about the nature of farming systems dynamics and approximate effects of practices are assumed (Halbrendt *et al.*, 2014). This was a significant gap in the Mogotio innovation platform that this study addressed.

The Context- Mechanism -Outcome Theory (CMO) supports access strategies to complex contexts and engages with the community, ensuring informed decisions where impartiality and access to interrelated socio-cultural behaviors and milking strategies were ensured and inform the learning agenda (Pawson, 2015). The study aimed to introduce a conceptual shift away from researcher and extension provocateurs' practices that have a top-down and technocracy dependence on better knowledge (Gray *et al.*, 2014).

This model (Figure 2.4 in the final report) explicitly identifies the distinction in practice and perception generated from local knowledge on milking practices as opposed to scientific knowledge, and potentially can identify where distinctions arise and create new knowledge and improved collaboration. Although specialized and unique, the need for trusted research tools and community-level modified and analyzed tools, this analysis could provide better context and forms of locally focused context that have been reminiscent of previous forms of community development practices (Biggs *et al.*, 2011).

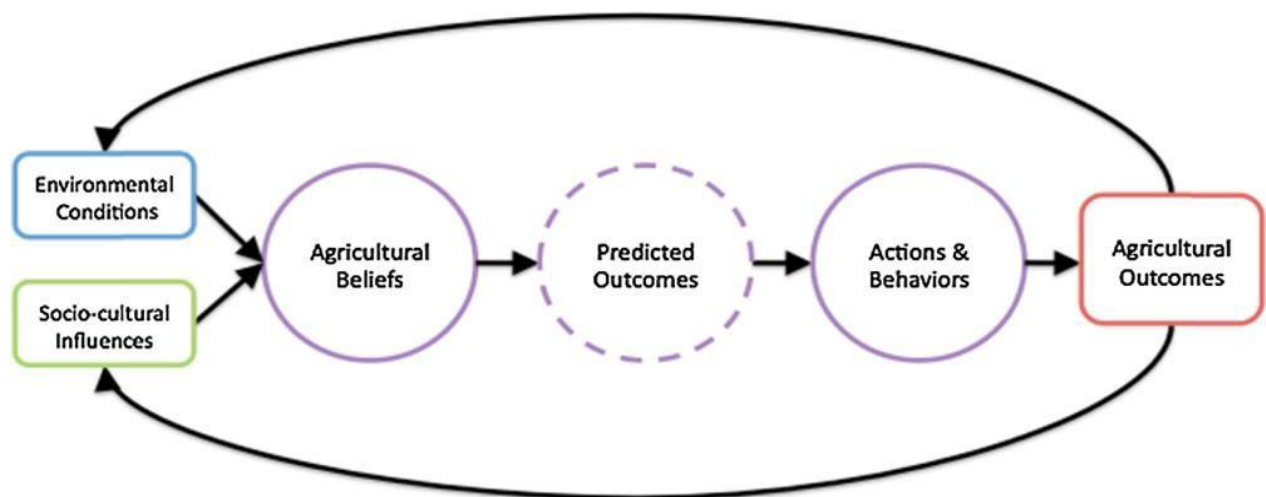


Figure 2.3: Factors that influence knowledge construction, actions and behaviours and agricultural outcomes

Source. Adopted from Halbrendt *et al.* (2014)

The framework utilized in this research is suitable to examine how rural dairy farmers conceptualize agricultural practices and environmental conditions from a socio-cultural perspective. It guided intervention (re)design in a stage of cycle one and highlights the drivers and factors leading to farm-level milk losses. Stakeholders were determined to have position interests and power within the milk value chain and local institutions to be studied through the lens of agency. Context was assessed in what farmers entered to contribute to a decrease in the level of milk losses. Context was assessed on the potential or actual benefits of the proposed interventions (Manzano, 2016).

Following this framework, action and behavior will become critical in stimulating further adoption strategies or extension materials developed in consultation with the farming community using research methods that incorporated and localized and analyzed at the community level; kind of site, community and citizen's geography specific data base; which has been the absence of conventional methodologies/processes, procedures of community development (Gray *et al.*, 2014).

Agriculture practices requires local understanding of the systematic socio-environmental complexities and the different meanings/opinions assigned to them, it has been explained by the farmers belief that we're in a symbiotic relationship with it, who are more likely to adopt farming practices in harmony with nature and are more likely to look after his economic resiliency in this scope (Pawson, 2015). This research was considering socio-economic practice related to dairy sometimes in an acceptable agriculture sense. The specific emphasis was training on on-farm milk loss.

2.11 Conceptual Framework

The Lewin Theory of Change Model and the Context-Mechanism-Outcome theories guided the study's conceptual framework. The conceptual framework was formulated to address the study objectives on the extent of milk production and farm-level milk losses amongst smallholder dairy farmers, the development of pathways for sustaining an innovation platform-based capacity building programme, and the effect of an innovation platform-based capacity building programme on farm-level milk losses amongst smallholder dairy farmers.

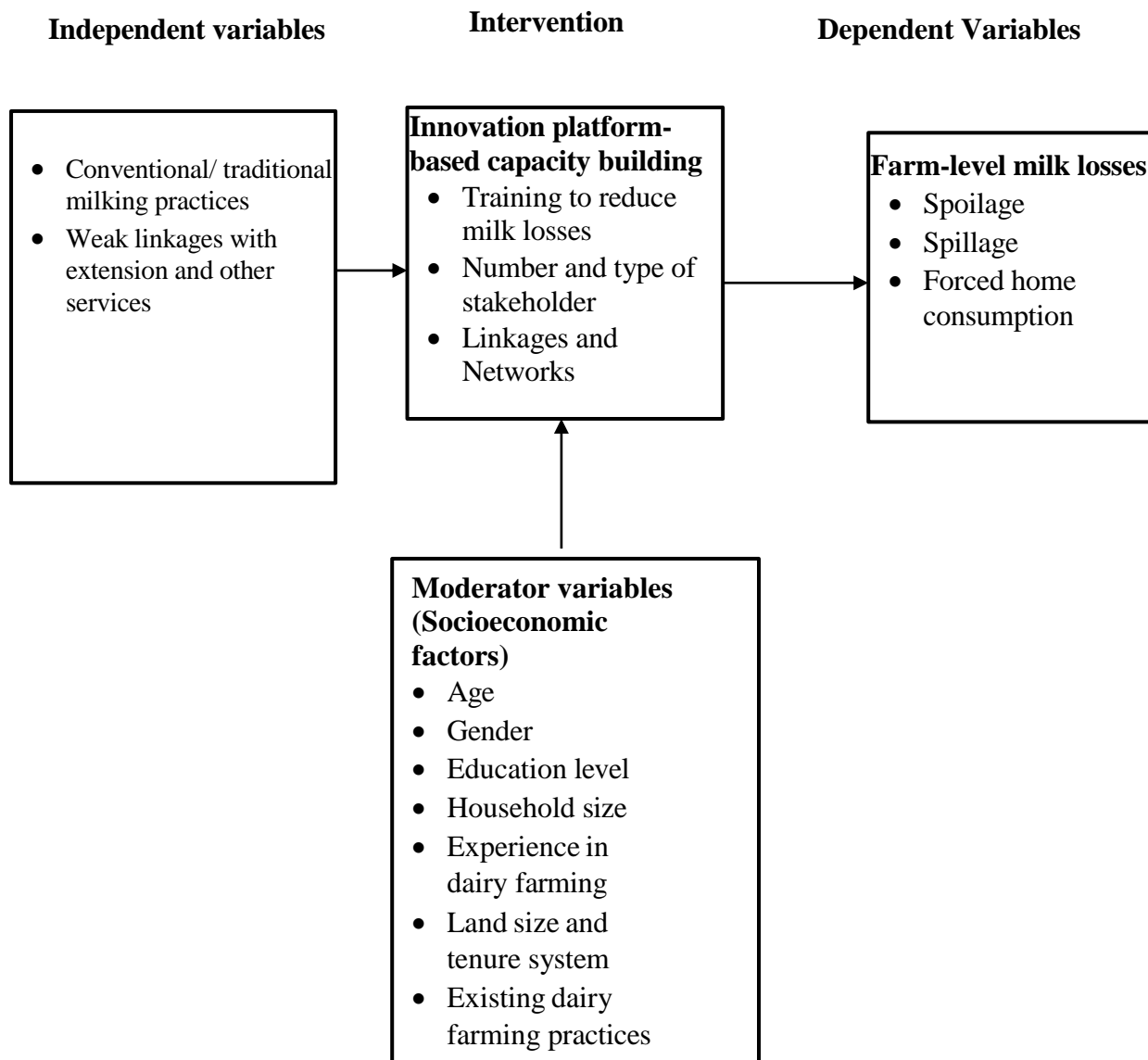


Figure 2.4: Conceptual framework

The interventions in the conceptual framework (Figure 2.4) involved training activities, support services, level of participation, the number, type and role of stakeholders, and linkages and networks in Mogotio innovation platform. The intervention was executed with an aim of reducing farm-level milk losses. The intervention was also designed in a manner that it able to solve the challenge of weak linkages on dairy advisory services using Mogotio cooling plant innovation platform and enhance knowledge by training actors. The present context in the framework represents some of the factors that can influence the independent variable. Such context includes the milking practices, animal feed, farm structures, farm breeds and dairy production system.

The moderating variables were the age, gender, education level, household size, experience in dairy farming, land size and land tenure system and existing dairy farming practices of the smallholder dairy farmers of the Mogotio sub-county (Paul *et al.*, 2023). The influence of moderating variables on farm-level milk losses was assessed and the results used to enhance the already existing education modules on proper dairy production modules for training (International Livestock Research Institute (ILRI, 2019). The common problem identified as milk losses needed a common concerted effort by all stakeholders thus calling for clear road map in achieving the goal.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the methodologies used in the study. It outlined the research design, setting of the study, the population, sampling methods, and sample size. It also describes the data collection instruments, validity and reliability of the instruments and data collection procedures and methods of data analysis.

3.2 Research Design

The study utilized a mixed research design. Mixed research design provides a thorough view by using the advantages of both quantitative and qualitative techniques, enabling validation through triangulation, providing rich and flexible data, addressing different research questions, improving design, and offering valuable insights into complex phenomena for more credible and informed decision-making. The study used surveys to characterize the dairy farmer respondents in terms of demographics, socio-economic, farm, and institutional support services. Key informant interviews with agricultural extension staff, county government staff, dairy cooperative staff, and processors were also conducted. Focused group discussions involving selected farmer representatives from wards and villages were also conducted.

While quantitative research design was important in gaining greater understanding on farm level milk losses and dairy production, qualitative research design using key informant interviews (KIIs) and FGDs provided in-depth and detailed understanding of the study variables (farm-level milk losses, opportunities in the utilization of innovation platform-based programme to build capacity in proper milking practices, influence of innovation platform-based capacity-building programme on farm level milk losses). Specifically, FGDs provided information that was used to triangulate survey data. Triangulating data sources in mixed research design is important because it strengthens the validity and trustworthiness of the research through the comparison and cross-checking of findings from different data sources, methods, or lenses which provides corroboration of findings, minimizes bias, and gives the reader a fuller and more accurate representation of the research problem.

Participatory Action Research was also a utilized in the study. PAR is a research strategy that

fully engages those in the community, or stakeholders in the research effort. PAR aims to better understand the world by attempting to change it collaboratively and reflectively. This approach describes it as one in which the action researcher and a client work together in agreement on the identification of a problem and in the development of a solution based on that identified problem. PAR recognizes the changing social, economic, and political environments that shape how technology and innovations are developed and disseminated. PAR offers approaches that engages several actors to create knowledge and actions that empower institutions and communities. PAR involves is fostering collaborations during research process. Thus, PAR is the linchpin in agriculture that connects researchers in several areas of research, ranging from innovations and technology, environmental conservation, livestock, and livelihoods (Méndez *et al.*, 2016; Méndez *et al.*, 2017).

Furthermore, PAR is a pluralistic approach that entails collaborative identification of challenges facing rural farming societies, implementation of solutions to the problems, and tracking the impacts of the implemented solutions (Shames *et al.*, 2013). Research, non-research, and other relevant partners are involved in fair and equitable participation in reflection and action such as applying agricultural practices, community development or social change process (Bacon *et al.*, 2005). To achieve its purpose, PAR involves identification of stakeholders, conversations about common activities, consolidation, and validation of multi-stakeholder feedback, and taking action.

PAR was utilized as a means to reveal challenges that are at the root of farm-level milk losses and locate solutions and opportunities for sustaining innovations that reduce farm level milk losses. In the first stage of use of PAR, dairy cooperative society producers were engaged in stakeholder selection to engage in the action stage. In this research, some of the stakeholders in the community engaged with the professional researchers from KALRO in continuous steps of the research process, from initial study design, to data collection and analysis, to the presentation of findings and discussion of their actions and implementation.

3.3 Location of the Study

The study was carried out in Mogotio Sub-County of Baringo County, Kenya. It can be approximately mapped between the coordinates 35.602 °E, 36.277°E and 0.541°N, 0.723°N at an altitude of 870 - 2499 meters above sea level (asl). Total area of Mogotio sub-county is 1,375 km² and a projected population of 91,104 with 46,014 male, 45,088 female and 18,184

households (KNBS, 2019). Baringo County shares boundaries with eight counties, namely Kericho and Uasin-Gishu in the southwest, West Pokot in the northwest, Laikipia in the east, Nakuru in the south, Turkana County on the north, Samburu on the northeast and Elgeyo-Marakwet County to the west. Major ethnic groups in Baringo County include Tugen, Pokot and Ilchamus and other minority ethnic groups include Endorois, Nubians, Ogiek, Kikuyu, and Turkana (KNBS, 2019).

Baringo County has six sub-counties (Baringo North, Baringo Central, Baringo South, Tiaty, Eldama Ravine and Mogotio) but this study was based in Mogotio Sub-County. The county has been subdivided into four ecological zones based on hydrology, elevation, vegetation cover, soil types and precipitation. These four zones are indicated as the low land zone at 1000 masl, which has perennial bodies of water, for example, Lake Baringo and Lake Bogoria. Part of the study area, Mogotio Sub County is situated in the mid-altitude zone, which ranges from 1000 to 1500 masl. The study area covered the highland zone (1,500 - 2,300 m asl) and the riverine zone on the border of Karoi River (elevation range of 1100 - 1200 m asl) (Ochieng *et al.*, 2016).

Annual rainfall averages between 300 to 1500 mm and temperature ranges from 16 °C for highland to 42 °C for lake ecosystems (Odada *et al.*, 2006). The rainfall pattern is tri-modal, with one peak rainy season (long rainy season) occurring in the period from March - May, and two (short rainy seasons) periods of peak rainfall occurring from June - August, and the final peak from October to December.

Dairy Farming is significant agricultural activity in Baringo County. The study site has a good climate in some of its highly productive areas such as Eldama Ravine. Hence, Baringo County economic potential in milk production had not been fully exploited. In 1960 Baringo County had cooperatives, including some of the earliest dairy cooperatives in the country, with the beginning of the cooperative movements challenging the monopoly of a state (Kenya Co-operative Creameries (KCC)). The cooperative movements groups began with the intent to increase bargaining power of smallholder farmers and increase their productivity and milk production potential. Further, farmers in Baringo County partake in mixed farming and pastoralism, with mixed farming to be conducted in the highlands and pastoralism in lowlands. Other activities that are engaged in are beekeeping, fish farming and fishing facilities on Lake Baringo. Therefore, Baringo rural areas, communities, were viewed as a platform or point of departure starting point towards innovating avenues for economic

diversification of sustainable resilient development. Mogotio Sub-County has a land area of approximately 2407 km². The Sub-County has three (3) administrative wards. These wards are; Mogotio, Kisanana, and Emining has a typical Rift-Valley climate with both semi-arid and agro-ecologically beneficial areas. Precipitation trends are seasonal, fall between short or long rainy seasons that shaped agriculture activities. (Chemase & Muhindi, 2024). This Sub-County has one of the Kenya oldest dairy cooperative societies, Mogotio Farmers' Cooperative Society (MFCS), which was first registered in 1963. The MFCS has over 2500 members. In terms of the cooperative's capacity, MFCS receives nearly 7000 litres of milk daily from regular farmers, while Sabatia's milk reception is only around 3000 Litres (a previously viewed study (Chebet, 2020).)

3.4 Target Population

The target population consisted of 2,500 dairy farming households in Mogotio Sub- County (MOALF&I, 2019). The accessible population comprised 840 smallholder dairy farmers supplying milk to Mogotio cooling plant. Five cooling plant employees, two researchers from KARLO and three county government livestock extension staff in Mogotio Sub-county were also involved.

3.5 Sampling Procedure and Sample Size

Baringo County was purposely picked due to its increased dairy production potential compared to the neighbouring counties; however, Mogotio Sub-County was chosen because of its poor dairy sub-sector performance in comparison to Eldama Ravine a dairy rich sub-county within Baringo County. The choice of the sub-county was also informed by presence of milk cooling plant marketing innovation platform and a big number of smallholder dairy farmers.

This study adopted a probability sampling strategy on dairy farming households in Mogotio Sub-County. The probability sample has an advantage over non- probability sample in that each member of a population has the same chance of being part of the sample which allows us to generalize sample data to the population of interest. The sampling used to select farmers to take part in the study provided that each farmer had same chance of participating. The sampling frame to select the farmers was a list of farmers obtained from the Mogotio dairy farmers' cooperative society and therefore the population of interest was finite.

The sample size for this study was estimated using the Nassiuma (2000) formula.

$$n = \frac{NC^2}{C^2 + (N - 1) e^2}$$

$$n = \frac{840*(0.25^2)}{0.25^2 + (840 - 1)0.02^2}$$

$$n = \frac{52.5}{0.4} = 131.9$$

$$n = 132$$

Where: n = Sample size,

N = Population,

C = Coefficient of variation,

e = Standard error.

The study used 25% as the coefficient of variation (C), e=0.02 or 2% for the standard error (e) and N=840 as the population. The resulting sample size was a sample size of 132 farmers.

Probability proportional to size (PPS) was used to determine the sample size for each ward. The formula from Skinner, (2014) was used to calculate the ward specific sample size. Prob. 1= (a x d) ÷ b (a= Cluster population, b= Total Population., d= Number of Clusters) Prob. 2= c / a (a= Cluster population c= Number of individuals to be sampled in each cluster). For participant selection in the action learning process, the dairy farmers of Mogotio cooperative selected from their representatives to participate based on Garforth, (2011) the farmers need to select their representatives in project or group engagements to be successful. Action learning research was used in an innovation platform which also brought in the required stakeholders identified in the baseline survey. We involved selected members of the cooperative in discussions to select dairy farmers for involvement in action learning in the IP. A total of 120 dairy farmers signed up to take part in action learning in the Intervention Phase (IP). The number of participants was satisfactory given that this is a qualitative study with smaller groups and participants are interacting and operating within the specifics of an

environment that allows the researcher to give an average insight into the behaviours patterns that occasionally emerge among the participants in the specific environment at a point in time and context, and provide generalizable findings (Craig, 2009).

For triangulation purposes thirty FGD participants and ten key informants identified from respondents were drawn from the study. Craig, (2009), defines triangulation, as data differing in forms, provide analysis yielding similar results confirming the researcher. The key informants included representation from county agricultural extension officers, input suppliers, dealers, KALRO researchers, dairy cooperative personnel, and dairy processors.

Table 3.1: Target Population and Sample Size

Sub-group	Number
Accessible population	840
Target respondents:-	132
- FGD	30
- Key informants	10

3.6 Instrumentation

The instruments used to collect data in the research included: A Baseline Survey Questionnaire (Appendix A), Focus Group Discussion Guide (Appendix B), Key Informant Interview Guide (Appendix C), and Endline Questionnaire (Appendix D).

3.6.1 Baseline Survey Questionnaire

A baseline questionnaire constructed by the researcher was the main instrument for collecting data from 120 (90.1 % response rate) smallholder dairy farmers (Appendix A) in Mogotio Sub-County. The questionnaire was utilized to collect data on a variety of parameters to estimate milk losses at the farm level. The baseline survey questionnaire collected socio-demographic, economic, and institutional characteristics of the farmers, which included gender, age, level of education, size of farm, land tenure, size of farm enterprises, household income, membership to dairy cooperative societies, and access to credit and extension services. The questionnaire also collected farm-level dairy management practices which included dairy breed, feeding, fodder production, milking methods, milk production, and

marketing. Open-ended questions were included to further understand the context of the dairy farmer community.

3.6.2 Focus Group Discussion Guide

A Focus Group Discussion guide (Appendix B) was also utilized to conduct a group discussion with three groups of dairy farmer groups- male only, female only and mixed. The group discussions were comprised of smallholder dairy farmers that sold milk to local dairy cooperative societies. There were three Focus Group discussions conducted in each ward in Emining, Kisanana and Mogotio. The focus group discussion (FGD) guide was utilized for collecting qualitative data to triangulate the quantitative data collected from smallholder farmers. Focus Group Discussions are commonly used as qualitative method for collecting rich data surrounding social issues. Rather than use a statically representative sample from the broad population of smallholder farmers, this method is intended to gather data from a purposely selected sample of individuals (Nyumba *et al.*, 2018).

3.6.3 Key Informant Interview Schedule

The key informant interview schedule (Appendix C) was administered for qualitative data collection from 10 key informants. Some of the topics solicited in the KII schedule addressed dairy value chain actors, underlying causes of farm level milk losses, practices used to mitigate farm-level milk losses, sources of dairy advisory services, and main opportunities and challenges facing the Mogotio innovation platform. Key informants included representative from county agricultural extension office, input suppliers, traders, KALRO researchers, dairy cooperative employees, and processor. Key informant interviews (KIIs) are very important in qualitative research, especially regarding policy areas, since they usually yield very useful information. Interviews were a component of additional research strategies like surveys and focus groups. On the other hand, given the value and familiarity of the key informant, key informant interviews can be thought to yield good and valuable knowledge, and are extremely important in action research, insufficiently in that they can provide, in detail, an understanding of process and problem that often does not go beyond 5-6 participants, but is able to document problematic and transformative issues that likely involve many participants. Key informants are having representatives of organizations that are believed to play a role in the project, and researchers seek to solicit knowledge and information from key informants of whatever is relevant to the project that is being supported

to a community (Hennink *et al.*, 2022; Lokot, 2021; McCabe *et al.*, 2018; McKenna *et al.*, 2013).

3.6.4 Endline Questionnaire

The endline questionnaire (Appendix D) was administered during field visits to a sample of 120 dairy farmers (a participation rate of 90.1%). The endline survey's main objective was to evaluate the changes brought by capacity building on lowering farm level milk losses as an intervention. In the end-line survey, additional questions were added to track aspects of change of dairy farming practices and empowerment which are important to reduce farm-level milk losses. A significant change in tool design was in separating the questions so that each dairy farmer was interviewed separately.

An endline survey is a systematic approach to evaluating a phenomenon or intervention at a specific point in time (Kumar *et al.*, 2023). This study employed an endline survey to assess changes resulting from capacity-building activities aimed at improving smallholder dairy farmers' practices to reduce farm-level milk losses. The survey questionnaire included reflective questions that enabled innovation platform participants to compare their experiences before and after engagement, while remaining aligned with the study's objectives and research questions. As Faujdar *et al.* (2020) stated, "the endline with reflective questions resulted in rich data with the opportunity for comparison".

3.6.5 Farmers Training Guide

The farmer training guide for capacity building to smallholder dairy farmers on dairy farming practices to reduce farm level milk losses (Appendix E) was developed to address the gaps that arose from the base-line survey. The content of the training manual was developed by the researcher and organized by topics using extensive information from research and background data of dairy production practices and milk handling practices. The capacity building manual adopted the education on proper dairy production modules for training (International Livestock Research Institute [ILRI], (2019). The module in the manual has the topics Dairy cattle Nutrition, Feed formulation, Fodder/Foliage Production, Fodder Conservation, Manure Management, Disease Prevention, Milk Quality and Udder Health, Factors of Clean Milking Practices, Reproduction and Breeding Management, Dairy Cattle Feeding and Management.

3.7 Validity

Validity refers to the extent to which the results of data analysis accurately represent reality (Sürücü & Maslakçı, 2020). Content Validity is the extent to which items in the measuring instruments are representative of the content domain. Face Validity is the extent to which the measuring instruments are pleasing aesthetically and in experiential design. Whiston (2012) identified that validity consists of obtaining data that are “applicable to all intended uses of the measuring instruments”. According to experts from the Department of Agricultural Education and Extension, Faculty of Education and Community Studies (Egerton University), validity of the instrument was established. Experts reviewed which concepts the instrument measures, and whether the items or indicators were linked to the concepts under consideration. The suggestions from those assessments were incorporated to revise and adapt the instruments so they could produce valid data from which appropriate, useful, and meaningful inference (Middleton, 2021) could be drawn. The evaluation of the process of establishing the face and content validity created content validity. The content validity index is 0.81 from this study using Liu’s (2010) content validity index calculations presented as follows:

$$\text{Content validity index} = \frac{\text{No of items declared valid}}{\text{Total no. of items}}$$

3.8 Reliability

Reliability refers to the consistency and accuracy of a data collection instrument, indicating that repeated use under similar conditions would yield comparable results. To assess reliability, the instruments were pilot-tested in Marigat Ward, Baringo South sub-county, which shares similar environmental and socioeconomic characteristics with Mogotio sub-county. A total of thirty farmers participated in the pilot test. According to Connelly (2008), a pilot study sample should comprise approximately 12% of the intended sample for a larger study, while Perneger et al. (2015) recommend a minimum pre-test sample of 30 to identify dominant issues in the research instrument.

The reliability assessment ensured that the baseline and endline survey questionnaires were accurate, stable, and reproducible. Data collection methods were carefully standardized across households to maintain consistency in measurements. Internal consistency of the

survey questionnaire was evaluated using Cronbach's Alpha Coefficient, which yielded a reliability score of 0.781, exceeding the acceptable threshold of 0.7. Additionally, participant involvement was incorporated to enhance reliability and credibility, allowing respondents to corroborate and provide input on the data collection process, consistent with best practices suggested by Patton (2002) and Yin (2009).

3.9 Data Collection Procedure

Data collection commenced after receiving relevant approval from both the Graduate School of Egerton University, and the National Commission for Science, Technology and Innovation. The County Commissioner and County director of agriculture and livestock development also gave clearance. Data collection began with a baseline survey. The sampling frame was accessed from a list provided by the manager of Mogotio cooling plant, who facilitated identifying sample respondents and their homes. From each ward, three enumerators were selected, and they were trained for two days to help them to understand the objectives and questionnaire items of the study.

The study began with a baseline survey with a questionnaire and trained enumerators. Each enumerator visits the respondent's homestead and four farmers were requested to fill a questionnaire each day of the survey which lasted for ten days. To prevent restriction of language barrier, enumerators selected were residents in the county.

After the baseline survey, 120 farmers were selected from three wards of Mogotio Sub-County to participate in trainings on the Mogotio innovation platform. The training was participatory and members were supported to interact freely on topics on reduction of farm level milk losses, innovation platform prospects and challenges. The trainings were conducted weekly for eight weeks. The study participants underwent capacity building activities that focused on topics: conventional and traditional milking practices, clean milk procedures, milking shed construction and maintenance, machine milking, milk cooling methods and preservation, and milk value addition that were created. The training module was customized from the dairy production training module. (ILRI, 2019) and used by researchers and Mogotio cooling plant staff in the training forums.

At the start of the study, Mogotio innovation platform members were involved. The innovation platform also served as social and linking researchers to the diversity of

stakeholders including farmers, agricultural extension, county government, milk processors and others between public and private service providers. Small action teams consisting of dairy farmers, advisory service providers and members of Mogotio cooling plan were formed through the self-reflective spiral of actions cycles of planning, acting, observing, reflecting and then re-planning. This learning was necessary for more transparent dialogue and in the negotiated process of decision making for action. In this case the farmers were part of generating the knowledge and listening to how the livestock development workers are going to fix their issues. This was shared ownership of research project, community-based analysis of social issues and community action. Following the intervention, an endline survey was conducted after the eight-week training where participants came together weekly to identify post-training influences of capacity building on production of milk and mitigating on farm milk losses that the participants experienced. The end of survey questionnaire was utilized to assess the influence of the Innovation platform on the status of farm level milk losses, innovation platform opportunities for dairy production in the sub county, and innovation platform influence on farm level milk losses reduction. The PAR started with modified participation by consultation (Pimbert, 2011) as the first step of data collection. Meetings and discussions were arranged with selected farmers and other stakeholders including, processors, Ministry of Agriculture and livestock Development to discuss what activities should be undertaken. Interactions between farmers and researchers were facilitated by Mogotio innovation platform, and the second step was facilitated to ensure accurate and correct learning and understanding by farmers of what the processes were. During the meeting researchers and farmers jointly identified and defined actions. The aim of the PAR was to find out information from various viewpoints in a participatory manner about action. The third step presence verification, elaboration, validation, and consolidation of information collected was the exclusive domain of the researchers.

Hence, the second and third steps involved context analysis and identifying solutions to farm-level milk losses informed by the four-step model. These involved planning, acting, observing, and reflecting to collectively maintain and improve for effectiveness of through dialogues and analyses. The different FGDs sessions involved questions concerning farming systems, farmer group involvements, and dairy commercialization. The researcher ensured that the participants were a mix of male, female, and youth participants to get diverse perspective on dairy production in the sub-county. Participatory forums were utilized to gain local and regional knowledge as well as farmer experiences and their effect on dairy

production.

Development and implementation of strategies was followed up with continuous monitoring to ascertain the added value of diagnosis jointly developed by researcher and farmers. Continual follow-up on the farm was conducted as well where emerging technologies and impact on the household system were discussed and debriefed upon via the innovation platform. The households were monitored to assess overall household conditions and the opportunities to adopt farm level milk losses reductions strategies. FGDs were conducted pre/post IP intervention. The FGDs were also intended to facilitate the participants to practice resilience and utilize reflection to enhance their learning often since learning is the fundamental tool in interrogating some questions to accepted thinking of “what works” moreover demonstrate FGDs is not only to generalize an understanding about an issue, FGDs is ALWAYS to highlight prominent perspectives to an issue. The discussions were conducted in order to verify data collected with survey.

The FGDs included the dairy farmers that participated in the IP interactive learning. This was aimed at capturing the information of dairy practice and use of, and benefits received. An end line survey was conducted with the dairy farmers involved in the study. In addition, 10 key informants among the participants were specifically sampled based in part on representing each stakeholder institution/organization and having knowledge of based issues around dairy farming and livelihoods in the study area.

The key informants included representative from county livestock extension, an input supplier, KALRO researchers, dairy cooperative, and processors were used as key informants, such as living here or operating here. Interviews are useful in action research because they provide in-depth understanding of processes and challenges, even if there is a low sample size (Hennink *et al.*, 2022). Key informants were representative of dairy considered to have some significance in dairy farming in the Sub-County. McCabe *et al.* (2018) states that key informants are usually representative of dairy that has some significance in dairy farming in the Sub-County. KI are often asked by researchers to share information and knowledge related to a project that is supported within a community (McKenna *et al.*, 2013). While key informants in this study were ward livestock extension officers and sub-county extension officer. The end line survey instrument was a design used to measure the innovation platform-based capacity building capacity of mogotio innovation platform. Data was collected in an endline survey questionnaire whose outcomes were

generated from selected dairy farmers, who are members of the Mogotio milk cooling plant. The endline survey instrument questions focused on the milk stakeholder interactions in alleviating the farm level milk losses.

An important aspect of any research design with human participants is end line data collecting, and involves meaning, succinct, complete, and comprehensible study background on studies and the instrument items the participants will be asked. In study questionnaire items, participants frequently show limited understanding (Falagas *et al.*, 2009). Participants were made to understand the aims of the studies well enough from baseline survey studies before actions were being taken. Understanding is augmented by interacting with the survey and consent process (Palmer *et al.*, 2012). Training that utilizes the innovation platform approach could support training of dairy unless if it will be meaningless; it may assist in terms of reducing losses of milk. Endline data collection techniques were systematically robust and protected the privacy of respondents (Lawrence *et al.*, 2020).

3.10 Data Analysis

Data cleaning was completed in order to condense the data log to give an overall interpretation of the data collected. It needed to be done right after the researcher completed the day's field survey. Quantitative data was analyzed using Statistical Package for Social Sciences (SPSS) software version 25 and Microsoft Excel. Qualitative data was analyzed using NVivo software (version 12). Data analysis was both descriptive and inferential. Measures of central tendency which included mean and median, and measures of dispersion which is standard deviation were used to summarize the distribution of the quantitative data. Inferential statistics which included independent samples t-test and chi-square test of independence were used to test significance in distribution of the data. The results from the analysis was entered into tables and visualized using pie charts, and tables.

Table 3.2: Summary of Data Analysis

Research Question/Hypotheses	Independent variables	Dependent variables	Data analysis
Q1: What is the status of farm-level milk losses among smallholder dairy farmers in Mogotio Sub-County, Baringo County?	Smallholder dairy farmers context	Status of farm-level milk losses	<ul style="list-style-type: none"> • ANOVA • Descriptive statistics (frequencies, percentages, means, standard deviations)
Q2: How can an innovation platform-based capacity building programme be utilized to build capacity in proper milking practices among smallholder dairy farmers in Mogotio Sub-County, Baringo County?	Innovation platform-based capacity building programme	Capacity building in proper milking practices	<ul style="list-style-type: none"> • Thematic content analysis • Descriptive statistics (frequencies, percentages, means, standard deviations)
H0₁: Innovation platform-based capacity building programme does not have a statistically significant influence on farm-level milk losses among smallholder dairy farmers in Mogotio sub-County.	Innovation platform-based capacity building programme	Farm-level milk losses	<p>Descriptive statistics (frequencies, percentages, means, SDs)</p> <p>One-way ANOVA</p> <ul style="list-style-type: none"> • Chi-square

3.11 Analysis for Objective One

Objective one was to assess farm-level milk losses from smallholder dairy farmers. First, quantitative data (were to measure patterns or trends in the data). Followed by the qualitative phase, which was to gather detailed data (through questionnaire or focus groups) which might be able to provide more contextual or explanation of quantitative results. Any raw data, qualitative data from survey questionnaire, focus grouped discussion, observation or even other qualitative data collection was written in a sheet using data logging and analysis was used data coding and thematic content analysis. Vignette software was really good for representations of narratives or story, metrics on whether the representation, the research was trying to interpret with respect to person, their knowledge, or circumstances. The analysis involved data coding and thematic content analysis.

3.12 Analysis for Objective Two

Objective two was to explore the possibilities of conducting innovation platform-based capacity building on proper milking practices with smallholder dairy farmers. Qualitative data were used to conduct a thematic content analysis, as each themes were identified and checked whether they contained all of the included data, and quality, boundaries, meaningfulness, and coherence (Castleberry & Nolen, 2018). The themes were grouped, taken apart, and remade into codes and categories of the concepts mapped out of the data. Every interview was recorded, transcribed, coded and analyzed utilizing frameworks analysis method. Quantitative data was collected and measured and therefore analyzed the Pooling patterns or trends and presented in pie chart and tables. The explanations and items responses regarding the capacity building of farmers and dissemination of knowledge, explained strategy were used primarily in the data analysis subsequently.

3.13 Analysis for Objective Three

The objective was to evaluate the impact of an innovation platform-based capacity building program on farm level milk losses to smallholder dairy farmers. Measures of central tendency were used including mean, frequency, and percentages. There was also inferential statistics one-way ANOVA to test difference in means.

3.11 Ethical Considerations

The researcher assured the respondents that their anonymity would be maintained and reminded them that the survey was only for academic purposes. The respondents voluntarily chose whether or not they wanted to participate after informed consent. After receiving clearance from Egerton University Ethics Review Committee (EUREC) a letter of authorization to conduct research was obtained from Graduate school that was used to obtain a research permit from NACOSTI. The permit was granted from NACOSTI, and permission from sub-county administration was sought.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

In this chapter, results of the study conducted on the effect of innovation platforms-based capacity building on-farm level milk losses of smallholder dairy farmers in Mogotio Sub-County, Baringo County, Kenya are presented. The results were highlighted with reference to the objectives of the study. The results are presented in descriptive and inferential statistics. The discussion is extended to how the results were consistent or otherwise with other published work.

4.2 Socio-economic Characteristics of Smallholder Dairy Farmers

The study sought information about socio-economic characteristics of the respondents. Some of the characteristics that were studied include gender, relationship with the household head, level of education, land ownership system, and sources of household income. The socio-economic characteristics of smallholder dairy farmers are important in explaining farm-level practices and participation in innovation platform-based programmes. The social characteristics of the milk producers are presented in Table 4.1. The demographic information and representation were organized as categorical variables and continuous variables. Results in Table 4.1 show that most households were headed by males who comprised of 84% while only 16 % were headed by the females. This shows majority of the dairy farming is controlled by the males which is attributed to cultural norms in the study area. This has implications on the decisions and practices that may have a bearing on farm-level milk losses that may be undertaken and solely determined by the heads of the households. This corroborates to findings by Kosgei *et al.* (2020) whose findings indicated that majority of the dairy farming households were headed by males. In addition, dairy farming in Baringo is labour intensive, and majority of those involved are the males who usually prepare the feeds, herd the cows, transport the milk to the market and are also involved in other dairy farming management practices.

Table 4. 1: Social Characteristics of Smallholder Dairy Farmers in Mogotio Sub-county (n=120)

Description of variables	Percentage
Categorical variable	
Gender of household head	
Male	84
Female	16
Relationship to household head	
Self	93
Wife	7
Son	0
Daughter	0
Relative	0
Education level	
None	27
Primary	20
Secondary	37
Tertiary/University	16

The study results in Table 4.1 showed that in terms of relationship to household head majority 100(93%) of the respondents were the head of the household themselves. However, 8(7%) of the respondents were the wives of the household head. The mean age for household head for respondents in Mogotio Sub- County was 54 years. This because majority of aged people prefer dairy farming as opposed to the young ones. Dairy farming generally requires a substantial amount of capital which in most cases young people are unable to raise. Similar results were documented by Maina (2018) who found out that the mean age of dairy farmers in Nyeri County ranged between 50-57 years meaning that most of the farmers were in an older age bracket. This means that majority of the young farmers had not embraced dairy farming relative to older farmers. In relation to the average age of the farmer, it is true that dairy farming requires extensive knowledge and strategies to succeed. The study findings however are not in agreement with the findings of a study by Tesfaw (2013), which found that the age of the household head has a negative impact on market participation decisions. This is because as the household head gets older, they shift to less labor-intensive farming

alternatives.

With regards to the education levels of the respondents, most of them possessed secondary education as their highest education level comprising of 37% of the total respondents. Others included 27% that had no formal education, 20% that had primary education and 16% that had tertiary education. The willingness to accept modern technological advances in dairy farming is highly influenced by the level of education. Farmers with higher education levels tend to easily accept modern dairy management practices as they are relatively appreciative of the evolving technology with the dairy. They are also easily appreciative of the improved dairy breeds of cattle which are more adaptive and resilient to their immediate climatic conditions. Odhiambo (2021) and Muriithi *et al.* (2014) established similar criteria, with the majority of farmers having completed secondary school. The findings also show that farmers can gain more knowledge on various dairy farming techniques through education, so it is prudent for them to use their proceeds from their farms to become enlightened through education. Furthermore, Maina (2015) show that as one's education progresses, they become empowered with skills necessary to market their products and achieve lucrative returns in the end. Majority of the dairy farmers in the sub-county owned land without title deeds accounting for 71% of the farmers as shown in Table 4.2.

Table 4.2: Land ownership and sources of household income of smallholder dairy farmers (n=120)

Variables	Percentage
Land ownership system	
Owned with title deed	27
Owned without title deed	71
Rented	2
Sources of household income	
Livestock farming	57
Crop farming	32
Salary from employment	7
Small scale business (Hawking, kiosk, hotel, shop)	5

The results in Table 4.2 shows t only 27% owned land with title deeds and 2% who had rented land for dairy production. Application of technologies for agricultural and natural resource management is influenced by land tenure and property rights. Securing property rights provides farmers with enough incentives to boost output in milk production and guarantee environmental sustainability. Owning a title deed is also essential for securing credit from banks and other financial institution which can be used in expanding dairy production. Additionally, these lending institutions provide farmers with incentives to boost their output. In addition, the mean area under dairy production was 1 acre which was approximately 50% of the mean areas/land owned by the farmers which was 2.3 acres. According to Muriithi *et al.* (2014), the majority of farmers owned less than 2 acres of land, implying that farmers needed to incorporate modern farming techniques that involved high intensification of feed production as they involved both cash crop and horticulture farming on the same piece of land, making dairy farming land scarce. This is however the findings by Otieno *et al.* (2020), documented that inappropriate animal husbandry and farming practices, poor access to breeding, animal health and credit services in addition to the high cost of artificial insemination (AI) service are additional limiting factors for dairy production in Kenya.

In relation to sources of income for the household, 57% of the household incomes are from livestock farming while 32%, 7% and 5% are from crop farming, salary from employment and SMEs respectively. This shows that majority of the population in Baringo County are dependent on livestock farming as their main source of income and livelihood. Contrary to these findings, Muriithi *et al.* (2014) found out that smallholder farmers in Baringo county received low income per month from their dairy businesses as opposed to other livelihood.

4.3 Status of Farm Level Milk Losses Among Amallholder Farmers in Mogotio Sub-county

The first objective of the study was to assess the status of farm level milk losses among smallholder dairy farmers in Mogotio Sub-County. The main aspects that were covered included feeding systems used, production record keeping, types of breeds kept, average milk production, milk handling attributes, level of farm level milk losses and current training focus. The findings were as follows:

4.3.1 Feeding Systems

Feeding systems play a significant role in determining milk production and the potential for milk losses. Pasture only grazing system makes use of proper milking techniques difficult as smaallholder farmers prefer the practice of simultaneous milking and suckling at their grazing fields. Pasture only system pose abilities of farmers to conserve. The results on feeding systems are summarized in Table 4.3. The results indicate that farmers in the region were dependent on pasture only as the main feeding system, accounting for 53% of the farmers.

Table 4.3: Feeding systems used by dairy farmers (n=120)

Feeding systems	Frequency	Percentage
Zero grazing	32	27
Natural pasture and zero grazing	24	20
Pasture only	64	53
Total	120	100

About 27% and 20% of the respondents used zero grazing and combination of pastures and zero grazing, respectively. This was highly attributed to the following factors that highly influenced dairy farming in the region; the availability of large tracts of lands that were quite unsuitable for crop production and therefore favored pastoral raring of dairy cattle, the climate of the region that did not highly favor the growth of fodder crops and nappier grass that are essential during zero grazing, the breed of dairy cattle that the farmers reared could easily survive on natural pastures as they were hardy and resilient cattle for hot and dry areas, cultural influences that heavily influenced the feeding practices within the region were pastoralist community and the high cost of feeds necessary for zero grazing. However, the pastoral feeding system has its own disadvantages over other feeding systems which include It is challenging for milking cows to consume the substantial amounts of grain required to maintain the high levels of production anticipated due to the high moisture content of pasture, rising temperatures and fly issues, wasted feed from trampling and inconsistent feed quality, as well as variations in the quality of feeds and challenges calculating pasture intake. Wilkes *et al.* (2020) discovered dissimilar findings that zero-grazing was the most used feeding system, followed closely by semi-zero grazing and grazing only.

According to Chepkemoi (2020), the most common feeds available for consumption by cattle were natural pasture, Napier grass, maize, commercial and homemade concentrate, and other feed resources such as crop residues and industrial by-products. Therefore, there is a need for more emphasis on zero grazing for maximum production of milk and for better planning and feeding practices. Also, zero grazing helps the farmer make comparisons between the input levels versus the output levels.

Previous research on milk production in Africa has either used modelled farm characteristics (Brandt *et al.*, 2018), assumed characteristics of "typical" farms (FAO and NZAGRC, 2017a, 2017b), or actual data collected from small samples of farms (Udo *et al.*, 2016; Weiler *et al.*, 2014; Woldegebriel *et al.*, 2017). Most research on how milk production is impacted by the feeding arrangement is contradictory. Studies based on presumptive typical values of farm parameters in Kenya and Ethiopia reveal there are considerable disparities in milk production across different feeding regimes (FAO & NZAGRC, 2017a, 2017b).

Analysis of data from a large sample of farms is required to pinpoint the causes of variability in feeding systems. Differences in feeding systems may be caused by management choices. Efficient and well-managed feeding system helps ensure that cows are healthy, well-nourished, and able to produce milk optimally. Addressing issues related to feeding practices can help minimize milk losses (Henriksson *et al.*, 2011).

4.3.2 Dairy Production Record Keeping

Record keeping influences the estimation of both production levels and any losses that may occur. Table 4.4 shows the dairy records kept by smallholder dairy farmers. Approximately, 68% of farmers kept dairy production records and 32% did not. The types of records that most farmers kept were livestock register (26%), daily milk yield register (21%), calving register (18%) and calf register (16%).

Table 4.4: Dairy production records of smallholder farmers (n=120)

Production records	Frequency	Percentage
Livestock register	31	26.0
Calving register	22	18.3
Daily milk yield register	25	20.5
Calf register	20	16.4

Production records	Frequency	Percentage
Growth record of young stock	9	7.3
Herd health register	7	5.5
Cattle breeding register	4	3.7
Animal history sheet	3	2.3
Total	120	100

Dairy production record keeping is difficult for smallholder farmers due to factors such as limited education and training, time constraints, lack of access to technology, inconsistent data collection, financial limitations, lack of motivation, fluctuating production conditions, and cultural barriers. For smallholder farmers to increase efficiency and decrease low milk levels, accurate records are essential (Verhoosel *et al.*, 2015). Moreover, dairy farming in the era of precision farming is thought to be more crucial for information provision and for capturing a competitive market; as a result, the need for a variety of data sources that contain the dynamic and static cow data about feeding, calving, nutrition, insemination, and the process of milk production is necessary (Kino *et al.*, 2019). This necessitates accurate dairy cow record keeping for innovation in smart dairy farming to lower farm level milk losses.

According to Verhoosel *et al.* (2015), innovation in dairy farming processes and production (milk output) are linked and may reduce farm level milk losses. The key players in innovation in farming are dairy farm producers. According to Begum *et al.* (2014), a product in an organization is anything that will be produced by a business and sold to another firm or the client. The milk that dairy farmers generate in their farms is sold to other milk organizations. While the milking process on a dairy farm is the sole activity that can be considered a single process, there are several other tasks that are carried out on the farm, including feeding, cow monitoring, and milk preservation, all of which require accurate record keeping in managing dairy output.

4.3.3 Type of Cattle Breeds Kept

The data in Table 4.5 shows the breeds and dairy stock kept by the smallholder farmers. The types of dairy breeds kept show that indigenous dairy cows were common with approximately 65% of the farmers keeping them and 35% of the farmers kept

improved/exotic breeds. In arid/semi-arid area and where nomadic pastoralism is practiced (e.g. Baringo County), there is a greater preference for indigenous breeds of cattle. Among the reasons given for keeping this type of breed were that they can survive in the region's tough dry and semi-arid conditions. Smallholder farmer also believe that they are more resistant to regionally prevalent diseases than highland breeds of high productivity, ensuring higher survival rates and reducing costs for veterinary services, they can survive on low-quality fodder and can better withstand local weather extremes and times of feed scarcity. This makes proper milking a challenge as most will practice free range and no milking parlors. Onono and Ochieng (2018) in their study indicated that majority of the dairy farmers kept indigenous cattle breeds which had the ability to produce milk under harsh climatic conditions hence the preference.

In terms of stock, most farmers owned three cows and at least one bull, as well as steers, heifers, male calves, and two female calves. Majority of farmers preferred the cows over other stocks. This perception and preference were heavily influenced by dairy farming. Dairy farming, which encompasses milk production, distribution, and sale, provides excellent opportunity for smallholder farmers in low- and middle-income countries to raise their standard of living through the sale of milk and to enhance household nutritional status through increased milk intake. However, most of the farmers were still operating at smallholder level with limited stock of dairy animals. Previous research found similar results that dairy farmers kept a minimum of three cows, while bulls were mostly kept being sold later for household income generation (Reinecke & Casey, 2017; Wang *et al.*, 2016; Wilkes *et al.*, 2020).

Table 4.5: Type of breeds and stock of smallholder farmers (n=120)

Type of breeds	Frequency	Percentage
Indigenous	78	65
Improved/exotic	42	35
Total	120	100
Type of stock	Mean	Standard deviation
Bulls	1	0.50
Cows	3	1.44
Steers	1	0.50
Heifers	1	0.50
Male calves	1	0.50
Female calves	2	0.65

Assessing the differences in milk value per breed is crucial for optimizing dairy farming practices, as it enables farmers to make informed decisions about breed selection based on economic efficiency, milk yield, and quality. Different breeds demands varying management levels hence difference in farm level milk losses. The difference in milk values per breed is summarized in Table 4.6.

Table 4.6: One-Way ANOVA results for the test of differences in milk values per breed (n=120)

Type of breeds	Milk Mean (Litre)	N	Test statistics F	Sig.
Friesian	1	120	0.06882	0.000**
Ayrshire	3	120		
Jersey	1	120		
Sahiwal	1	120		
Crosses	1	120		

** significant at $p \leq 0.05$

The results in Table 4.6 show that Ayrshire breeds were the ones that yielded most milk (average of 3 litres) in the study area. For the rest of the breeds, each produced an average of 1 litre of milk per day.

Generally, this study confirmed that the milk production in the study area was relatively low. Low milk production in the study area could be due to a combination of factors including poor nutrition, inadequate health care, and sub-optimal management practices especially recorded for friessian which otherwise could be topping in the list.

The Kenyan government has taken the concept of dairy productivity its top priority (Erdaw, 2023). The County government of Baringo now imports a significant volume of dairy goods since domestic production cannot keep up with demand (Mutinda *et al.*, 2024). Low milk yields were associated with the rearing of indigenous cow breeds (especially through pastoral systems), poor genetic ability for producing milk, the animals' challenging living environments, and a general lack of essential inputs like feed and veterinary care. The County administration of Baringo has supported artificial insemination campaigns that advocate for the adoption of exotic dairy cattle as part of bigger efforts to boost local dairy output.

Farmers' decisions on the improved dairy cattle breeds were limited because they did not have proper information on prospective livelihood gains. Most farmers fear adoption of exotic dairy breeds due to inadequate advisory service providers, inadequate knowledge on disease and parasite control, and lack of capital (Ochieng *et al.*, 2016).

4.3.4 Average Milk Production by Smallholder Farmers in Mogotio Sub-County

With regards to the milk production parameters, Table 4.7 indicates that the mean number of cows milked per household was two while the average milk production per day was 7 litres. Of the 7 litres produced daily, 6 litres were sold and one litre was consumed on average.

Table 4.7: Amount of milk realized before implementation of innovation platform-based capacity Building Programme (n=120)

Milk in litres	N	Percentage
1-5	20	16.6
6-10	30	25.0
11-20	24	19.8
21-25	17	14.6
26-30	29	24.0

Total	120	100.0
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According to the study findings in Table 4.8, prior to the introduction of the innovation platform, the majority of farmers (25.0%) received 6-10 litres per day. However, 23 farmers (24.0%) got 26-30 litres of milk each day. According to the survey, 19(19.8%) of farmers' milk 11-20 litres per day, whereas 16(16.7%) milk 1-5 litres per day. Furthermore, 14 (24.0%) of the farms produce 26-30 litres of milk each day. Table 4.8 displays the results.

Table 4.8: Mean milk production of smallholder farmers after the intervention (n=120)

Variables	Mean	Standard deviation
Number of cows milked	2	0.65
Number of milking months	5	0.59
Average milk production per day	7	3.04
Average litres of milk sold	6	3.05
Average litres of milk consumed	1	0.00

Following the implementation of innovation platform-based capacity development programme on reduction of farm level milk losses among smallholder dairy farmers in Mogotio sub-county, the amount of milk increased. In Mogotio Sub-county, the milk production levels in litres were found to be low in comparison to the number of cows under production. The average milk production per day of 7 liters is much lower against a potential of 15 to 25 liters of milk per day when high-yielding breeds are considered. This could be attributed to several factors including poor breeds, lack of feeds and pests and diseases. The high cost of fodder within the region causes severe ration shortages or imbalances in minerals and supplements rich in protein, calcium, phosphorus among other nutrients, similarly reported in earlier work by Fraval *et al.* (2019). Smallholder farmers have limited ability to satisfy animal water demands and frequently collect water from water sources for both household and animal usage (Ochieng *et al.*, 2016).

Additionally, the feeding schedule, the quantity and quality of feed in smallholder farms varies greatly not just from week to week but also from season to season. On the basis of incomplete data, it is difficult to estimate milk output for each lactation. In developing countries, only a tiny minority of farmers maintain regular longitudinal records of milk

output. Less than 1% of all farms engage in test-day (TD) recording programs in the Kenyan highlands, where resource-constrained smallholder farming is predominant (Kosgey *et al.*, 2011).

Table 4.9: The chi-square results for the milk yield before farmers acquired knowledge on milking techniques (n=120)

Milking season (Months)	Milk Mean (Litres)	N	F	Sig.
1	0.57784	120	8.519	0.001**
2	0.75309	120		

** significant at $p \leq 0.05$

4.3.5 Market Outlet for Milk

Understanding market outlets is essential for assessing farm-level milk losses among smallholder farmers. Market outlets significantly influence the status of farm-level milk losses among smallholder farmers through factors such as quality standards, pricing variability, and transportation efficiency. Different outlets impose varying quality requirements, which can lead to rejected or discounted milk if farmers are unprepared. Additionally, access to diverse markets affects pricing, and farmers may incur losses if they miss out on better pricing opportunities. Inefficient transportation and inadequate storage facilities can exacerbate spoilage, while fluctuations in consumer demand may result in excess production that goes unsold. Furthermore, certain outlets provide access to better resources and technology, enabling farmers to adopt practices that minimize losses.

Sixty-four percent (64%) of milk producers sold their milk to dairy cooperatives while only 8% sold their milk to retailers (see Table 4.10). This indicates that the cooperative acts as the main market for majority of the farmers in Baringo County. When compared to selling to local customers and retailers, selling milk to cooperatives ensures a continuous market supply of milk throughout the year. Cooperatives provide members guidance on appropriate milk management and production methods, as well as market and economic statistics. They also assist county extension agents in putting state experiment station suggestions into effect. Many farmers turn to their cooperatives for more extensive purchasing and marketing

services. By combining milk products of a specific grade or quality, many marketing cooperatives are better positioned to satisfy the demands of large-scale purchasers. They also have established export markets, which allows them to produce more than they can sell locally. Cooperatives increase market price for milk items, services provided, and the quality of materials purchased by farmers. Individual farmers can gain "muscle in the marketplace" despite their limited purchasing and negotiating power by joining cooperatives, allowing them to sell their milk and goods through cooperatives rather than running separate corporations.

Table 4.10: Market outlets for milk among smallholder dairy farmers (n=120)

Market	Frequency	Percentage
Cooperative	77	64
Middlemen	33	28
Retailers	10	8
Total	120	100

Ayyano et al. (2020) and Makoni et al. (2014) suggest that most farmers preferred to sell their milk to middlemen, retailers, and local customers rather than milk cooperatives because they were assured immediate payment, unlike milk cooperatives. The findings from this study differ from Wairimu et al. (2020), which found that milk producers preferred selling their milk to local traders instead of cooperatives because traders provided higher farm gate prices compared to the low prices provided by cooperatives.

4.3.6 Influence of Variable Costs on Clean Milk Production

In dairy farming, variable costs are expenses that fluctuate with the level of production and other operational factors. Understanding and managing these variable costs is crucial for minimization of farm losses and optimizing dairy farm profitability. Table 4.11 presents the variable costs incurred in dairy production among the farmers in Mogotio. These costs include hired labour, purchase of feed/fodder, purchase of water, vaccination, deworming, tick control and curative treatment. The results indicate that most (60%) of the farmers did not hire extra labour to help them with dairy production. This might be influenced by most farmers solely depending on livestock keeping for a source of living hence hiring extra labour might turn out to be extra costs for them. Moreover, 88% of the farmers purchased

fodder for their cattle. This is because it had to supplement natural fodders which were not enough and also lacked proper nutrients required for high milk production. This was caused by the arid conditions in the region which did not support the growth of enough natural pastures for their cattle.

The arid and dry conditions of the area also forced some of the farmers (44%) to purchase water for their animals through water boozers and other individual water ferries. However, those that did not purchase water complained of the amount of water not being enough for their cattle as well as the quality of water being poor. On disease and pest control, 58% of farmers vaccinated their cattle against disease. This was quite a low number thus much needed be done by both the national and county government by making such vaccines available at fair prices to farmers in the region.

Table 4.11: Status of variable costs incurred by smallholder dairy farmers (n=120)

Variable costs	N	Percentage
Hired labour	48	40
Purchase of feed/fodder	105	88
Purchase of water	53	44
Vaccination of animals	70	58
Deworming of animals	81	68
Tick control	102	85
Curative treatment	73	61

In relation to deworming animals, 68% of the farmers reported that they dewormed their cattle. This was a substantial percentage given the farmers purchased these dewormers from local agro-vet shops in the region. Furthermore, 88% of farmers reported that they carried out tick control, either by spraying themselves or paying others to do it for them. This corresponds to findings by Wairimu *et al.* (2020), who observed that cows were sprayed once per week in the majority of households with the goal of controlling tick-borne diseases. Only 61% of farmers used the curative treatment on their cattle. The results of Focus Group Discussions (FGDs) confirmed that most of the farmers had limited access to veterinary

services in the region. Most of them bought medicine from local agro vets and administered them directly to their cattle without prior knowledge of the disease being treated.

4.3.7 Milk Handling Attributes of Smallholder Dairy Farmers

Milk handling practices are critical to minimizing farm-level milk losses. Proper handling practices ensure that milk is collected, stored, and transported in ways that preserve its quality and reduce wastage. Some of the aspects of milk handling that were investigated include; hand washing when milking, washing of milk containers, smoking of the milking containers, use of detergents or soap to wash milk containers, udder cleaning and types of milking containers. The results in Table 4.12 indicate that 75% of the farmers did not practice hand washing before milking their cows. This indicates poor milking practices and moreover, possible contamination of milk. With regards to a water source for the farm households' use, the predominant source of water was deep well water. According to the results, 37% of the households depended on deep well water as their main water source. This is explained by the study area being in a typical arid Kenyan area which is characterized by seasonal rivers and watering ponds and, an almost non-existent piped water connection. Gülzari *et al.* (2020) note that the quality of water is vital for ensuring that milking containers are kept clean hence it is important to use clean water for such purposes to avoid contamination of the milking containers (Amenu *et al.*, 2016).

Table 4.12: Milk handling attributes of smallholder farmers (n=120)

Description of variables	Frequency	Percentage
Hand washing when milking		
Yes	30	25
No	90	75
Water source for household use		
River water	26	21
Pond water	31	26
Deep well water	45	37
Tap water	19	16
Washing of milk containers		
Use of cold water	102	84
Smoking the container	18	16

Description of variables	Frequency	Percentage
Use detergents or soap to wash milk Containers		
Yes	28	77
No	92	23
Udder cleaning		
Washed using clean water	26	21
Washed using warm water	94	79
Use of towel to clean udder		
Yes	103	86
No	17	14
Type of milking containers		
Aluminium	40	33
Plastic	80	67

The findings of the study showed that the predominant milk container cleaning practices were by use of cold water and smoking the containers. Farmers who used detergents or soap to wash the containers, accounts for 77%, which indicates good milk equipment handling knowledge and practices. Most of the farmers (79%) practiced udder cleaning using warm water and cleaning the udder using a towel before milking. However, most of the farmers (67%) used plastic milk containers, which is worrying as only a few of them are food-grade approved. This is a risk factor for milk post-harvest losses due to microbial contamination (Kashongwe *et al.*, 2017a ; Wairimu *et al.*, 2020).

4.3.8 Level of Farm Level Milk Losses Experienced by Smallholder Farmers

The current section presents the findings related to farm level milk losses of the smallholder farmers. The findings in figure 4.1 indicates that most of the farmers (82%) had experienced losses in their farms.

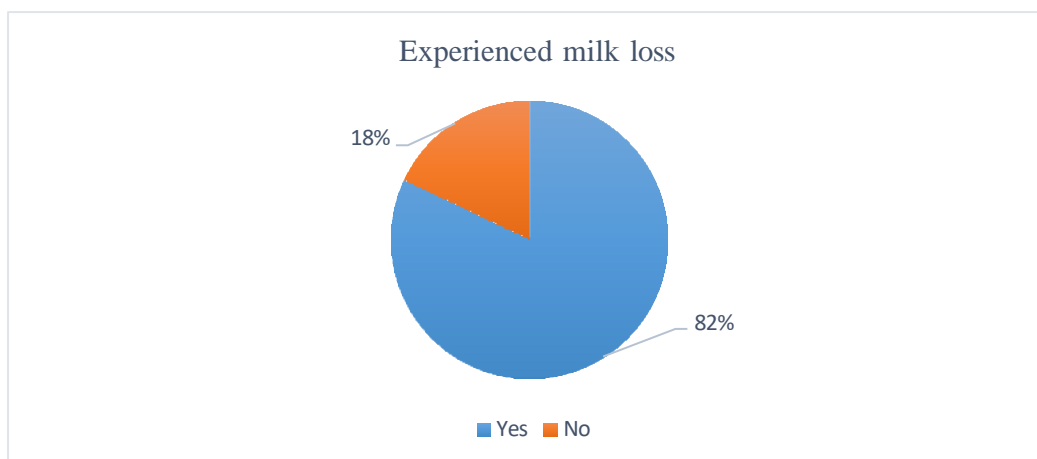


Figure 4.1: Level of farm level milk losses experienced by smallholder farmers

With regards to the types of milk losses, the most frequent types of milk losses were calf consumption (30.56%), spillage (26.85%), spoilage (16.67%), non-collection of milk (13.89%), contamination (8.33%), and discarded (3.70%) as depicted in table 4.13.

Table 4. 13: Types of milk losses on farms of smallholder farmers (n=120)

Type of milk losses	Frequency	Percentage
Spillage	32	26.85
Excessive consumption by calves	37	30.56
Non-collection of milk	17	13.89
Spoilage	20	16.67
Contamination	10	8.33
Milk thrown away due to diseased cow	4	3.70

The findings from the study shows that high losses are witnessed through excessive consumption by calves (37%) with milk spillage 26%. Spoilage 20%, Non-collection of milk due quality test failure (17%), contamination (10%), milk thrown away due to diseased cows (4%) are also other milk losses avenues. In order to find sustainable techniques in milk handling to lower losses, it is advisable to promote participation among many stakeholders (Sumner *et al.*, 2018). Given limited knowledge regarding good dairy practices by farmers and stakeholders who work directly with the dairy industry and with dairy smallholder farmers, farmers were experiencing high farm-level milk losses.

4.3.9 Findings from Focus Group Discussions on Farm-level Milk Losses

Three focus group discussions one per ward were conducted during the study period. The

participants drawn from Mogotio, kisanan and Emining were divided into ten member groups and guided into discussion on farm-level milk losses. Response of farmers on main source of milk loss reveal that five of the participants in focus group discussion one indicated that use of calves that may suckling excess during milking may be the cause of milk loss. Other farmers also reported that irregular milking periods due to free range grazing system and long-distance watering points, which are always crowded has contributed to milk loss. A farmer in focus group 4 reported that.

“Contamination of milk by saliva due to suckling calves may be the cause rejection in milk collection centres”

Milk can get spoiled as a result of bacterial infections in calves. If a calf is infected with bacteria, these pathogens can potentially be transmitted to the milk through poor hygiene practices, such as inadequate cleaning of milking equipment or contamination during handling. This implies that milk should be handled carefully after milking in order to prevent milk losses during delivery. According to EFSA Panel on Animal Health and Animal Welfare *et al.* (2023), one of the recommended and indicated interventions is the prompt weaning of calves between the ages of 4 and 12 weeks. Another suggestion from this focus group member is consistent milking time, which allows farmers to monitor visual indicators of mastitis, which can damage teat ends.

Farmers in this group also disclosed that the main source of milk loss is spillage during milking because of aggressive calves as depicted in Figure 4.2. From the group, most of the members attested that before milking, during milking and after milking aggressive calves are associated with disturbances and this contributes to milk spillage. Also, strategies to reduce milk spillage were considered to be important because they aided in minimizing possible risks of udder diseases.

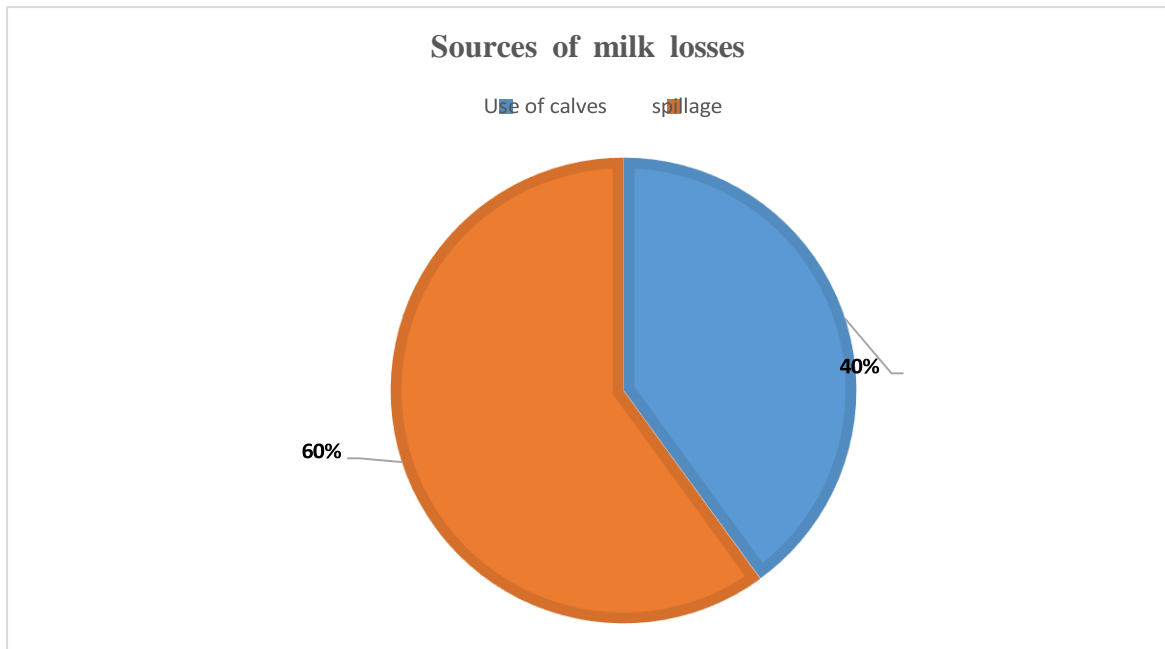


Figure 4.1: Sources of milk losses (n=120)

Farmers who participated in focus group discussion 7 revealed the main reasons for milk losses that were identified. The FGD participants revealed that use of calves that suckle excess during milking is among the main sources of milk loss. Farmers in this focus group discussion have carefully restricted calf suckling and calf milk feeding as they revealed that use of calves that suckle excess during milking is unprofitable. One farmer from focus group 7 reported that:

“Calves drink 5-7 litres of milk each day while they are young, which lowers the amount of milk anticipated.” (Dairy farmer).

Farmers who participated in focus group discussion 5 confirmed that other sources of milk losses at the farm level included poor handling and storage practices, equipment failures, and health issues in cows like mastitis. The FGDs also revealed that inadequate nutrition and contamination from unsanitary conditions or dirty equipment can also affect milk quality and yield. Additionally, environmental factors such as extreme weather and unpredicted weather lead to operational inefficiencies. Inadequate training or poor management practices, can also contribute to milk wastage. Addressing these challenges involves maintaining equipment, ensuring proper hygiene, providing balanced nutrition, and implementing effective management and training protocols to minimize losses and ensure high-quality milk production (Zelmar *et al.*, 2025).

4.3.10 Focus Group Discussion and Dairy Advisory at IP Intervention in Mogotio Sub-County

The focus group discussions (FGDs) focused on initiatives to address the problem of milk losses among Mogotio Sub-county smallholder dairy producers. The results in Figure 4.3 show that the common interest group training approach targeted areas such as feed formulation, pasture development, and feed storage as part of these interventions leaving out the milk losses area that is critical for milk production at farm level. Participants, 20% at focus group discussion stated that they were able to manage feeding concerns by switching from grass forage to farm feed formulation. Focus group discussion training has helped 40% of participants enhance cattle output, illness reduction, and resistance to climatic shocks through breeding management. FGDs training has also benefited in disease surveillance by identifying new and current diseases. Improving cattle disease control has evolved into a viable tool for allowing animals to adapt to climate change.

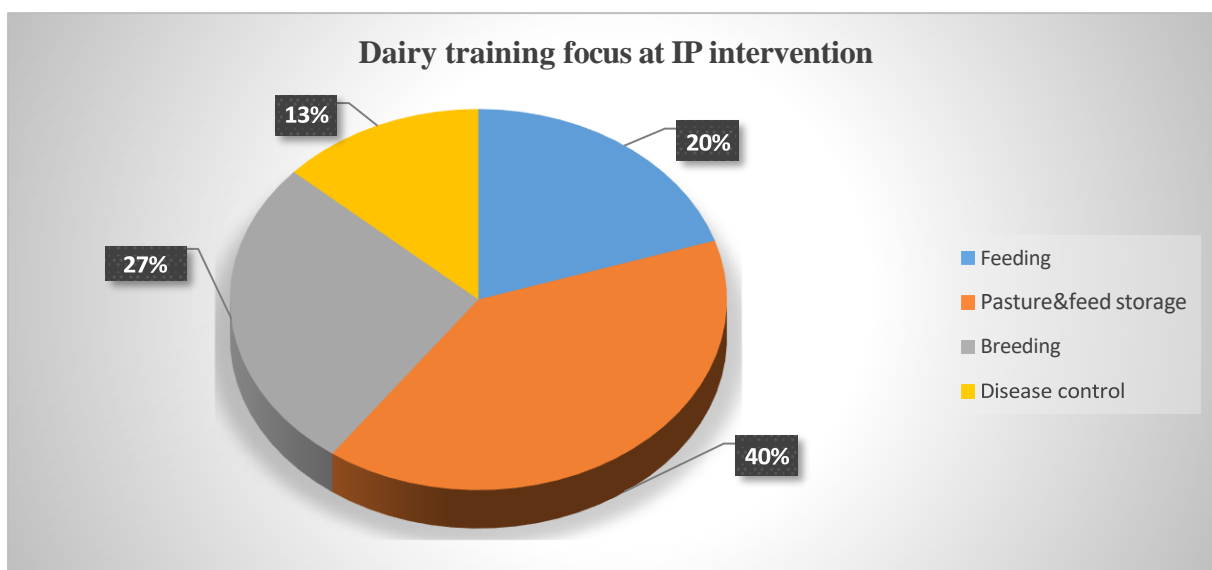


Figure 4.2: Dairy training at innovation platform intervention (n=120)

The focus group discussion highlighted that several initiatives are being made to promote the engagement of women and youth in decision-making on minimizing farm level milk losses at the beginning of the dairy value chain. Eleven members of the group stated that the use of ICT to foster participation improves the promotion of innovation platform interaction, with 14 indicating that involvement of women and adolescents will improve participation (Figure 4.4). By including women and youths in innovation platform activities and leadership, young people are enabled to take on important roles in development and gain critical skills for

reducing farm-level milk losses. Furthermore, five members indicated that higher profitability of agricultural operations is obtained through lowering production costs.

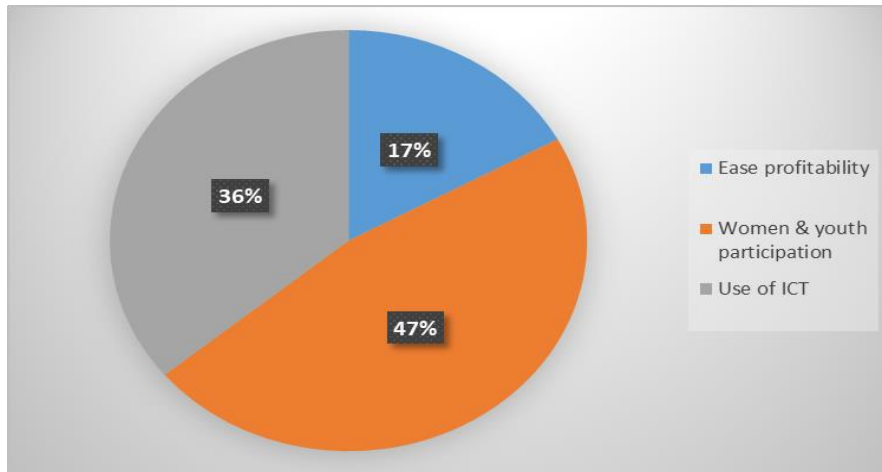


Figure 4.3: Promotion of participation (n=120)

4.4 Opportunities for the Utilization of Innovation Platform-based Programme to Build Capacity in Proper Milking Practices

The Mogotio innovation platform at the mogotio cooling plant aimed to target farm level milk losses for smallholder dairy farmers. The innovation platform included 120 farmers/stakeholders who met weekly for 8 weeks. The stakeholders included two staff from Kenya agriculture and livestock, five cooling plant staff, and three county government livestock staff. This was performed to collect data for the second objective and to interactively tackle the problem of farm level milk losses. The second objective of the study was to investigate possibilities to conduct innovation platform based capacity building on good milking practices for smallholder dairy farmers in Mogotio sub- county.

4.4.1 Nutritional Management Technologies

Innovation platform-based programmes offer significant opportunities to enhance dairy management practices by facilitating the integration of cutting-edge technologies and knowledge-sharing among farmers. This section highlights the dairy management practices used by farmers and opportunities integrated to reduce farm level milk losses among smallholder dairy farmers. Table 4.14 presents the results of the nutritional management

practices. The results showed that 79% of the farmers only provided grass to their livestock as feed. This highlights poor nutritional practices that can affect milk production and livestock performance. Additionally, 71% of the farmers practiced free suckling methods, which can reduce milk yield. However, 58% of the farmers practiced feed conservation, with 58% of them preserving maize stover hay.

Table 4.14: Smallholder farmer’s nutritional management practices (n=120)

Description of variables	N	Percentage
Type of feeds given		
Grass only	94	79
Grass and other fodder	19	16
Grass, fodder and concentrates	7	5
Calf-feeding methods		
Controlled	32	27
Free suckling	86	71
Bottle/bucket feeding	2	2
Fodder conservation method		
None	42	36
Maize Stover hay	70	58
Grass hay silage	8	6

Enhancing the diets of dairy cows, particularly nursing cows, has the potential to significantly enhance human nutrition and lessen the consequences of poverty by increasing milk sales. Regarding environment management, especially the milking, feeding and resting area, the study found out that the dairy farms environmental management was poor, with 95% of the farmers not having milking parlours. Additionally, 85% of farmers were using poorly maintained traditional structures (Table 4.15), this necessitated the platform to enhance knowledge on improved feeding use of milking parlours to reduce milk spillage. About 80% of those with designated parlors exercised good cleanliness, while 65% of their resting yards were crowded. Despite the overpopulation, slurry collection from these yards was mostly done weekly (80%).

Table 4.15: Milking area management by smallholder farmers (n=120)

Description of variables	Frequency	Percentage
Type of housing for dairy cattle		
Traditional	102	85
Semi-permanent	12	10
Permanent	6	5
Milking parlour		
Yes	6	5
No	114	95
Milking parlour cleaning		
Cleaned daily	96	80
Cleaned weekly	18	15
Cleaned fortnightly	6	5
Size of animals' resting yard		
Congested	78	65
Not much congested	24	25
Spacious	12	10
Frequency of slurry removal in the yard		
Weekly	96	80
Daily	24	20

With regards to reproduction management (Table 4.16), most farmers (63%) used any bull service breeding strategy. This strategy has disadvantages as it exposes progeny to susceptibility to diseases, pests and poor performance due to inferior genes. This is more so because the bull selection for breeding is mostly done (76%) without any criteria.

Table 4.16: Opportunities to improve breeding strategies by smallholder dairy farmers (n=120)

Description of variables	Frequency	Percentage
Breeding strategies		
Any bull service	75	63
Serving with upgraded bull	27	22
AI	18	15
Bull selection		
No selection done	91	76
Done based on observation	22	19
Done using bull catalogue	7	5

Poor quality dairy cow breeds among smallholder dairy farmers in Mogotio Sub-County may be due the low heritability estimates and the difficulties of finding readily measurable phenotypic characteristics or genetic markers that correspond with relevant qualities making it challenging for breeding programs to incorporate reproductive variables (Höglund *et al.*, 2016). This is consistent with earlier work in European breeding programmes which show that the heritability of growth and carcass characteristics runs from 0.25 to 0.5. The "Genotype plus Environment" (GplusE) initiative, which is supported by the EU, attempts to find novel milk-based phenotypes for breeding programs, perhaps predicting conventional features like conception rates and uterine health. This could enhance breeding practices and enhance the welfare of animals (Atashi *et al.*, 2020).

4.4.2. Opportunities to Improve access to Advisory Services through Innovation Platform

Access to dairy advisory services helps smallholder farmers adopt novel information and technologies. In accordance with these findings, 62% of farmers benefited from dairy advisory services through the innovation platform-based capacity building programme. The specific advisory services included animal husbandry practices, animal health management (disease prevention and treatment), nutrition advice, farm management (financial planning, record-keeping systems), and sustainability practices (waste management, environmental impact reduction).

This concurs with earlier work by Ogutu *et al.* (2014), Hildebrandt *et al.* (2020), and Bonina

et al. (2021), in that advisory services affect agricultural production practices, since they provide critical flows of information that can improve farmers' and other rural peoples' welfare. Table 4.17 shows how innovation platforms enhance access to dairy advisory service.

In terms of the source of information received by dairy farmers, the results in Table 4.17 show that the majority 102(94.4%) of respondents get their information on milking techniques from the ministry of agriculture, while 3(2.5%) and 3(2.5%) get their information from other government of Kenya organizations and the media. Only one (1.3%) respondent learns milking techniques from social media.

Table 4.17: Sources of information opportunities on proper milking techniques before innovation platform- based programme (n=120)

Source of information on proper milking technique	N	Percentage
Ministry of Agriculture	114	94.3
Other GOK organizations	2	1.9
Media	2	1.9
Other farmers	2	1.9
Total	120	100

These findings agree with Maulu *et al.* (2021), in most developing countries, extension services are typically offered by the government because they play a crucial role in promoting agricultural productivity, improving livelihoods, and fostering sustainable development. Governments often have the infrastructure, resources, and mandate to reach rural communities and provide essential knowledge and technical support to farmers and small-scale producers.

Table 4.18: Means value for Level of knowledge on milking techniques before training (n=120)

Level of knowledge technologies	Very low %	Low %	Moderate %	High %	Very high %	Mean	Std. Dev
Restricted suckling	2.8	11.1	41.7	34.3	10.2	3.38	0.914
Free suckling	5.6	7.4	45.4	35.2	6.5	3.30	0.910
Non-suckling	2.8	9.3	35.2	30.6	22.2	3.60	1.023

The results in Table 4.18 reveal that the mean level of knowledge for restricted suckling had increased to 4.14, while that of free suckling and non-suckling had increased to 4.36 and 4.04, respectively.

Smallholder dairy farmers need more technical guidance in production system management (as compared to their large and medium scale counterparts). For producers with adequate and proper structures and equipment's of dairy production, continuous improvement investments are suggested in the three factors analyzed in this work - nutritional, technical, and milking. Such actions may maintain or increase the production and lower farm-level losses in these dairy systems (Blanco-Penedo *et al.*, 2019).

4.4.3 Opportunities in Maintaining the Mogotio Innovation Platform

Mogotio innovation platform attracted county government extension staff who participated in the platform. The extension staff were able to interact with farmer and stakeholder making the platform an efficient way of reaching more farmers. The youth members of the platform were also showed alot of interest in the use of information technology during interactive learning. The study recorded several opportunities of maintaining Mogotio innovation platform during the interactive sessions as depicted in Figure 4.5.

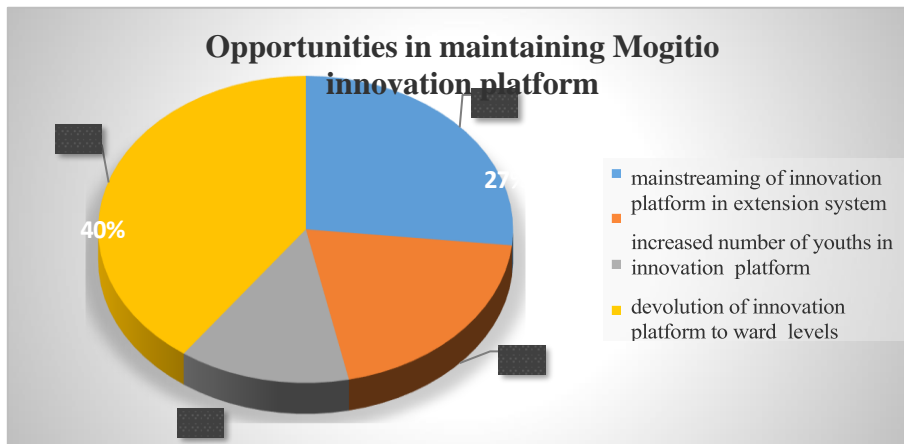


Figure 4.5: Opportunities in maintaining the Mogotio innovation platform (n=120)

Majority of the respondents (40%) recorded constant monitoring and evaluation of innovation platforms as an opportunity for maintaining Mogotio innovation platform. Other opportunities include mainstreaming of innovation platform in extension system (27%), increased number of youths in innovation platform (20%), and devolution of innovation platform to ward levels (13%). Dairy innovation platform creates a more integrated, dynamic, and accessible system for delivering extension services to dairy farmers. It empowers farmers with knowledge, connects them with the resources and experts they need, and creates a supportive ecosystem for innovation and sustainable dairy farming (Bonina *et al.*, 2021). Mogotio innovation platform also played a pivotal role in mainstreaming youth involvement in agriculture by providing them with access to cutting-edge technologies, training, and market opportunities in the dairy sector (Babu *et al.*, 2021).

4.4.4 Attendance of Trainings on Reduction of Farm Level Milk Losses

According to the study findings after training as shown in Figure 4.6, 102 (94.9%) of respondents agreed that they had attended training related to farm-level milk losses, whereas 6 (5.1%) reported that they had skip some of the trainings. Knowledge transfer is critical for achieving the required innovative technologies. Gülzari *et al.* (2020) and Karzis *et al.* (2018) say that continuous information transmission on dairy farming is critical for dairy producers because it is the first step in dairy control of losses through diseases like mastitis. They also stated that by teaching farmers, cow screening for various diseases can be easily carried out, diseases can be easily diagnosed, and farmers may employ the separation method to prevent cows from infecting each other, particularly during milking.

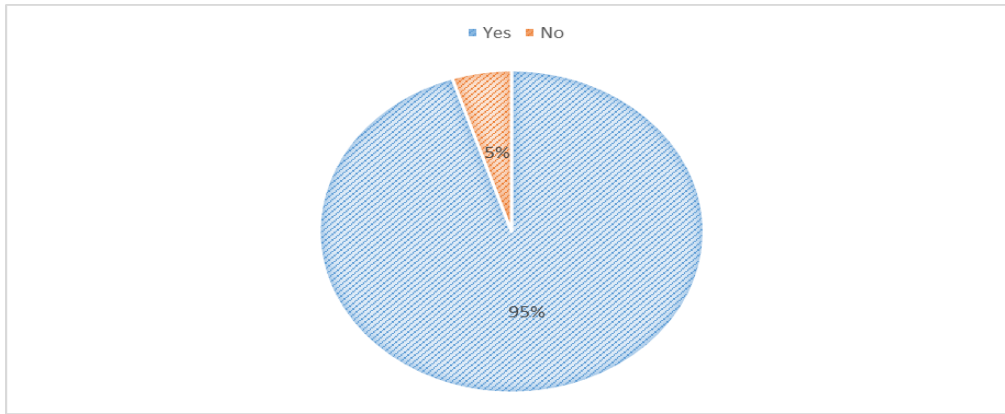


Figure 4.6: Attendance of training on reduction of farm-level milk losses (n=120)

Farmers reported that they received training on early weaning and proper milking techniques strategies to prevent milk losses from excessive consumption by overage calves. The interactive training also equips farmers in control of spoilage and spillage. The restricted milking system allows calves to suckle their dams for a limited time after milking and causes residual milk in the cows' udders, which is not good for udder health. Restricted suckling enhances calf growth rate but decreases milk yield and saleable milk of the cow while reducing mastitis incidence and having little or no detrimental effect on reproduction. Early weaning offers the additional benefit of promoting the cow's milk supply, perhaps increasing the overall amount of milk produced by the cow. Farmers were educated on the benefits of early weaning, such as reduced labor requirements, capital investment, and calf mortality.

Farmers were also trained on early weaning practices by the innovation platform. Early weaning aims to manage breeding herds proactively during periods of feed scarcity or drought, which the majority of farmers in Mogotio encounter. This approach tries to prevent milk losses, particularly among dairy calves, which are increasingly being fed with a lot of milk. Figure 4.7 shows that the majority of farmers (82%) practised early weaning, with only 18% not doing so, which may be linked to the knowledge they got through the innovation platform.

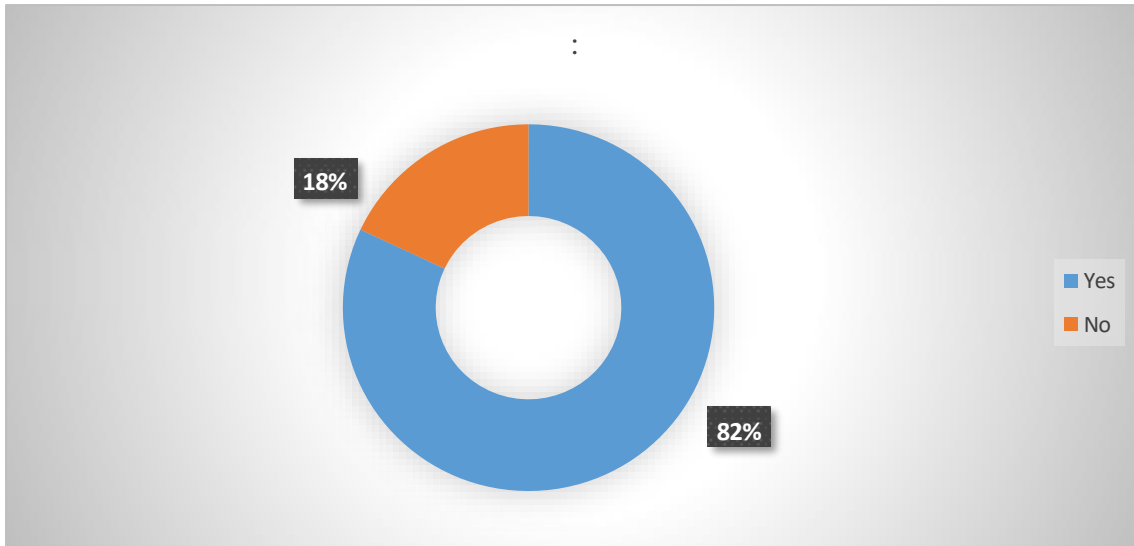


Figure 4.7: Calves early weaning Practice (n=120)

In order to increase the influence of agricultural research beyond its original development, innovation platforms (IPs) have been recommended (Schut *et al.*, 2019). They seek to bring together important stakeholders in order to create scale effects, but this hasn't gained much traction yet (Davies *et al.*, 2018). The existing body of literature emphasizes capacity building for dairy practice improvement before evaluating innovative processes, as this study finding show. According to Hounkonnou *et al.* (2018), IPs foster an atmosphere that makes innovations like new technology, processes, and business models more likely to be adopted.

4.4.6 Training Mode and Training Aids Used Mogotio in the Innovation Platform

Training module and training aids are crucial in a capacity-building innovation platform. This is because they enhance the effectiveness and efficiency of the interactive learning process. They help reinforce learning, facilitate practical application, and ensure that participants can retain and apply new knowledge effectively. Together, they play a key role in developing competencies, fostering innovation, and achieving the platform's capacity-building goals.

The findings show the farmers responses on the training modes and training aids utilized in the innovation platform (Table 4.19). Farmers' responses on training modalities and training aids indicated that Common Interest Group (CIG) training was led by extension officers under the Kenya Climate-Smart Agriculture Project (KCSAP) programmes. One of the farmers in focused group discussion noted,

“We are trained at common interest groups in many instances and facilitated by extension officers through the current KCSAP programme to improve our dairy farming activities. The focus on increasing production is through breeding, feeding and establishment of pastures. Breeding encourages dairy farmers breed animals that are resilient to climate stress and are more resistant to diseases” (Mogotio dairy farmer).

Table 4.7: Training modes preference assessment after the innovation platform capacity programme (n=120)

Training	N	Percentage
Module guided	40	33.3
Interactive learning	56	46.7
Community-Driven Development Committee (CDDC)	24	20.0
Total	120	100.0

The findings reveal that 33.3% of respondents reported that the innovation platform-based capacity-building programme provided module-guided training sessions. This shows that training and training aid has helped to promote production among farmers, with farmers improving on pasture establishment and training to improve on productivity. Dairy production has also benefited from breeding as animals become more resistant to climatic stress and disease. Common interest group (CIG) approach of members only training is limiting as other community members to benefit from information and new technologies. Only members of specific common interest group (CIG) are capacity built, posing a setback on non-members.

Interactive learning was found beneficial by 46.7% of respondents for sharing information and productivity improvement. Farmers who participated in the study also reported that multi-stakeholder’s involvement is a key aspect. One of the farmers in focus group 2 reported that:

“Technical service providers and platform facilitators address issues on diverse areas, including farm level milk losses, irrigation, energy use, nutrient management and organic agriculture. They provide planning services on milk production, conservation, design, implement and monitor activities.” (Mogotio dairy farmer).

Farms also stated that, despite the efforts of technical service providers to assist farms, there remain natural resource concerns. Most farms benefit from services such as conservation planning, conservation practice, and conservation implementation. Management and conservation are used to handle natural resource issues for farmers. Based on the findings of the focus group research 6 (20%) of those surveyed stated that a community-driven development committee improves agricultural enterprise growth. Study findings from interviews showed that Enterprise capacity building are only those identified by development committee during application of funds. Farmers in focus group 3 reported that.

“Farm enterprises are only those that are predetermined by the community driven development committee” (CDDC).

Farmers contributed that interactive capacity buildings help in capacity building needs, development of farming projects and programmes delivery on good farming practices.

4.5 Influence of Innovation Platform-based Capacity Building Programme on Farm Level Milk Losses

The third objective of the study was to determine the influence of an innovation platform-based capacity building programme on farm level milk losses among smallholder dairy farmers in Mogotio sub- County. The results are presented in the following sub-sections:

4.5.1 Influence of the Dairy Innovation Platform-based Capacity Building on Milking Techniques

The influence was determined by the data that was obtained through the endline survey. Table 4.20 presents the level of knowledge of farmers with regard to milking techniques obtained from the survey done, after the capacity building. The results show how the innovation platform- based capacity building influences the mean level of knowledge on milking techniques with a mean of 3.38, free suckling 3.30 and non-suckling 3.60.

Table 4.20: Mean values for level of knowledge of milking techniques after training (n=120)

Level of knowledge technologies	of Very low %	Low %	Moderate %	High %	Very high %	Mean	Std. Dev
Restricted suckling	0.0	5.6	7.4	54.6	32.4	4.14	0.779
Free suckling	0.0	0.0	6.5	50.9	42.6	4.36	0.603
Non-suckling	0.0	2.8	12.0	63.9	21.3	4.04	0.669

Table 4.21: One-way ANOVA for the differences in mean milk values across the milking methods (n=120)

Milking method	Milk Mean		
	(Litres)	N	F
Restricted	0.75309	120	1.323
Free suckling	0.5390	120	
Non-Suckling	0.6670	120	

** significant at $p \leq 0.05$

According to Nimbalkar *et al.* (2021), capacity building on milking techniques through a dairy innovation platform contributes significantly to adoption of improved dairy practices. By providing farmers with access to up-to-date knowledge and training on best practices in milking, the platform can enhance adoption of better milking techniques that by extension can be help achieve superior milk quality, increase yields, and reduce the risk of diseases such as mastitis.

4.5.2 Influence of Innovation Platform-based Capacity Building on use of Home-made Milking Structures

Training dairy farmers on appropriate milking structures was one of innovation platform-based capacity building activity to lower on the farm-level milk losses among smallholder dairy farmers in Mogotio sub-county as presented in Table 4.22 presents the findings.

Table 4.22: Use of home-made milking structures (n=120)

Milking structures	N	Percentage
Parallel	25	20.8
None	23	19.8
Abreast	44	36.5
Circular	28	22.9
Total	120	100

Study findings in Table 4.22 showed that majority (36.5%) of the farmers used Abreast milking structures while (22.9%) of the farmers used circular method. However, (20.8%) of the participants used parallel and 19.8% used walk-around/none milking approach. This shows a remarkable number of smallholder farmers adopting the use of milking structures so as to control spillage from unrestrained cow.

4.5.3 Influence of Innovation Platform-based Capacity on Daily Milk Yields

The study sought to determine the influence of innovation platform-based capacity building programme on farm level milk losses. The number of farmers and amount of milk in litres were as recorded in Table 4.23.

Table 4.23: Amount of milk realized after implementation of innovation platform-based capacity building programme (n=120)

Milk in litres	Frequency	Percentage
1-5	13	10.4
6-10	36	30.2
11-20	24	20.8
21-25	18	14.6
26-30	29	24.0
Total	120	100.0

The study found that 30.2% of farmers experienced a positive shift in milk production after

participating in the IP-based capacity building innovation platform. However, 24.0% of farmers reported no change in production. 20.8% of farmers milked 11-20 liters daily, while 10.4% milked 1-5 liters daily. 14.6% of farmers milked 21-25 liters daily, showing no change in production. This shows a positive shift in milk production after attending the interactive innovation platform engagements. After the implementation of innovation platform-based capacity building programmes on farm level milk losses among smallholder dairy farmers, farmers were found to have gained interest on these programmes.

Innovation platform-based capacity-building programme can be integrated with extension systems for better support of agricultural growth. This way, it can improve local collaboration and knowledge exchange among farmers, researchers, and extension workers, and it increases the number of youth in the platform, which contends with the earlier work by Wenner *et al.* (2018). Shifting innovation authority to people at the ward level expands the opportunity for farmers to exert influence (Stringer *et al.*, 2020). Innovation is seen as an effective technique for improving the development of agriculture (Ashraf *et al.*, 2021).

These findings are supported by earlier research by Arinloye *et al.* (2015), Mbile *et al.* (2015) and Wenner *et al.* (2018) which shows that a similarly powerful driving force is needed for innovation platforms to be properly maintained and managed. Non-governmental organizations, development agencies, governments, private companies, and local communities' interest in participating in the platforms were mentioned as driving forces in the global preservation of innovation platforms. In addition to the studies mentioned above, Breuer *et al.* (2018) show that non-governmental organizations have been at the forefront of supporting the push for the sustainability of innovation platforms at the county level with the support of the public sector.

According to Kilelu *et al.* (2013) who also concur with the findings, well-maintained innovation platforms give smallholder dairy farmers options. These options include providing dairy farmers extension services, learning through countless interactions, and conflict resolution at different actor interfaces throughout the dairy value chain. Other findings by Bonina *et al.* (2021) and Moitra *et al.* (2018) have also linked access to appropriate information and market access to innovation platform membership.

These findings are consistent with those of Chilundo *et al.* (2020), who found that farmers who were members of agricultural innovation platforms increased their production yields

using innovative technologies and trainings compared to those who were not. Moreover, Totin *et al.* (2020) also found out that agricultural innovation platforms have continuously presented several opportunities to dairy farmers by scaling up their production yields. Farmers' knowledge of milking techniques before and after capacity building through the IP in the innovation platform-based capacity development were compared using the paired samples t-test.

According to the findings in Table 4.24, there was a significant difference in dairy milking technique before and after the dairy advisory service scores ($t_{107} = 8.519$, $p = 0.001$). On average, milking techniques knowledge scores after the training were 0.75 points higher than before the training scores (95% CI [0.58, 0.93]). This indicates farmers had increased their knowledge on reducing of milk losses by adopting the appropriate milking techniques.

Table 4.24: Chi-square results for the milk yield after farmers acquire knowledge on milking techniques (n=120)

Milking season (Months)	Milk			F	
	Mean (Litres)	N			
1	4.1790	120	0.4612	0.04438**	
2	3.4259	120			

The difference in dairy milking technique before and after implementation of the innovation platform indicate that the platform shaped the milking process in addressing the weaknesses which had been causing milk losses of smallholder dairy farming and contributed to outcomes in relation to access to services and inputs and improved productivity.

Table 4.25: Accessibility of dairy advisory services through innovation platform capacity building (n=120)

Access to dairy advisory service	Frequency	Percentage
Yes	74	62
No	46	38
Total	120	100

The findings on how innovation platform enhance access to dairy advisory service in Mogotio Sub-County, align with Knierim *et al.*'s (2015) work, suggesting that despite past fears of reducing numbers of extension officers due to privatization of public extension services, there is still hope. This observation 74 (62%) highlights the importance of addressing the concerns surrounding the future of extension science.

After the introduction of innovation platform-based capacity building programme, there were a number of farmers who requested to be enlisted in the innovation. The findings on the gender distribution of the farmers who were enlisted in the innovation platform is presented in Table 4.26.

Table 4.26: Gender distribution of farmers requesting enlisting on the innovation platform-based programme

Number of farmers	N	Percentage
Male	64	53.5
Female	56	46.5
Total	120	100

The study shows an encouraging almost equal male to female ratio, the male farmers (53.5%) and female farmers (46.5%) who requested to be enrolled in innovation platforms through their peers (Table 4.26). This is due to an increased interest among platform users in obtaining knowledge on the new technologies made accessible, as well as witnessing the knowledge gained, advantages obtained, and better production yields. Chilundo *et al.* (2020) discovered that most farmers are only interested in joining agricultural innovation platforms after witnessing the milk yield results of those who have already joined the platforms, which is the only way they are persuaded that the platforms are worthwhile investments.

Farmers who are engaged in novel activities as an alternative to the intense dairy farming model often share their experiences with their peers. Lave and Wenger (1991) first

envisioned peer-to-peer learning, and Wenger expanded on this idea in Communities of Practice (CoPs). A CoP is an unofficial learning community that has grown through time and is distinguished by its members' shared practice, voluntary participation, and common repertory of communal resources (routines, norms, artefacts, terminology, styles).

Communities of practice such as the innovation platform are crucial for social learning systems, according to Wenger and Snyder (2000) since they serve as "social containers of competencies". With a few notable exceptions, CoPs' significance in the innovation of the dairy industry has received little attention despite having been explored in organizations and showing promise for organizational growth (Morgan, 2011; Madsen & Noe, 2012).

According to research on knowledge commons in the context of a dairy farming community, agricultural information is frequently handed down through the generations (Galang & Vaughter, 2020). The fact that farmers learn via trial and error, experimentation, formal and informal training, and networking is also acknowledged (Dolinska & d'Aquino, 2016). Farmers use their expertise and the limited local resources available to them in innovative ways to accomplish sustainable agriculture (Altieri & Nicholls, 2017). Through the management and innovative use of knowledge enabled by this strategy, their agricultural methods are sustained.

4.5.4 Challenges Addressed by Mogotio Innovation Platform

The innovation platform identified the challenges of long distances, lack of mainstreaming and low network coverage as the main challenges at the innovation platform. The use of innovation platform-based capacity building programme addressed several challenges. This study interactively addressed the challenges by devolving the platform interaction to wards where farmers were getting advisory services from the county government staff wards, collectively working with the county government staff to mainstream the innovation platform approach and lobbying for network transmitter to be installed in low network area which was successfully achieved. The results are summarized in Figure 4.8. Thirteen percent (13%) of respondents noted that interacting with the Mogotio innovation platform solve the inadequate internet access by attending the interactive sessions at the platform and sharing information through networking with other farmers. This had an impact on productivity since this enable farmers to work at their own speed and the time gained has an influence on the growth and outcomes of agricultural operations in their farms.

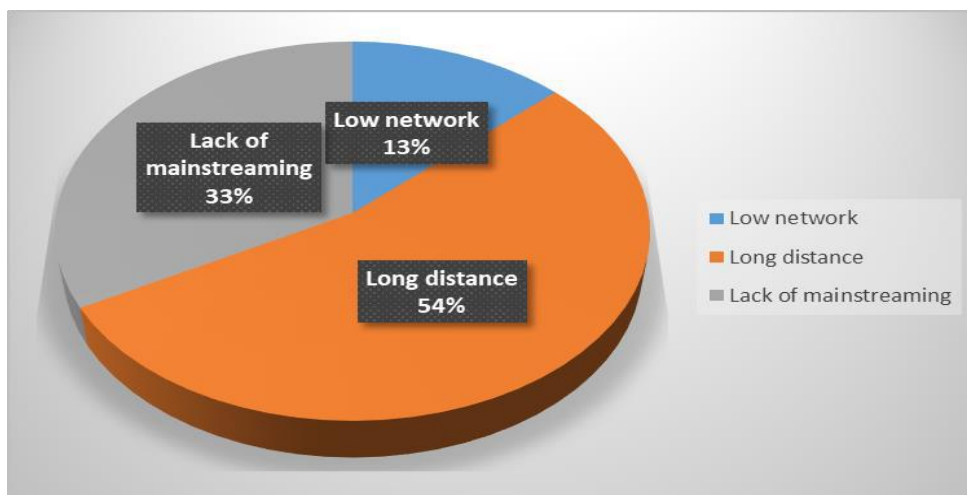


Figure 4.4: Challenges addressed by Mogotio innovation platform (n=120)

About 54% of farmers at the baseline survey respondents indicated that one of the obstacles was the considerable distance between county wards. This was solved by placing the platform centrally and using the participants to purposefully interact with their peers. According to Chelang’a (2024), long distance between wards has an influence on cattle, farmers, and dairy products markets. It affects movement of cattle in search of pasture and when cattle move for a long-distance causes stress to cattle and reducing the amount of time available for farm activities (Mwanyumba, 2014). Stress has a declining effect on quality of dairy products posing serious economic issues to farmers (Hernández-Castellano *et al.*, 2019). Long distance also affects delivery of dairy products and animal feeds and to some extent milk delayed on delivery spoil (Chelang’a, 2024). Findings reveal 33% of the farmers indicated that the inadequate mainstreaming of innovation platform activities in the county extension system, directly influence dairy farming activities.

Responses of farmers from the focused group discussions revealed that there were challenges of low internet connectivity. The participants in the focus groups noted low networking having contributed to lack of information, security concerns and low adoption of new farming techniques. The innovation platform helps to reduce the variability as there was the use of interactive learning and information sharing at Innovation Platform.

Farmers from focus group 6 reported that:

“We are concerned about the distance covered during trainings.”

Farmers who participated in the discussion also reported that long distance between the wards in the sub-county is also a challenge. One of the opportunities revealed by the participants is that increased number of youths in innovation platform. Increased number of youths in innovations increases innovation platforms in terms of employment, improve security and generation of income. This helps to drive away poverty through increased productivity and connections to other sectors. The rolling of the innovation platform to ward levels helped to promote a conducive environment for problem solving at different levels.

One of the potential challenges in maintaining Mogotio innovation platform that was cited included low participation of women and youth. However, responses by farmers from focused group discussions revealed that there are strategies that can be taken to increase participation of youths and women in decision making on how to reduce farm milk losses. This implied that women and youth can provide the best solutions to reduce milk loss levels. One participant from focus group 6 said that;

“In our community, women are vital in rural economies and are considered as the main custodians of knowledge on dairy farming and are also responsible for food production but lack mainstreaming.” (Mogotio dairy farmer)

The study found that innovation platform is interactive, flexible thus giving equal opportunities all. Women and youth were given an opportunity to be responsible for designing and implementing new technologies at the Mogotio dairy innovation platform. The best way to involve the young women and youths was by discussing the easiest way to reducing the cost of production so as to increase profit of agricultural enterprises.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

The study was carried out in Mogotio sub-county, Baringo County, and the purpose was to assess the status of farm-level milk losses, opportunities of maintaining innovation-based capacity building, and assess the influence of innovation-based capacity building among smallholder farmers. Findings indicate that the most prevalent techniques for cleaning milk containers were cold water, smoking, and the use of detergents or soap. Udder cleaning was done with warm water and a towel. Dairy producers utilized plastic milk containers, which increased the possibility of microbial infection, leading to post-harvest losses.

Opportunities for the utilization of an innovation platform-based programme to build capacity in proper milking practices among smallholder dairy farmers existed. Initially, improper milking practices, such as limited suckling, late weaning, and concurrent milking and suckling, exposed overage calves to 20% of the total milk, resulting in lower income and household living standards. Delayed weaning also contributed to farm-level milk losses, affecting dairy farmers' income. Suckling, a pre-milking palpation routine, hinders milk quality, quantity, and safety, causing post-harvest contamination and rejection by processors. Innovation platforms were utilized to address these issues interactively. The innovation platform provided dairy farmers access to innovative technologies for lowering milk losses, enhancing feeding systems, and expanding their product's market networks. The Mogotio platforms encourage owners of enterprises to zero in on milk by-products, enhance the health of animals and milking procedures, and underscore the value of learning in restrained suckling and calf feeding systems.

Milk losses are a significant economic challenge for smallholder dairy producers in Mogotio Sub-County, Kenya. The dairy farmers who joined the innovation platform experienced significant benefits from technological innovations in dairy farming through reduced milk losses. Other benefits included increased milk yields, continuous market demand, income, improved livelihoods, and improved dairy farming. Additionally, they were able to build market networks with stakeholders and gained knowledge through training and extension services.

Incorporating the innovation platform within the extension system was critical to enhancing dairy farming knowledge and information while also lowering farm-level milk losses

5.2 Conclusions

The study concludes that:

- i. Smallholder dairy farmers in Mogotio Sub-County experience significant farm-level milk losses. Most of them use traditional dairy farming practices, limited production records, suckling, and a preference to indigenous cattle over exotics. They also experience low milk yields, high contamination, and spoilage.
- ii. There are a plethora of opportunities for innovating platform-based programmes to enhance capacities in proper milking practices with smallholder dairy farmers in Mogotio Sub-County, Baringo County. Interactive Innovation platforms fostered improvement in animal health and milking practices for smallholder dairy farmers, thereby improving production as well as productivity with higher income. The platform was also associated with improving production and milk productivity. Most producers were able to invest in proper milk value addition processes and appropriate equipment, and enhanced interaction in the innovation platform provided.
- iii. The innovation platform-based capacity building programme positively influenced farm-level milk losses among smallholder dairy farmers in Mogotio sub-county. The innovation platform shaped the milk post-harvest handling in addressing the weaknesses which had been causing milk losses among smallholder dairy farmers. The innovation platform also complemented the conventional government extension system to address the ever-reducing agricultural extension staff. A positive shift from producing less than average milk production of 7 litres was attributed to the implementation of the innovation platform.

5.3 Recommendations

The following recommendations can be drawn from the study conclusions.

- i. The Ministry of Agriculture and Livestock Development and development agents

such as NGOs and farmer's organizations should sensitize smallholder dairy farmers on the dangers of dairy farming practices that contribute to milk loses and low yields. This sensitization can be implemented through innovation platform approach.

- ii. The Ministry of Agriculture and Livestock Development should adopt an innovative platform approach, namely the use of digital platforms for smallholder dairy farmers and milk value chain participants. The platform should supplement the current extension system for enhancing smallholder farmers' capacity to practice proper milking practices. The platform should be adopted and devolved to ward levels in order to address the challenges of on-farm milk losses among smallholder dairy farmers in Mogotio sub-county.
- iii. Financial support from the county and national government as an effort for upscaling of the platforms.

5.4 Suggestions for Further Research

Based on the findings, this study identified the following gaps for further research:

- i. To evaluate the influence of emerging dairy farming trends on the adoption of the innovation platforms approach.
- ii. To investigate the contribution of feedback mechanisms, collaborative learning, and dynamic management of the innovation platforms as a mainstream effort on the dairy industry.

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APPENDICES

Appendix A: Baseline Survey Questionnaire

Introductio

I am Siele Joseah a PhD Agricultural Education student in Egerton University, Njoro Campus conducting research. The study's goal is to find out how innovation platform-based learning for capacity building might help smallholder dairy farmers in Mogotio Sub-County reduce farm milk losses. I kindly request you to spare some time and fill in this questionnaire to assist me in conducting this research. Please answer all the items given in this questionnaire honestly and accurately as possible. The information will be treated as confidential. Please do not write your name on the questionnaire.

SECTION A: Socio-economic background

1. What is the sex of household head
 - 1) Male 0) Female
2. Age of Household head (Years) _____
3. Relationship to household head
 - 1) Self [] 2) Wife [] 3) Son [] 4) Daughter [] 5) Relative []
 - 6) Other (specify) _____
4. Education level _____
 - 1) None, 2) Primary, 3) Secondary, 4) Tertiary/University)
5. what is your experience in dairy farming (Years) _____
6. How many acres of land do you own and what acreage is used for dairy production?
Total acreage (Acres) _____
Area under dairy production (acres) _____
7. Which land tenure system do you use
 - 1) Owned with title deed [] 2) Owned without title deed [] 3) Rented []
8. Indicate your sources of household income and total earnings per year Source of income
 - 1) Livestock farming 2) Crop farming 3) Salary from employment
 - 4) Small scale business (Hawking, kiosk, hotel, shop, (specify)..... 5) Others
9. Which feeding system do you use in your farm
 - 1) Zero grazing, 2) Natural pasture and zero, 3-pasture only)

10. Do you keep dairy production records?

1) Yes 0) No

11. If yes to 10, which records do you keep?

1) Livestock register 2) Calving register 3) Daily milk yield register

4) Calf register 5) Growth record of young stock 6) Daily feeding

7) Herd health register 8) Cattle breeding register 9) Animal History sheet

10) Financial register

SECTION B: Milk production parameters in the farm B1. Dairy production

Ownership		Milk					
1. Stock of livestock owned in the last 12 months?	2. Type of livestock does this household currently own?	3. How many cows were milked in the last 12 months?	4. How many months on average, were the cows milked for?	5. What was the average milk production per day per cow during this period?	6. During this period, how many litres of liquid milk did you sell per day?	7. During this period, how much of the milk was consumed by your household each day either in the form of liquid milk?	8. Where did you sell most of the milk and processed dairy products?
1. Bulls= 2. Cows= 3. Steers= 4. Heifers=	1= Indigenous 2=Improved/ Exotic (Friesian	Numb er	Month s	Litres	Litres/d ay	Litres/day	1=Cooperati ve 2=Middlem en
5. Male calves= 6. Female calves=	Ayrshire Zebu Sahiwal (Crosses)						3=Retailers
CODES							

B2. Variable costs incurred (Labour, feeds and water)

9. a) Did you hire any labor to help you with the livestock in the past 12 months?

- 1) Yes 0) No

b) What was the total cost of this labor for livestock in the past 12 months?

KES.....

10. a) Did you purchase any feed / fodder for your livestock in the past 12 months?

- 1) Yes 0) No

b) How much has this household paid to feed the livestock in the past 12 months?

KES.....

11. a) Has this household ever paid to water in the livestock in the past 12 months?

- 1) Yes 0) No

b) How much has this household paid to access the main water sources for the livestock in the past 12 months **KES**.....

B3: Animal health services costs (vaccination, deworming, tick control and curative treatment)

12. Animal health services	13. Did you receive the following animal health service in the past 12 months? (Yes=1, No=0)	14. Who administered the animal health services? i) Private vet clinic ii) District vet clinic iii) Ngo/project iv) Other, specify.....	15. How much did you spend in total on vaccines, preventive measures, treatments and other veterinary costs in the last 12 months?
Vaccination			
Deworming			
Tick control			
Curative treatment			

SECTION C: Milk handling attributes of milk producers

C1. Do you wash your hands with soap and clean water before milking?

- 1) Yes 0) No

C2. 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)

C3. Washing of milk containers

- 1) use of cold water, 2) use of warm water, 3) No washing practice,
- 4) Smoking the containers)

C4. Do you use detergents or soap to wash your milk containers?

- 1) Yes 0) No

C5. Udder cleaning

- 1) washed using cold water 2) washed using warm water, 3) No washing

C6. If you clean your cow's udder do you use a towel to clean and dry cows' udder?

- 1) Yes 0) No

C7. Do you use a different towel for each cow milked?

- 1) Yes 0) No

C8. How do you preserve your milk?

- 1) cooling 2) boiling, 3) chemical preservation,
- 4) other) Briefly explain.....

Section D: Farm level milk losses related challenges

D1. Have you ever experienced milk losses?

- 1) Yes 0) No

D2. If yes, what are the losses have you experienced?

- i. Spillage
- ii. Forced consumption
- iii. Non-collection of milk
- iv. Spoilage
- v. Contamination
- vi. Milk thrown away due to diseased cow such as mastitis or effect of deworming drugs

D3. What type of milk containers, milking churn and milking items do you use?

- i. Aluminum
- ii. Plastic containers

1= Tarmac

0 = Murram

E4. What tactics have you used to manage with the selected milking technique?

Technique	Coping strategy
Ease of milking	
Time taken to complete milking	
calmness of dam	
Milk let-down time	
Calmness of calf	

E5. Apart from advisory services, which other services did you receive from the cooperative?

- i. Provision of cheap inputs/subsidized
- ii. Bulking of milk
- iii. Marketing of milk
- iv. Provision of credit

Section F: Integration of innovation platform dairy advisory

F1. Which is your main source of information on proper milking techniques?

- 1) Ministry of Agriculture []
- 2) Other GoK Organizations []
- 3) NGOs/CBOs []
- 4) Media []
- 5) Internet []
- 6) Other Farmers []

Others, specify _____

F2. Have you attended any training related to proper milking?

- 1) Yes
- 0) No

F3. If yes, who trained you? _____

F4. Which topics were you trained on? _____

F5. Please indicate the level of knowledge you have acquired on the listed milking techniques and adaptation.

Technology	Level of knowledge				
	1 very low	2 Low	3 moderate	4 high	5 very high
Restricted suckling					
Free suckling					
Non-suckling					

Section F: Dairy management practices

A. Nutritional management

Please tick the nutritional management practices that you use in your farm

F1. Type of feeds given

- i. Grass only
- ii. Grass and other fodder
- iii. Grass, fodder

and concentrates F2.

Calf-feeding methods

- i. Controlled
- ii. Free sucking
- iii. Bottle/b

ucket feeding

F3. Fodder

conservation

method

- i. None
- ii. Maize Stover hay
- iii. Grass hay and silage

B. Environment management

F4. What is the type of housing for your dairy cattle?

- i. Traditional
- ii. Semi-permanent
- iii. Permanent

F5. Do you have a milking parlour?

- 1) Yes 0) No

F6. Milking parlour cleaning frequency

- 1) Cleaned daily, 2) cleaned weekly, 3) cleaned fortnightly,
4) cleaned monthly, 5) cleaned after

more than a month F7. What is the size

of the resting yard for your animals?

- i. Congested
- ii. Not much congested
- iii. Spacious

F8. What is the frequency of slurry removal in the yard?

- i. Weekly
- ii. Daily
- iii. Hourly

C. Reproduction management

F9. What are your breeding strategies?

- i. Any bull service
- ii. Serving with upgraded bull
- iii. AI

F10. How do you do bull selection?

- i. No selection done
- ii. Done based on observation
- iii. Done using bull catalogue

Appendix B: Focus Group Discussion Guide For Smallholder Dairy Farmers

Introduction

1. Climate setting session
2. Introduction and meetings schedule

Main questions

1. What is the meaning of innovation platform?
2. What are the challenges the farmers encounter in dairy production practices in Mogotio Sub-County?
3. What were the causal factors in farm-level milk losses in Mogotio Sub- County?
4. What are the practices to reduce the milk losses?
5. How do you cope with the mentioned challenges?
6. What the milking practices in Mogotio Subcounty dairy farmers?
7. Who are the stakeholders working with you in the dairy production in Mogotio Sub-County?
8. What are their roles?
9. Any challenges in getting advisory services on dairy farming? (probe)
10. What are the dairy production practices you use in Mogotio Sub-County (probe milking handling and containers used)?
11. How to do manage the milking losses from your dairy animals? (Probe challenges)
12. What are the benefits of the practices? (Probe: other farmers learning from them, adoption of the practices by other farmers not in the platform, causal work opportunities for the youth, others?)
13. What challenges do you encounter in dairy marketing?
14. What do you do individually to try and gain more milk yields in Mogotio Sub-County?
15. How do you wean the calves in your farms?
16. How do dairy farmers form the action plan groups? (Probe on group number, host farmers, marketing, financial, fodder)
17. What milking handling practices make dairy farming successful?

Appendix C: Key informant schedule

1. Who are the current actors and specific interventions the Department of Livestock is undertaking to address the issue of low milk production among smallholder dairy farmers in the sub-county?
2. Milk handling attributes of milk producers in Mogotio Sub-County?
3. What are the causal factors of farm-level milk losses related challenges?
4. What tactics have you used to manage the selected milking techniques to lower farm- level milk losses?
5. What are the challenges and opportunities in the accessibility of dairy advisory services in Mogotio Sub-County?
6. What challenges and opportunities are there in dairy nutritional management practices in Mogotio Sub-County?
7. What is the type of housing for your dairy cattle?
8. What steps are being taken / could be taken to increase equal participation of all in decision-making on reducing farm-level milk losses at the initial levels of the dairy value chain?
9. Which additional mechanisms and arrangements may be needed to broaden the coverage and impact of Mogotio milk cooling plant?
10. What are the major opportunities and challenges in maintaining Mogotio milk innovation platform?

End

Appendix D: End-line Survey Questionnaire

Section A: Household Characteristics

1. Farm size? Owned _____, rented _____, Total _____ (acres)
2. Land tenure system: Owned with title deed Owned without title deed Rented
3. What is your income level? Low Average High
4. Do you belong to any social grouping other than the Mogotio cooling plant membership? Yes No
5. b). If yes, what benefits do you derive from the group(s)
 - a. _____
 - b. _____
 - c. _____

Section B: Farm level Milk losses

6. *How often do you experience shortages and excess milk production in your enterprise over the last year? (Tick as appropriate)*

	Always	Sometimes	Rarely	Never
Shortage supplies				
Excess supplies				

7. *How serious are each of the following milk farm level losses. Indicate by ticking using a scale of 1- very serious, 2-serious, 3-moderate and 4- Not a problem.*

Problem item	Very serious	Serious	Moderate	Not a Problem
Milk not collected on time				
Milk goes bad while being transported				
Inadequate market for milk products				
Buyers fail to pay on time				
Prices are unsatisfactory				
Inadequate dairy stock				
Poor dairy breeds				
Inadequate value addition to milk products				
Inadequate dairy supplements and feeds				

Inadequate veterinary services /Dairy diseases				
Inadequate land				
Dairy production equipment's/ assets				
Credit services accessibility				
Inadequate dairy information/training				
Inadequate finance				

8. Milk wasted on average at each of the following points and the frequency level

Point of milk loss	Quantity wasted/ lost per day in Litres	Frequency: 1=Very frequent. 2=Frequent; 3=Moderate; 4=Not frequent
On farm and during milking		
During transportation		
During storage		
Failure to collect/deliver milk		

Section C: Milk Value chain stakeholders

9. How many stakeholders do you interact with during the period of the innovation platform-based training? What was his/her role in the IP? What was the purpose/benefit of the interaction? What was the frequency of the interaction?

Stakeholder's Name	Interaction (Y/N)	Who has the stakeholder interacted with in the dairy value chain? (1 = Farmer 2 = milk collector 3 =KCC 4 =Extension, 5 =Research, 6 = Trader 7 =Agrovet 8 =Brookside dairy 9= Spin- knit dairy 10. Transporter 11 = Admin 12= KFA 13= Financial 14=Other (specify)	Frequency (1 =once 2 = twice 3=more frequent)	Purpose of the interaction	How satisfied are you with the interaction? 1 = V. satisfied 2 = Satisfied 3 = Neutral 4 = Unsatisfied 5 = V. unsatisfied
1					
2					

3						
4						

Section D: Output of innovation platform

10. Please indicate the quantity of milk obtained before and after participating in Mogotio innovation platform using the following milking practices

Milking practice	Before joining IP (Litres)	After joining IP(Litres)	Milk changes (Litres)
Restricted suckling			
Free suckling			
Non-suckling			

11. Please indicate the level of knowledge you have acquired on the listed milking techniques and adaptation.

Technology	Level of knowledge				
	1 very low	2 Low	3 moderate	4 high	5 very high
Restricted suckling					
Free suckling					
Non-suckling					

11. Which is your main source of information on proper milking techniques?

1) Ministry of Agriculture [] 2) Mogotio innovation platform [] 3) NGOs/CBOs []

4) Social media [] 5) Other Farmers []

Others, specify _____

12. Rate training on proper milking techniques in Mogotio innovation platform by ticking correct number

1=very low, 2=low, 3=moderate, 4=high. 5=very high				
1	2	3	4	5

Thank you

Appendix E: Farmer Training Guide

Dairy Farmer Training Manual

1. Dairy cattle nutrition

Topic objectives: This topic aims to enhance farmers' knowledge on feeding dairy cattle and apply it to various livestock categories.

- Dairy cattle nutrient requirements to support optimal health.
- The quality of bulk fodder. The feedstuff must be digestible, and the nutrients absorbed, if feed is to be useful to the animal.
- Dry matter daily intake equivalent of at least 3% of its body weight.
- Energy, protein, minerals, vitamins, and water roles in producing healthy dairy cattle. Too much, or too little of any of these, will negatively impact the animal.
- Balance high fibre and low in energy, and concentrates. The two must be balanced to prevent limited energy intake, milk fat depression, rumen acidosis, or other health problems.

2. Ration formulation

Topic objectives: This topic focuses on preparing basic rations for dairy cows using available fodder.

- Formulation of simple rations for dairy cows, based on available fodder.
- Farmers plan rations to meet target milk yields and coincide with periods when the cows are experiencing peak productivity (during lactation).
- Gauging the dairy cows' energy requirements to meet milk yield targets.
- An ideal dairy cow ration is nutritious, palatable and has a good effect on the cow's health.
- Use of the Pearson method, and the trial and error method.

3. Fodder/forage production

Topic objectives: To improve farmers' knowledge and skills in fodder establishment and management.

- Fodder crops are plants cultivated on arable land. They are grazed or fed to livestock either green or in a conserved form, like hay or silage.
- The factors that influence fodder yield are land preparation, soil management, quality seeds/certified seeds, plant population (calibration/fertilisation), weather and crop management.

- The nine most important varieties of fodder plants are sweet potato, fodder maize, Rhodes Grass (*Chloris gayana*), Desmodium, Lucerne, Lablab (*Dolichos lablab*) and fodder trees.
- Climate, rate of growth and ability to provide good soil cover are among numerous factors to consider when selecting which fodder to grow.

4. Fodder conservation

Topic objectives: This topic aims to train farmers on fodder conservation and its benefits in hay and silage.

- Due to distribution of rainfall patterns, pasture and fodder can only be made intermittently.
- Good quality hay is leafy and odourless.
- The principles of harvesting and curing hay, as well as of baling, storing it and feeding it to cows.
- Evaluation of the right type of fodder for the ensiling process.
- Limitation of fodder losses during the silage process, the type of silo, and precautionary measures followed.

5. Manure management

Topic objectives: To improve farmers' manure utilization for crop production and fodder production.

- Guidelines for handling, collecting, transporting, storing, treating and applying manure.
- Building a multi-layer compost heap to optimise the interplay between ash, vegetation and dung.
- Manure benefits in terms of ease of preparation, affordability and effectiveness in improving soil.
- Disadvantages of compost: labour-intensiveness, irregular nutrient composition and incompatibility with dry areas.
- Bioslurry: A superior organic fertiliser.

6. Disease Prevention

Topic objectives: The overall objective of this topic is to enable the farmers to know how to control and manage common diseases at the farm level.

- Importance of keeping good records, handling drugs responsibly, managing dairy herd health of existing stock, or reducing risks to humans.
- Body and behaviour signs and condition of cow's health: Gait, skin, coat, eyes, appetite, temperature and respiration.

- Parasites, microbial agents, accidents, nutrition and predators causing health problems in cows.
- Disease prevention: Isolation and vaccination, and hygienic conditions.
- Guidelines to prevent diarrhoea, pneumonia, worms, ticks, hoof problems, mastitis and wounds occurring in cows.

7. Milk quality and udder health

Topic objectives: To increase farmers' knowledge on the importance of quality milk, identify sources of contaminants and the importance of udder health in the production of hygienic milk.

- Practise good hygiene to limit contamination.
- Guidelines to clean and disinfection of the milking equipment, the environment, and the milk handlers to reduce potential sources of contamination on a farm.
- Use of sanitary techniques, proper cooling facilities, good quality feed and an adequate water supply.
- Principles of hand milking to observe optimum hygiene standards.
- Mastitis causes economic losses for farmers: Limit milk yields and/or render the milk produced unsaleable.

8. Factors that affect clean milk production at farm-level

- Milking techniques.
- Cooling and storage of milk.
- Feeding routines.
- Control of flies.
- Water supply.

9. Reproduction and breeding management

Topic objectives: To improve farmers' knowledge and skills in dealing with herd reproduction challenges for prudent breeding decisions.

- Reproductive performance of dairy cattle: Good recording, regular observation, heat detection, insemination at the right time, and length of the interval between calvings.
- Breeding: A long-term solution for high milk production and a good genetic pool for the farmer.
- Natural mating, and artificial insemination (AI).

- Important breeds: Friesian, Ayrshire, Guernsey and Jersey.

-

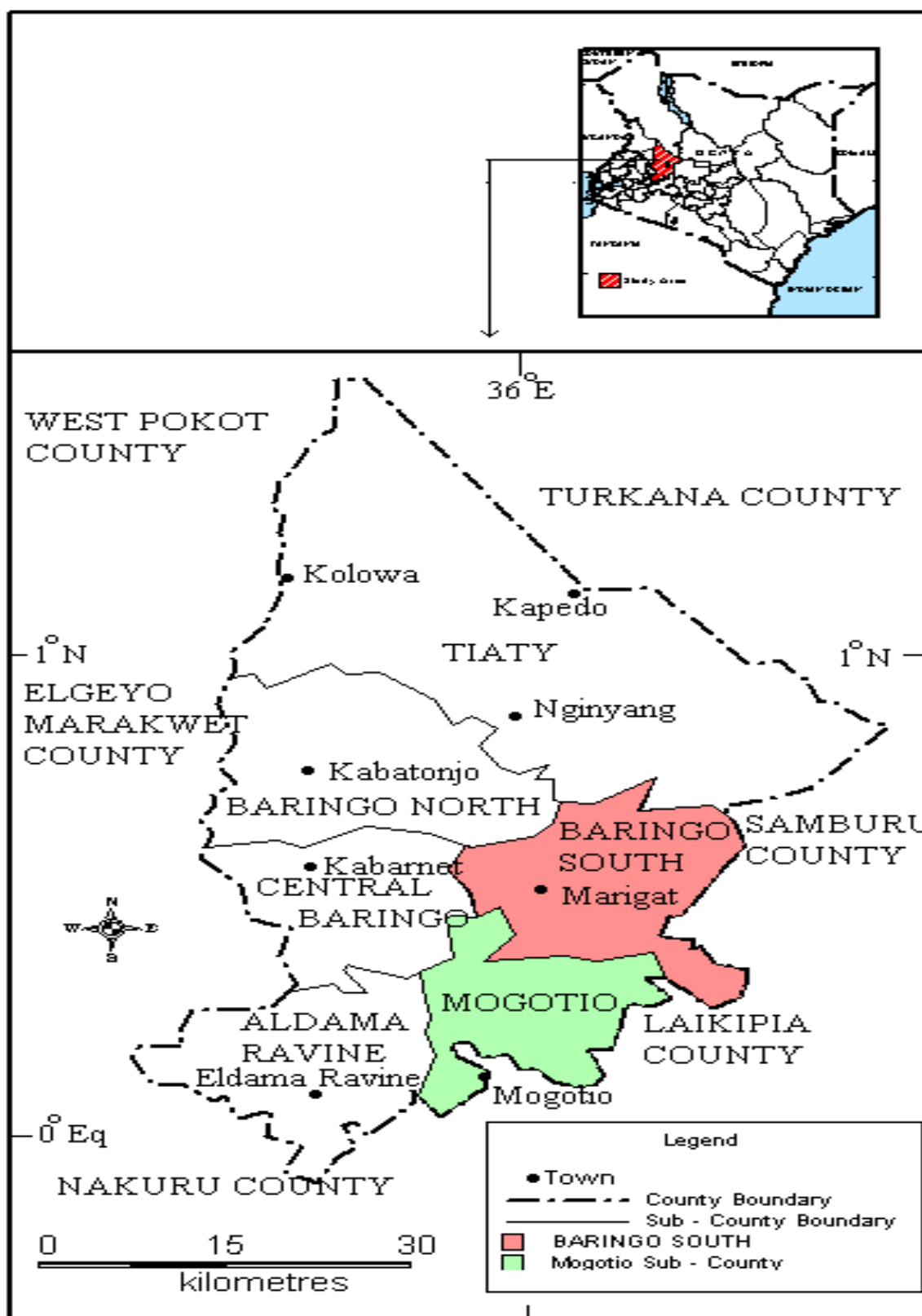
10. Dairy cattle feeding and management

Topic objectives: The overall objective is to impart knowledge on raising calves from birth to weaning as well as feeding the heifers, milking animals and dry animals in the herd.

- Management, preparation and awareness of animal health protection practices.
- Colostrum feeding.
- Raising heifers: After weaning, a growth rate of 500–700 g/day to ensure to come on heat at the right time.
- Feeding during dry periods (when cows are not lactating).
- Feeding high-energy, highly palatable and digestible feed, or starchy fodder and molasses: During the 3 weeks immediately before and after calving.

*** THE END – THANK YOU

Appendix F: Map of the Study Area



Appendix G: Research Permit

 <p style="text-align: center;">REPUBLIC OF KENYA</p> <p>Ref No: 130681</p> <p style="text-align: center;">RESEARCH LICENSE</p> <div style="text-align: center;">  </div> <p>This is to Certify that Mr. SILELE JOSIAH of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Baringo on the topic: INFLUENCE OF INNOVATION PLATFORM-BASED LEARNING ON- FARM LEVEL MILK LOSSES AMONG SMALLHOLDER DAIRY FARMERS IN MOGOTIO SUBCOUNTY, BARINGO COUNTY, KENYA for the period ending : 13/December/2022.</p> <p style="text-align: center;">License No: NACOSTI/22/22439</p> <p style="text-align: center;">Applicant Identification Number: 130681</p>	 <p style="text-align: center;">NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION</p> <p style="text-align: right;">Date of Issue: 13/December/2022</p> <p style="text-align: right;">Director General</p> <p style="text-align: center;">NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION</p> <p style="text-align: right;">Verification QR Code</p> <div style="text-align: center;">  </div>
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 - iv. Result in exploitation of intellectual property rights of communities in Kenya
 - v. Adversely affect the environment
 - vi. Adversely affect the rights of communities
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Appendix H: Abstracts of Published Papers



Asian Journal of Agricultural Extension, Economics & Sociology

Volume 41, Issue 6, Page 118-124, 2023; Article no. AJAEES.98205
ISSN: 2320-7027

Influence of Innovation Platform-based Learning on Farm-level Milk Losses among Smallholder Dairy Farmers in Mogotio Sub-county in Baringo County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

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Published: 06/05/2023

Review Article

ABSTRACT

Smallholder dairy farmers make up to 80% of total dairy producers and produce 56% of total milk in Kenya. Income from milk is the main source of their annual recurrent revenue. The critical point in the milk supply chain where improvements can contribute to increased income is through the reduction of farm-level milk losses. An innovation platform-based capacity building programme is a programme that brings together all relevant actors to assist in addressing the gaps left by the conventional government extension services when minimising farm level milk loss among smallholder dairy farmers in Mogotio sub-county. This study used a tailor-made capacity building

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Asian J. Agric. Ext. Econ. Soc., vol. 41, no. 6, pp. 118-124, 2023



Assessment of the Current Status of Milk Production and Farm-level Milk Losses among Smallholder Dairy Farmers in Mogotio Sub-county, Baringo County

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2023/41111835

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Received: 22/11/2022

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Published: 02/02/2023

Original Research Article

ABSTRACT

Smallholder dairy farmers account for up to 80% of total dairy producers and 56% of total milk production in Kenya. The reduction of farm level milk losses at the farm level is a critical point in the milk supply chain where improvements can contribute to increased income. The target population included 840 accessible smallholder dairy farmers and 120 dairy farmers who were purposefully sampled as study respondents during the baseline survey. Thirty farmers were purposefully chosen to participate in focus group discussions. A structured questionnaire, Focus Group Discussion guides, and a Key Informant Interview schedule were used to collect data. Focus Group Discussions and Expert Interviews yielded qualitative data. The data's reliability was then

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Appendix I: Selected Data Analysis Outputs

One-Way ANOVA for the differences in milk values across the milking methods

```
ONEWAY milk_values BY Milking_methods
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS.
```

Descriptives

Milk Mean (Litres)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Restricted	44	.7531	.03065	.01533	.6778	.7753	.50	.75
Free sucking	57	.5390	.04132	.02066	.4788	.6102	.60	.60
Non sucking	19	.6670	.03350	.01675	.5969	.7036	.30	.75
Total	120	.6404	.08430	.02433	.5869	.6940	.30	.75

ANOVA

Milk Mean (Litres)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.067	2	.033	1.323	.000
Within Groups	.011	117	.025		
Total	.078	119			

One-Way ANOVA results for the test of differences in milk values per breed

ONEWAY milk_values BY Dairy_breeds
 /STATISTICS DESCRIPTIVES
 /MISSING ANALYSIS.

Descriptives

Milk Mean (Litres)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Ayrshire	18	3.3000	1.72999	.44668	2.3420	4.2580	1.00	6.00
Crosses	67	.5333	.37408	.35479	.4724	.5943	.50	4.00
Friesian	17	.7667	.42511	.36796	.5775	.9559	.50	5.00
Jersey	11	.6333	.28823	.33262	.4199	.9467	.50	4.00
Sahiwal	7	.6667	.47223	.25103	.4283	.5151	.50	3.00
Total	120	2.5800	1.41908	.16386	2.2535	2.9065	.50	6.00

ANOVA

Milk Mean (Litres)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15.787	4	.010	.069	.000
Within Groups	133.233	115	.138		
Total	149.020	119			