ANALYSIS OF TECHNICAL, ORGANIZATIONAL AND INSTITUTIONAL DAIRY PRACTICES AND THEIR EFFECT ON THE POVERTY STATUS OF FARM HOUSEHOLD IN THE HIGHLANDS OF KENYA

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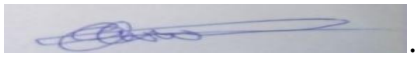
Signature. ...  ..... Date…08/08/2023

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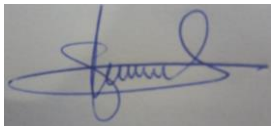
Signature..…  … … Date…Wed 9th Aug 2023…

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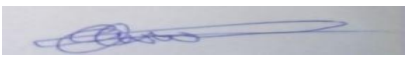
Signature…  Date:....08/08/2023.....

DEDICATION

This work is dedicated to my siblings and friends, whose encouragement motivated me to complete my studies.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

AHAs:	Animal Health Assistants
AI:	Artificial Insemination
APEs:	Average Partial Effects
ASDSP:	Agriculture Sector Development Support Programme
AU:	African Union
CATPCA:	Categorical Principal Component Analysis
CIDP:	County Integrated Development Plan
DFBAs:	Dairy Farmers Business Associations
DH:	Double Hurdle
DIP:	Dairy Innovation Practices
DPs:	Dairy Practices
EADD:	East Africa Dairy Development
ESR:	Endogenous Switching Regression
FFS:	Farmer Field Schools
FMD:	Foot and Mouth Disease
GDP:	Gross Domestic Product
GoK:	Government of Kenya
HCL:	Happy Cow Limited
IBM:	International Business Machine
IDPs:	Institutional Dairy Practices
IV:	Instrumental Variable
KALRO:	Kenya Agriculture and Livestock Research Organization
KDB:	Kenya Dairy Board
KMO:	Kaiser Meyer Olkin
KNBS:	Kenya National Bureau of Statistics
MNL:	Multinomial Logit Model
MTP:	Medium Term Plan
MWDL:	Mukurweini Wakulima Dairy Limited
NCCAP:	National Climate Change Action Plan
NGOs:	Non-Governmental Organizations
NKCC:	New Kenya Co-operative Creameries

NLP:	National Livestock Policy
NLPCA:	Non-Linear Principal Component Analysis
ODPs:	Organizational Dairy Practices
OIDPs:	Organizational and Institutional Dairy Practices
ODK:	Open Data Kit
PSM:	Propensity Score Matching
QBMP:	Quality Based Milk Payment System
QR:	Quantile Regression
SDGs:	Sustainable Development Goals
SES:	Social Economic Status
SNA:	Social Network Analysis
TDPs:	Technical Dairy Practices
TLU:	Tropical Livestock Unit
VCA:	Value chain analyses
VIF:	Variance Inflation Factor

ABSTRACT

Promotion of technical, organizational and institutional dairy practices by the dairy stakeholders could address the continued decrease in milk quantity and quality in Kenya. The study considered a sample of 1146 households from three milksheds (Mukurweini Wakulima Dairy Limited, Happy Cow Limited and New Kenya Cooperative Creameries) and achieved four objectives. The first objective characterized dairy practices adopted by dairy farmers using a Categorical Principal Component Analysis (CATPCA). A double hurdle (DH) model assessed adoption determinants of technical dairy practices and intensity of adopting organizational and institutional dairy practices in the second objective. The third objective used principal component analysis to create an asset index and thereafter an ordered probit regression to assess the impact of improved dairy practices grouped into technical, organizational, institutional and a combination of different dairy practices on poverty.

The Multinomial Logit Model (MNL) established the dairy farmers' perception on farmer field schools (FFS) in the fourth objective. The CATPCA results revealed that more farmers in the milkshed of Mukurweini Wakulima Dairy Limited (MWDL) adopted technical and organizational dairy practices like milk sale through groups and artificial insemination unlike households in New Kenya Cooperative Creameries (NKCC) and Happy Cow Limited (HCL). The double hurdle results indicated that access to dairy information positively influenced adoption of technical dairy practices in the three milksheds. Intensity of adoption of organizational and institutional dairy practices were influenced by income, farm size, and access to dairy information. Adoption of technical dairy practices reduced poverty in the three milksheds.

Moreover, in MWDL, the joint adoption of organizational and institutional dairy practices decreased the probability of households to remain poor. Household head age and group membership were among positively influenced perception of farmers on FFS. The study conclude that the adoption of dairy practices at the farm and milkshed contribute in improving the the dairy farmers' welfare. As a result of low adoption of organizational and institutional dairy practices, the study suggests more intervention by the development partners, national and county governments to promote the adoption of the three types of dairy practices in three milksheds in an effort to reduce poverty. Special focus should be to the female headed households, particularly in lower income level. The county governments and development partners need to support cooperative societies to improve access to dairy information and linking farmers with fodder seed sources to boost farmers' perception on FFS.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

The Kenyan government has recognized the importance of the dairy sub-sector in improving household welfare as reflected by its prioritization in the Kenya Vision 2030, Medium Term Plan III (MTP III) and the Government of Kenya Big Four agenda 2017-2022, particularly on food security pillar (GoK, 2018). The Vision 2030 has highlighted livestock production programme and Value Chain Support Programme among its flagship projects running from 2018 to 2022. Under these two programmes, and particularly relevant to dairy sub-sector, the plan envisions interventions including production of breeding stock, increasing semen production, improvement of dairy value chain infrastructure, value addition of dairy among other interventions.

These government priorities on dairy sub-sector echo the Sustainable Development Goals (SDGs) one and two on ending poverty and hunger respectively (United Nations, 2015). Similarly, Agenda 2063 of the African Union aspires to eliminate hunger and food insecurity by 2063 (African Union Commission, 2015) which can be achieved through the support of the dairy sub-sector. The importance of the sub-sector is further revealed by its contribution to Gross Domestic Products (GDP) as well as to the livelihoods of dairy farmers. The sub-sector contributes up to 12 percent and 44 percent to Kenyan agricultural sector and livestock GDP's respectively (KNBS, 2019a).

Although the dairy industry is among the key economic industries in Kenya, supporting an estimated 1.8 million of smallholder farmers (KDB, 2020), it is faced with various challenges. Farmers are faced with limited quantity of feeds and poor quality feeds, lack of access to breeding stock, dairy cow diseases such as mastitis, lack of credit facilities and unreliable output market

(Omunyin *et al*., 2014; Kibiego *et al*., 2015). Additionally, livestock production is prone to the vagaries of climate change and socio-economic pressures that affect animal feeds and water availability (Thornton, 2010).

Dairy processors incur high milk collection costs due to seasonality and fragmentation of production between small farms while sourcing milk. Milk purchased is also of poor microbial quality (Makoni, 2014; Rademaker *et al*., 2016). As a result of low milk quantities received by processors, capacity utilization of processing plant is also low. Competition from the milk sales to the informal market where farmers are paid in cash, unlike processors who pay on monthly basis, is another challenge faced by processors. Additionally, limited enforcement of formal contracts describing the quality of raw milk to be supplied to processors and cooperatives hinder enhancement of milk quality (Nyokabi *et al*., 2018).

Consumers access raw milk or milk products of compromised quality and safety particularly adulterated milk, with antibiotic residues and Aflatoxin M1 (Kagera *et al*., 2019; Kuboka *et al*., 2019) from farmers and traders. Similarly, other actors in the dairy value chain add preservatives including hydrogen peroxide to prolong the shelf life and sometimes to reduce the cost of production. Moreover, some feed manufacturers sell feeds contaminated with Aflatoxin M1 (Senerwa *et al*., 2016; Kagera *et al*., 2019).

In an attempt to address the dairy value chain challenges, the Kenyan Government, together with its partners, have been supporting the actors through varied interventions. The interventions have been through various public institutions such as Ministry of Agriculture, Livestock Fisheries and

Cooperatives, Kenya Agriculture and Livestock Research Organization (KALRO), the Kenya dairy Board (KDB), universities, and training institutes. Non-Governmental Organizations (NGOs), development actors as well as donor funded programmes such as Land O'Lakes, Heifer International, TechnoServe, Netherlands Development Organization - Kenya Market-led Dairy Program (SNV-KMDP), East Africa Dairy Development (EADD), and Agriterra among other organizations and projects are also among key stakeholders in dairy farming. These institutions mainly supports development of diseases resistant fodder, acquisition of milk coolers for counties, ensuring quality based payment system, farm feed production and silage making, linking cooperatives with Kanters Holland B.V. company for supply of milk buckets, milking machines and calf milk powder (KDB, 2016; Rademaker *et al*., 2016; Kilelu *et al*., 2017).

Some counties such as Nakuru County offer dairy extension services, subsIDPzed Artificial Insemination (AI) services and animal health, as well as milk cooling tanks to dairy cooperative societies (Rademaker *et al*., 2016). Moreover, the counties of Bomet, Nakuru, Nyandarua and Nyeri have listed the dairy enterprise among their three priority value chains (GoK, 2017).

Despite the institutional support to dairy farmers in improving quality and quantity of milk production, milk supply to processors has remained low due to low adoption of dairy practices (technical, organizational and institutional). Technical dairy practices (TDPs) include feeding of dairy cows, animal health, milk hygiene, breeding and cow management such as housing, among others and they are aimed at increasing milk production at the farm level. Organizational dairy practices (ODPs)on the other hand, include for example building new collection centers or roads,

setting up a cooling center, creating new private collector or processing companies (or on the contrary setting up direct sales to consumers), creating farmers groups or cooperative societies.

Institutional dairy practices (IDPs) include changes in the formal and informal rules shaping the milk collection schemes and milk marketing channels. Examples of IDPs comprises contractual arrangements between farmers and collectors, written contracts between farmers and dairies, milk quality payment schemes, public milk quality regulations, loans programs or other financial devices. Furthermore, institutional dairy practices also includes more informal rules such as consumers' preferences, consumption habits and product perception and uses.

Collectively, dairy practices could improve milk quality and quantity sold by dairy farmers as well as improve efficiency in the dairy value chain. For instance, TDPs including local animal feed sourcing, improved cow feeding, health management, hygienic milking, reproduction management, and breed selection might increase milk production, decrease seasonality, and improve microbial quality of milk (Wambugu *et al*., 2011). To ensure inclusivity and efficiency within the milksheds, ODPs such as optimization of collection routes, implementation of collection centers, and introducing milk cooling systems could include more producers and reduce post-harvest milk losses (Odero-Waitituh, 2017). The IDPs such as quality and seasonality based payments, and credit schemes for feed, could encourage dairy producers to improve their practices (Holloway *et al*., 2000).

Failure to adopt technical dairy practices is a hindrance to improved milk quality and quantity while limited organizational dairy practices like lack of cooling and storage facilities constrain

smallholder farmers from delivering their milk to the collection centres (GoK, 2013). Smallholder farmers sell their milk informally to milk vendors because they offer a higher price at the farm, offer them credit advance and some processors delay milk payment (Odero-Waitituh, 2017). It is in response to these challenges the University of Nairobi in partnership with Wageningen University & Research implemented the AfricaMilk Project in three milksheds (MWDL, HCL and NKCC Sotik). The project (2018 to 2022) aimed to co-design and implement technical, organizational and institutional dairy practices that aim at increasing and securing local milk sourcing. This study was conducted in the framework of the AfricaMilk Project and analyzed the dairy practices adoption by farmers in the three milksheds.

1.2 Statement of the Problem

The Kenyan milk quantity and quality has continued to decrease threatening the competitiveness of the dairy industry in provision of raw milk for local consumption and dairy products for export, and farmers who rely on dairy to remain poor. The situation could be partially attributed to low adoption of sustainable technical, organizational and institutional dairy practices, which has remained a challenge among the Kenyan dairy farmers. Little attention, however, have been paid by researchers to establishing the dairy practices adopted by farmers, factors that influence their adoption and determining dairy practices contribution to poverty status of dairy households either separately or jointly. Additionally, studies on farmers' perception on farmer field schools are limited. Moreover, the few studies on dairy practices have focused on the potential of technical dairy practices alone. There is therefore limited information on the contribution of the three categories of dairy practices jointly to poverty status. Studies on farmers' perception of farmer field school (FFS), where farmers have an opportunity to learn and test what was taught despite its

importance in the decision to adopt new technologies, are also limited. There is therefore limited information on the contribution of the three categories of dairy practices jointly to poverty in the three milksheds practicing different farming systems including zero grazing, semi-zero grazing and free-range for MWDL, HCL and NKCC Sotic respectively. The joint analysis is further important in order to allow donors, researchers and extension agents to target dairy practices that have the highest potential in making milk system inclusive and efficient.

1.3 Purpose and Objectives

The purpose of this study was to evaluate the effects of dairy practices on poverty in milksheds of three processors; Mukurweini Wakulima Limited, NKCC Sotik and Happy Cow Limited.

The specific objectives of this study are:

i. To characterize the technical, organizational and institutional dairy practices adopted by dairy farmers in Kenya.
ii. To evaluate the factors that influence the intensity of use of technical, organizational and institutional dairy practices in Kenya
iii. To assess the effects of technical, organizational and institutional dairy practices on dairy farmers' poverty status.
iv. To assess dairy farmers' perception on use of farmer field schools

1.4 Hypothesis

The following hypothesis were tested. That;

i. Dairy practices adopted in Mukurweini Wakulima Dairy Limited, New Kenya Cooperative Creamaries and Happy Cow Limited are not different

ii. Socio-economic, institutional and technological factors do not influence the intensity of use of dairy practices.

iii. Dairy practices have no effect on farmers' poverty status

iv. Dairy farmers' socio-economic characteristics do not influence farmer's perception on access to information on cow feeding and nutrition through farmer field schools.

1.5 Justification

Promotion of dairy practices that enhance milk quantity and quality echoes Sustainable Development Goal (SDG) 1 and 2 specifically on ending extreme poverty in all forms by 2030 and end hunger, respectively, Kenya Vision 2030 MTP III and the Government of Kenya, Big Four priority agenda for 2017-2022, particularly the one on food security (GoK, 2018).

Enhancing increased income for dairy farmers including smallholder dairy farmers who add up to 1.8 million in Kenya is relevant and also in line with the agenda 2063 that lays emphasis on economic growth to advance incomes to the people. Characterizing the existing TDPs, ODPs and IDPs that are used by dairy farmers, assessing TDPs, ODPs and IDPs adoption determinants and assessing the effect of the three categories of dairy practices on the poverty status of dairy farmers is important to both farmers and promoters of dairy practices including development partners, government and non-governmental organizations. Additionally, understanding the farmers' perception on the use of FFS to stimulate dairy feeding and nutrition, could inform the likelihood of farmers planting the fodder promoted in the demonstration plots. The study aims to provide guidance to the promoters of the dairy practices and researchers to enhance their effectiveness in increasing the adoption rate by dairy farmers.

1.6 Organization of Thesis

The rest of this thesis is presented as follows. Chapter two presents the reviewed and theoretical frameworks. Chapter three outline the methodology of the study, while chapter four presents the first paper that addresses the first objective of this thesis, entitled '*characterization of dairy practices in selected milksheds in Kenya using a categorical principal component analyses'.* The second objective that is representing the second paper entitled '*factors affecting adoption of technical, organizational and institutional dairy practices in selected milksheds in Kenya*' is presented in chapter five. Chapter six presents the third objective, '*dairy practices effects on farmers' poverty status in selected milksheds in Kenya*' which addresses the third objective. Analysis of dairy farmers' perception on use of farmer field schools to improve dairy cows' feeding and nutrition in selected milksheds of Kenya corresponding to objective four is presented in chapter seven. **The** general discussion, conclusions and recommendations are presented in chapter eight.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Approaches used to Analyze Perceptions, Adoption and Impact

2.1.1 The Theory of Change

The theory of change as developed by Weiss (1995, 1998) shows a model of linking program inputs and activities that lead to observed outcomes (Rogers *et al.*, 2000; Rogers, 2014). Rogers (2008) points out that in this theory, there is a need to include the context of the program under evaluation and characteristics of the participants. In the AfricaMilk Project the inputs included training farmers on milk quality and increasing milk quantity, while the expected outputs included increased milk production and improved quality and reducing poverty among the dairy farmers. In the microeconomic theory of welfare, each *i* individual will attempt to maximize welfare.

2.1.2 The Diffusion of Innovation Theory

Rogers' Diffusion of innovation theory (1995) explain how new ideas are adopted. This theory defines diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system. Rogers described innovation as an idea or practice that is perceived as new by individuals. The theory highlighted uncertainty as an obstacle to practices' adoption and suggested to reduce this uncertainty, individuals should be informed about its advantages and disadvantages of practices to make them aware of all its consequences. The theory identifyies four key elements of diffusion innovation process as innovation, communication channels, time, and social system.

The theory further defines diffusion as a kind of communication with communication elements such as an innovation, two individuals, and a communication channel. The communication

channels are classified as mass media and interpersonal communication. While mass media channels include Television, radio, or newspaper, interpersonal channels consist of a two-way communication between two or more individuals.

The social system is defined as an establishment of interconnected units involved in joint problem-solving to achieve a common goal. Given that the diffusion of practices happens in the social arrangement, it is affected by the social structure of the social arrangement. The theory further stipulates that the nature of the social system affects individuals' innovativeness, which is the main criterion for categorizing adopter.

The theory categorized adopters into five groups namely innovators, early adopters, early majority, late majority, and laggards. In each of the adopter group is characterized with similar individuals terms of their innovativeness. Rogers opined that innovativeness facilitated in understanding the desired and behavior in decision making process regarding innovation . He therefore grouped the adopters based on their ability to innovate as illustrated in Figure 2.1.

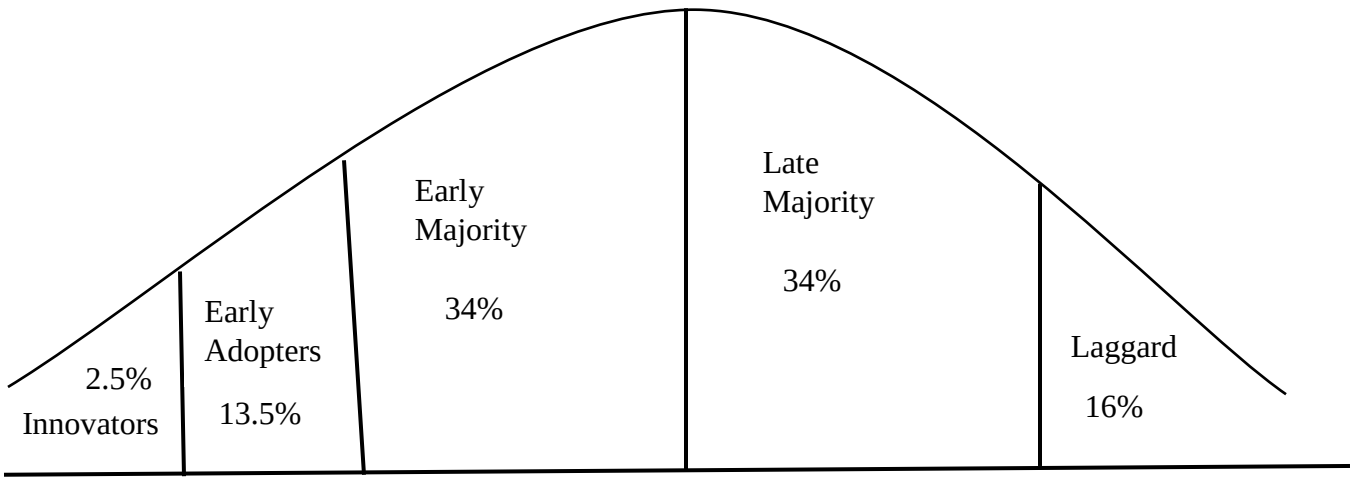

Figure 2. 1. Adopter categorization on the basis of innovativeness. Source Rodgers 2003

Each adopter group is defined using a standardized percentage of respondents in the normal distribution. The theory characterized innovators as a category that were prepared to take up new ideas and ready to take some uncertainty about the innovation.

Comparing the different adopters categories, the theory highlights that early adopters have high probability of holding leadership roles in the social arrangement and other members in the social system seek advise from them regarding the innovation. Additionally, early adopters are role models and take lead position in adopting an innovation. By taking the leadership role in adopting innovation, the early adopters, decreases the uncertainty about innovation in the diffusion process and also promote a new idea by adopting it (Rogers, 2003).

In contrast to early adopters, the early majority, lack leadership roles although their social networks are still important in the innovation-diffusion process. As illustrated in Figure 2.2 shows, the early majority adopts the new ideas just before the other half of their peers adopts. Following Rogers statement, this category of adopters are deliberate in adopting a new idea given that they adopt new ideas after early adopters and before the late majority their adoption decision of new ideas takes more time compared to time taken by the innovators and early adopters.

The late majority comprises one third of all the members of the social arrangement and are comparable to the early majority. Regarding their innovateness nature, the late majority are doubtful about the new ideas and their outcomes, economic necessity and therefore they adopt after their their peers adopt them. The late adopters may as a result of peer pressure adopt the new ideas.

The laggards are more doubtful about practices and change agents compared to the late majority. Additionally, they are the most confined group of the social arrangement and their relational systems mainly consist of other members of the social arrangement from the same category. More so, they lack leadership responsibilities and due to limited resources as well as lack of knowledge regarding new practices, they first ensure that new ideas are successful before they adopt. In the process of establishing whether the new ideas are successfully adopted by other members of the social arrangement, laggards take a relatively long time to make decision to take up the new idea.

This study adopted the diffusion of innovation theory by Rodgers (1995). According to the theory, there are five steps in innovation decision process that the adopter passes through while decIDPng to either adopt or reject the innovation or a technology. These steps include knowledge on finding out about the innovation, developing an attitude towards the innovation, decIDPng to adopt or reject innovation, execution of an innovation and lastly approval of the decision that in seeking reinforcement to continue, or reversing the adoption decision or reject the innovation(s). In this study, a dairy farmer is expected to go through the five steps before decIDPng to adopt dairy practices including technical, organizational and institutional.

2.2 Review of Past Related Empirical Studies

Using four groups of dairy practices namely; feeding, breeding, market, and animal health practices in creating the innovation index used as the dependent variable, Chindime *et al*. (2017), used Ordinary Least Square Regression to assess the sustainable innovation performance determinants by smallholder dairy farmers in Malawi. Findings of the study revealed access to credit together with training, and access to information had a significant effect on innovation

performance by smallholder dairy farmers. The study recommended the Government to develop extension services meant at improving access to inputs, knowledge and credit.

Gieseke *et al*. (2020) study in Germany assessed the effects of cubicle characteristics on animal welfare indicators in dairy cattle. Cows lying outside cubicles, cow cleanliness, and subclinical mastitis incidence were among the variables that represented animal welfare. The study adopted multiple linear regression approach and the results indicated that the cubicle's characteristics enhanced animal health. Specifically, pasture access, cubicle type were considered as potential influencing factors while the bedding type the highest effect on cow health and behavior.

Still on technical dairy practices specifically breeding, Mwanga *et al*. (2019) study determined farmers' breeding decisions in Ethiopia, Kenya, Tanzania and Uganda using logistic regression and factor analysis. The study revealed that farmer's experience, record keeping by farmers, water and feeds availability were significantly associated with adoption of AI by farmers with small herd size. On the contrary, farmers with large herd and large land were not likely to use AI services. Further, the distance covered by the AI service provider and the cost of AI services reduced the probability of AI use. The study recommended support on availability of AI service providers, animal feed, animal health provision to boost AI adoption, training on record keeping, and appropriate feeding. Unlike this study that only focused on one technical dairy practice specifically use of AI, the current study looked at several technical dairy practices including feeding, animal health such as regular vaccination, cow housing, hygiene milking, type of breed kept (pure or cross-breed) among others.

Considering fodder production, cross-breeding, and manure management as indicators of dairy intensification, Didanna *et al*. (2018), used a binary logistic regression to analyze the determinants of intensification of dairy production systems in Ethiopia. Herd size, farmland size, dairy training, and cooperative membership had significant effects on cultivating improved fodders. Furthermore, the dairy production arrangement, experience in dairy farming, and herd size had a significant association with rearing crossbred dairy cows alone.

Studies indicated the benefits of organizational dairy practices including ensuring inclusivity in milk supply chain and ensuring efficiency, including effects on milk production, household income and household welfare. The significance of milk sale through cooperative society was revealed by Bayan (2018) in India. The study used PSM to assess the dairy cooperatives impacts on technology adoption, farm income, and employment, among other aspects. Participation of farmers in dairy cooperatives had a positive impact on milk yield, farm income, and employment. While using variables including family size, herd size, age, ownership of crossbred cows, distance to market, education of the household-head, experience in dairy farming and access to institutional credit , the study recommended milk marketing by dairy farmers through cooperative societies, cooperatives societies to set milk prices and disseminate improved technologies to farmers.

To emphasize on the weaknesses in the functioning of dairy cooperatives as far as negotiating for higher prices of farm produce is concerned, Laishram and Chauhan (2019) study, indicated that dairy cooperatives were insignificant in improving milk yield and milk price in India. The study adopted propensity score matching technique to assess dairy cooperatives impacts on milk yield, milk prices and household income among other variables.

Focusing on the use of contracts as part of institutional dairy practice used to maintain milk quality along the milk supply chain, Nyokabi *et al*. (2018) study in Nakuru County, Kenya reported limited use of contracts describing the quality of raw milk marketed through cooperatives and processors constraining the milk quality. The study used Social Network Analysis (SNA) to examine relationships between various dairy sector stakeholders' role and the impact of their power on the quality of raw milk and dairy products sold in Nakuru County, Kenya. The study further revealed that cooperatives, processors, government agencies were the most powerful stakeholders in the network influencing milk quality along the dairy value chain.

Ngeno (2018) reaffirmed the importance of participation in the dairy hubs by dairy farmers. Using Endogenous Switching Regression (ERS), the study assessed the impact of dairy hubs on smallholder welfare in Kenya. Farmers' participation in the dairy hub resulted in increased milk yield and milk income. Other variables that were found to influence participation in dairy hub by farmers were distance to the dairy hub, education level of the farmer, access to extension services by the farmer, tropical livestock unit owned by the farmer among other variables. The results therefore showed the importance of socio-economic and institutional factors inclusion in the adoption model, but focused on only organizational innovation. The study failed to evaluate the impact of other practices, including technical and institutional practices that could have impact on participation in the hub and consequent influence on dairy farmers' household welfare.

2.3 Summary of the literature review

The reviewed literature revealed several knowledge gaps that guided this study in formulating its objectives and in choosing the appropriate econometric models used in achieving the study objectives. Adoption of dairy practices involve adoption decision and the intensity of adoption in terms of quantity of dairy practices adopted at the farm and at the milkshed. The existing studies have not considered adoption of the three types of dairy practices (technical, organizational and institutional) jointly.

Some studies have focused on TDPs and ODPs like adoption of improved dairy cows on household poverty (Kabunga, 2014) and organizational practices such as milk sale through cooperatives separately (Wambugu *et al*., 2011; Chagwiza *et al*., 2016; Bayan, 2018). Few studies exist that consider the effects of technical, organizational and institutional dairy practices on poverty jointly. One of those studies is by Alemu and Adesina's (2015) that considered both milk sale by household in Ethiopia through cooperative society and engagement in contract farming jointly representing organizational and institutional dairy practices respectively. This study aimed to bridge this gap by assessing the adoption of technical dairy practices determinants at the farm and intensity of adoption of organizational and institutional dairy practices at the milkshed together, because both decisions are equally important in uptake of technologies.

Few studies exist that consider the effects of technical, organizational and institutional dairy practices on poverty jointly. One of those studies is by Alemu and Adesina's (2015) that considered both milk sale by household in Ethiopia through cooperative society and engagement in contract farming jointly representing organizational and institutional dairy practices respectively. Other

existing studies on adoption of dairy practices considered adoption of technical dairy practices like adoption of improved dairy cows on household poverty (Kabunga, 2014) and organizational practices such as milk sale through cooperatives separately (Bayan, 2018). Further, few studies exist that have looked into the effects of dairy practices on poverty status in the context of rural areas.

Moreover, the few studies on dairy practices have focused on the potential of TDPs alone. This study therefore aimed to show the effect of the three types of dairy practices on poverty status among the dairy farmers. Additionally, studies assessing farmers' perception on the contribution of the farmer field schools in enhancing learning on improving dairy cow's feeding and nutrition are limited.

CHAPTER THREE: METHODOLOGY

3.1 Theoretical Framework

This study was grounded on the expected utility theory (EUT) developed by Morgenstern and Von Neumann (1953). The theory assumes that an individual tries to maximize his/her expected utility by choosing an optimal choice that that gives the highest utility (Batz *et al*., 1999). According to the theory a farmer could decide to adopt an innovation if the utility received by adopting it is higher than the utility of non-adoption (Nonvide, 2021; Ruzzante *et al*., 2021). The decision making is however faced with factors that are beyond an individual control (externalities), making it impossible for an individual to predict the outcome of the choices made. This implies that an individual can only estimate the outcome with an error margin. The EUT is therefore applied when choices are made within uncertainties (Polak & Liu, 2006). As a result, EUT, the outcome of the choices are only expected because individuals are not certain of the outcome choices. Farmers are presumed to take up innovation on the bases of maximizing the utility resulting from adopting that innovation. Farmers are therefore expected take up innovation if its utility say (Nk) surpasses the utility of an old technology (Tw).

The utility arising from an innovation is hypothesized to be a function of the vector of observed farm characteristics, farmer characteristics, institutional factors, perceived innovation characteristics (M_i) and a random disturbance term having a zero mean. This arises from unobserved variation in preferences, attributes of the alternatives, and errors in optimization. Perceived innovation characteristics themselves are usually a function of objective or subjective characteristics of an innovation, farm and farmer-specific characteristics.

Given that farmers are rational in their decision making, a farmer evaluates the utility resulting from adopting various practices and picks the one that provides a higher utility than the older practice (Adesina & Zinnah, 1993). Assuming a farmer expect to gain utility N_k (M) after taking up an innovation and the utility of taking up an older practice is T_w (M), the choice for taking up an innovation and old technologies could be demonstrated as shown in Equation 3.1 and 3.2:

$$N_K(M) = M\beta_k + \varepsilon_k \tag{3.1}$$

$$T_w(X) = X\beta_w + \varepsilon_w \tag{3.2}$$

where βk, βw and ε_k, ε_w represents outcome factors and error terms connected with an innovation adoption and adoption of an old practices respectively. The likelihood of taking up an innovation maybe represented by a variable Y, which is dichotomous in nature, where 1 represents if the farmer is ready to adopt the innovation and zero represents non-adoption. Figure 3.3 illustrates the likelihood of a farmer adopting an innovation.

$$\begin{aligned} L(Y=1) &= L(N_k > T_w) \\ &= L(M\beta_k + \varepsilon_k > M\beta_w + \varepsilon_w) \\ &= L[M(\beta_k - \beta_w) > \varepsilon_k - \varepsilon_w] \\ &= L(M\beta > \varepsilon) \\ &= C(M\beta) \end{aligned} \tag{3.3}$$

The likelihood function is represented by L, the vector of unidentified factors by, $\beta=(\beta_k-\beta_w)$ while $\varepsilon=(\varepsilon_k-\varepsilon_w)$ represents a random error term and, $C(M\beta)$ is the cumulative distribution function C evaluated at $M\beta$ (Rahm & Huffman,1984).

3.2 Empirical Methods

3.2.1 Characterization of Dairy Practices

Various methods exist that are used to characterize dairy farm households based on adopted dairy practices including Multivariate techniques involving Principal Component Analysis and cluster analysis (Kaouche-Adjlane *et al*., 2015; Todde *et al*., 2016), Factor analysis (Dantas *et al*., 2016) with only a few of the studies using CATPCA which was used in this study. Compared to other data reduction methodologies, CATPCA supersedes them because it reveal nonlinear relationships between the variables and jointly analyze continuous numerical, ordinal and nominal variables through optimal quantification of values of categorical nature to numeric. Additionally, CATPCA does not assumes linear relationship between variables.

Adoption of dairy practices may not be linear but complex given that dairy farms operate in complex systems where they have to allocate their scarce resources across many enterprises. This is because livestock farming at smallholder level who comprises a majority of dairy farmers in Kenya is generally a subsystem of mixed crop livestock production system rather than a production system in its own right. Similarly, characterization of dairy farms is complex because of many stakeholders involved and large number of variables required to define them and therefore adoption of a dairy practice say farm level may or may not have an influence in the other levels of the value chain. The CATPCA is therefore an appropriate method to reduce the original non-continuous numerical data set to fewer uncorrelated summary variables called Principal Components (PCs) that explain a substantial share of the total deviation in the data set. This study therefore revealed various dairy practices adopted by farmers which were captured using various measurements scale (numeric, ordinal and nominal).

3.2.2 Factors that Influence Adoption of Dairy practices and Intensity of Adoption

Although the number of dairy practices adopted by farmers are possess an integer nature of the data, which would rationalize the analysis of data using a Poisson regression model in place of an ordered probit model, the Poisson regression assumption that adoptions of all practices have an equal probability of adoption is disrupted. This is because, as the probability of adopting for example technical dairy innovation might not necessarily lead to the probability of adopting another technical dairy innovation or organizational or institutional dairy innovation, given the three types of dairy practices (technical, organizational and institutional) can be simultaneously adopted. In addition, Poisson model is recommended for data with zero responses (Cameron & Trivedi, 1998).

This study could have zero responses on adoption of dairy practices particularly organizational and institutional practices. In this case, the zeros could arise from dairy farmers who could not have adopted organizational or institutional practices due preference of other alternatives or due to limited resources or lack of access to organizational and institutional dairy practices. Multinomial logit/probit models can also be used in scenarios where dependent variable is unordered and the choices are independent. A multinomial logit model is however limited by its assumption of Independence of Irrelevant Assumption (IIA) (Train, 2003; Greene, 2007). The IIA assumption implies that the dairy farmer choice between say one of technical dairy innovation or organizational or institutional dairy innovation is not affected by choice of an alternative technical or organizational or institutional dairy practices that are at their disposal. This therefore, causes an overestimation of the probabilities and hence ordered probit model was appropriate. Various studies have used ordered probit model to determine factors influencing adoption of dairy

practices, benefits of participation in producer cooperative societies by dairy farmers and impacts of climate risks on milk production among other studies respectively (Aksoy *et al*., 2011; Alho, 2015; Abbas *et al.,* 2019).

In this study, since technical dairypractices were assumed to be adopted before either adoption of organizational or institutional dairy practices, a double hurdle model was used. The double hurdle model usage is justified because, the dependent variable particularly adoption of dairy technical dairy practices and decision to adopt organizational and institutional dairy practices are made sequentially condition on adoption of technical dairy practices. The first hurdle of adopters of technical dairy practices will be considered as farmers who have adopted at least half (50 percent) of technical practices). The assumption is that dairy farmers could only adopt organizational and/or institutional dairy practicess after adoption of technical dairy practices. The use of a double hurdle model is justified by assumption that productivity at the farm level rely on both adoption of practices and intensity of adoption and therefore it is imperative to consider determinants of both adoption and intensity of dairy innovation adoption.

In determining both the determinants of dairy practices adoption and intensity of adoption of dairy practices, many empirical models have been used. Morris and Alderman (1988) argued that there is no single theory that can fully factor in the different facets of farmers decision making. In principle, the decisions whether to adopt a dairy practices such as technical, organizational or institutional, and how much to invest (the number of dairy practices), can either be made simultaneously or sequentially.

While making decision to adopt dairy practices and intensity of adoption sequentially, adoption decision may precede the intensity of adoption decision (Gebremedhin & Swinton, 2003). In this case, determinants of dairy practices adoption and intensity of adoption decision may differ and therefore a double hurdle model was preferred. A double hurdle model unlike Tobit model that assumes that adoption process is made simultaneously (Gujarati, 1995), assumes that adoption process is made sequentially. In the event that adoption and intensity of adoption decisions are made simultaneously (Sureshwaran *et al*., 1996; Pender & Kerr, 1998) and the two stages affected by the similar factors the Tobit model could be used to analyze factors influencing adoption and intensity of adoption (Greene, 1993).

According to DH model, the determinants of adoption and intensity of adoption are allowed to differ. In the context of adoption of organizational and institutional dairy practices analysis, farmers who perceive low milk production due seasonality in production, exclusion from the value chain and low milk quality decided to either adopt technical, organizational and/or institutional dairy practices or not. This study assumed that a farmer could only adopt organizational and/or institutional dairy practices after adopting technical dairy practices. Therefore, the first hurdle involved the decision on whether they have adopted at least a half (50 percent of technical dairy practices or not.

This is based on the assumption that adoption is influenced by economic, social and demographic factors which are independent of a particular measure taken by the farmer. The first hurdle of the DH model modelled the discrete choice of whether the farmer had adopted half (50 percent) of the technical dairy practices or not, with a specification similar to that of the probit model.

Technical dairy practices included use cross breed, use of improved feed, feed conservation, use of AI services, use of better housing, hygiene milking and use of regular vaccination. The second hurdle was an index of intensity of adoption of organizational and institutional dairy practices. The index was computed as the proportion of number of organizational and institutional dairy practices adopted. The organizational dairy practices included presence of cooling systems, milk sale through cooperatives while institutional practices responses include quality and seasonality based payments, credit schemes for feed, contractual arrangements in milk supply, cooperative society shareholding and change in standard due adoption of practices.

The rationale for taking double hurdle model is that farmers make two sequential choices in their adoption decision and intensity of adoption of dairy practices. Each choice is determined by household demographic characteristics (e.g., education, income level, age, and farm size) and dairy practices characteristics (distance to collection centres, and change of standards of milk due to practices). In the first hurdle (a probit model) determined the probability that a household adopted at least half of technical dairy practices while the second hurdle (Tobit model) determined the intensity of adoption of organizational and institutional dairy practices. In the double hurdle specification, whether a household had adopted at least half of technical dairy practices took two choices of adopting or not and the number of organizational and institutional dairy practices adopted which was a continuous variable represented the intensity of adoption.

3.2.3 Impact of Adoption of Dairy practices on Poverty in the Selected Milksheds in Kenya

The study used an ordered probit regression, a model used to analyse an ordinal outcome variable alongside one or more explanatory variables. This model is used when the outcome variable has more than two ordinal groups. In an ordered probit regression nalysis, the outcome variable is ordered, and has more than two levels. In this study, a wealth index was employed to categorize the possible poverty levels orderly. An index was calculated based on the farmers' score out of the given number of assets owned. The outcome regression models are estimated separately for the several groups of adopters for each package of dairy practices adoption.

3.2.4 Assessment of Dairy Farmer's Perception on Farmer Field Schools

Binary logit model analysed farme's perception on FFS because the outcome variable (perception of FFS) was dichotomous in nature. The value of zero (0) was assigned to negative perception and 1 signified a positive perception.

3.3 Data Sources and Sampling Procedure

This study relied on primary data collected in five counties including Nyeri, Nyandarua, Nakuru, Bomet and Nyamira spread in three processors milksheds namely Mukurweini Wakulima Dairy Limited (MWDL), Happy Cow Limited (HCL) and New Kenya Cooperative Creameries (NKCC) Sotik. Two surveys were conducted, including a baseline survey and a follow up after the AfricaMilk Project implementation.

At the baseline survey, a multistage sampling procedure involving four stages was embraced to select farmers from the common milk collection systems in the three milksheds with an aim of

achieving three objectives. In the first stage, three processors (MWDL, HCL and NKCC) were purposefully identified. The second stage involved sampling of common milk collection systems across the three milksheds. The common collection systems was informed by the method used by processors to receive milk from farmers. Four milk collection systems were finally considered: i) individual farmers supplying milk directly to the processor, ii) traders supplying milk to the processor, iii) cooperative societies aggregating and cooling milk and a processor collects milk, and iv) cooperative societies delivering milk to the processors.

In the third stage, the main production areas (Sub-locations) in each of the milkshed where the selected milk collection systems are located were sampled. Whereas list of all dairy farmers was sought from the Assistant chiefs of the sampled milk collection systems, lists of farmers supplying milk directly to processors, through cooperative societies and brokers were received from processors, cooperative society's representatives and brokers respectively. The fourth and the last stage involved a systematic random sampling 35 suppliers (dairy farmers supplying milk to processors) and 35 and non-suppliers (dairy farmers selling milk to other buyers other than the targeted processors). Overall, 1146 farmers from the three milksheds were sampled.

For the follow up survey, a multistage sampling process was adopted to select 124 dairy farmers in three counties including Nyeri, Bomet and Nyamira which are within the two milksheds namely MWDL and NKCC Sotik because that is where two dairy innovation platforms were established and were operating at the time of the survey. The second stage involved purposive sampling of six (three cooperatives in each milkshed) cooperative societies that had demonstration farms. Dairy farmers to participate in the study were identified by seeking training attendance lists from

processors and cooperative societies. The lists were then sorted and one list per cooperative society was prepared which comprised all participants who attended at least one training. From the list, 160 dairy farmers from MWDL and NKCC Sotik had attended at least one training. The list of farmers also captured the name, cell phone number, and the village of residence.

The third stage involved visiting the villages where these dairy farmers hailed from. A simple random sampling method was then employed to sample farmers . From the list, dairy farmers were assigned a population number and the numbers that were picked, farmers were called and informed about the survey. A total of 124 dairy farmers were interviewed. The 11 key informants considered, included the representatives from seven cooperative societies, owners of demonstration plots' land and DIP representatives.

3.4 Measurement of Variables

The literature review findings helped in identifying the independent. A description of these variables as well as their hypothesized effects on the adoption of dairy practices (technical, organizational and institutional) and their effects on dairy farmers' household welfare specifically poverty status are provided. Adoption of technical dairy practices (TDPs) such as improved cow breeds could result in increased milk productivity and poverty alleviation (Kabunga, 2014). Selling milk through cooperative societies one of the organizational dairy practices (ODPs) could result in higher income among households due to collective bargaining power leading to reduced poverty (Alemu & Adesina, 2015). Adoption of institutional dairy practices (IDPs) such as credit could support farmers in purchasing a hybrid or cross breed cow (Kenduiwa *et al*. 2016; Omillo *et al*., 2013). Due to high productivity of the cow, farmers could receive high income hence reducing

their poverty status. The adoption of multiple dairy practices such as TDPs, ODPs and IDPs could improve farm income and reduce poverty (Zegeye *et al*., 2022).

Education attained by a household head in formal schooling was hypothesized to influence the adoption of practices by a dairy farmer positively and consequently reduce poverty. This is due to the fact that education is a good proxy of managerial ability. An educated farmer is expected to understand and interpret information better than a non-educated one. To add on, farmers with more education are more likely to be more confident in adapting to an practices (Abdulai & Huffman, 2014; Kumar *et al*., 2020).

More dairy farming experience result in farmers obtaining more information about improved technologies and practices from training and membership in farmers groups (Kumar *et al*., 2020). Farming experience significantly influenced the likelihood of dairy practices adoption and its intensity of adoption (Dehinenet *et al*., 2014).

As household size increases, there is likelihood of land size decreasing or family becoming financially constrained to engage in practices that may result to increased costs and time. Conversely, large family size which is a proxy of family labour provision can positively impact milk yield as well as household net income unlike hired labour that poses a moral hazard (Asfaw *et al*., 2012). The study then hypothesizes household size variable to either have a positive or negative effect dairy practices adoption. The negative effect of household size on dairy practices adoption could imply that households with large family size could be poorer than households with small household size (Bersisa & Heshmati, 2016; Kebede & Sharma, 2014).

Farm size captured in acres was hypothesized to either negatively or positively affect adoption of dairy practices. Large farms are likely to support a large number of cows (Kabunga & Ghosh, 2017). Similarly, large farm size is postulated to positively influence the likelihood of farmers participating in organizational dairy practices such as a cooperative milk sale or hub due to an advantage of the economies of scale particularly transportation costs and market information search costs (Rao & Qaim, 2011). On the other hand, farmers with small farms may adopt intensive farming resulting to high productivity of their farms compared farmers with large pieces of land (Chen *et al*., 2011) and hence opt to sell through cooperative than sell their large volume of milk directly. Farm being an asset, the size of farm could have a positive relationship with the wellbeing of households (Kassie *et al*., 2014; Bersisa & Heshmati, 2016).

Household head age was postulated to have a positive or negative effect on adoption of dairy practices. Older farmers are expected to be more experienced in farming activities and capable of understanding the attributes of practices compared to their counter parts younger farmers. Due to more experience in farming by older farmers, they could be risk averse unlike young farmers who could be risk takers and therefore older farmers are less expected to take up new technologies (Adesina & BaiduForson, 1995; Rahelizatovo & Gillespie, 2004). The variable, household head age was anticipated either positively affect adoption of dairy practices as it captures perception to practices hence reducing poverty (Kebede & Sharma, 2014).

Ownership of cross breed or pure breed cattle by dairy farmers measured as a dummy variable was postulated to influence the adoption of dairy practices positively. Rearing of cross breeds has the potential of enhancing milk productivity (Wong & Kibirige, 2009; Wambugu *et al*., 2011). In

addition, ownership of improved dairy cows is likely to positively affect milk commercialization, and food expenditure (Kabunga, 2014), hence reducing poverty.

Distance from farmer's homestead to cooperative society milk collection centre is hypothesized to negatively influence the adoption of practices offered through cooperative societies. This is because of more time and transportation costs associated with long distance to the cooperative societies and therefore dairy farmers may opt to sell their milk to milk vendors instead of selling to a cooperative society (Chagwiza *et al*., 2016; Fikadu *et al*., 2019).

Gender of a household head was assigned a value of 1 for male, and 2 for female and was postulated to negatively influence the adoption of dairy practices. Females are expected to be risk averse to practices and their concern for sustenance of food security and therefore, any technology that appears to affect the known equilibrium is expected not to be readily adopted. The risk averse nature of females could be associated with their limited access to resources and information than their male counter parts (Yesuf & Bluffstone, 2009). Due to failure to adopt practices, female headed households are more likely to be poor than male headed households (Tsehay & Bauer, 2012; Kebede & Sharma, 2014; Teka *et al*., 2019).

Access to credit was expected to have a positive effect on the adoption of dairy practices and the welfare of the households such as poverty (Teka *et al*., 2019; Tsehay & Bauer, 2012; Kassie *et al*., 2014). Table 3.1 outline the the variables, measurement and variable type.

Table 3. 1 General description of variables used in the study

Variable	Description of variable	Measurement	Type
Dependent			
TECHINNOVAT	Adoption of 50 percent of technical practices	1=Yes; 0=No	Dichotomous
ORGINNO/INSTIT	Ratio of organizational and institutional dairy innovation adopted by farmers to total available organizational and institutional	No unit	Continuous
POVERTY	Poverty status	1=Low income; 2=Middle income; 3=High income	Ordinal
Independent			
AGEHED	Household head age	years	continuous
EXPERIENCE	Experience dairy farming	Years	Continuous
INCOME	Total household income	Kenya shillings	Continuous
GEDRHED	Household head gender	1= Male; 2=Female	Dichotomous
HHEDUC	Complete years in formal	Yeas	Continuous
HHSIZE	Household size (Number of	Number	Count
TDCOWS	Total number of dairy cows	Number	Count
DAIRYINGINFOR	Access to dairying	1=Yes; 0=No	Dichotomous
FARMSIZE	Total land size	Acres	Continuous
EMPLOYEES	Number of employees	Number	Count
RECORDS	Keep records	1=Yes; 0=No	Dichotomous
YRCROSSBRED	Years household kept cross	Yeas	Continuous
CREDIT_ACCESS	Access to credit	1=Yes; 0=No	Dichotomous

CHAPTER FOUR: CHARACTERIZATION OF DAIRY PRACTICES IN SELECTED MILKSHEDS IN KENYA USING A CATEGORICAL PRINCIPAL COMPONENT ANALYSIS[1]

4.1 Abstract

This paper sought to characterize dairy practices used by farmers in three milksheds (New Kenya Co-operative Creameries Sotik, Happy Cow Limited and Mukurweini Wakulima Dairy Limited), representing one state, private and farmer-owned processor, respectively. Data were collected using a structured questionnaire from a sample of 1146 farmers. A Categorical Principal Components Analysis (CATPCA) was used to reduce 32 variables into four sets of uncorrelated components. Four categories were identified; principal component (PC) 1 (technical capacity), PC 2 (animal health management), PC 3 (organizational capacity) and PC 4 (milk hygiene). More farmers in the MWDL milkshed adopted technical and organizational dairy practices such as use of artificial insemination (AI) and milk sale through groups, respectively, than farmers in the NKCC and HCL milksheds. The county governments in the milksheds of HCL and NKCC Sotik need to strengthen cooperative societies to boost adoption of artificial insemination through arrangement in which milk is sold and payment of services offered on credit is settled from milk sale and ensure milk market availability throughout the year.

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4.2 Introduction

Dairy production is a key component of the livestock sector in Kenya generating an estimated 12 percent of the agricultural Gross Domestic Product (GDP) and approximately 4 percent of Kenya's total GDP (KNBS, 2019a). As a source of livelihood, the dairy industry supports smallholder dairy farmers summing up to 1.8 million and provide 1.2 million direct and indirect jobs (KDB, 2020). In recognition of this significant contribution of the dairy sector to the economy, the national government together with its development partners has been supporting the dairy value chain actors through various public research organizations, training institutes, Non-Governmental Organizations (NGOs) as well as donor funded programmes. Their support included development of disease resistant fodder, operationalized strategic milk reserves and procurement of milk coolers for counties, supporting the dairy hub, on-farm feed production and silage making, dairy infrastructure, ensuring quality based payment system among others (KDB, 2016; Rademaker *et al*., 2016; Kilelu *et al*., 2017; Ndambi *et al*., 2019).

Although the adoption of promoted dairy practices remains low (Omondi *et al*., 2017), there is limited information on already adopted dairy practices, particularly in the milksheds of Mukurweini Wakulima Dairy Limited (MWDL), Happy Cow Limited (HCL) and NKCC Sotik factory, representing processors that are farmer-owned, privately owned and state-owned, respectively. A milkshed refers to the milk collection area of a single dairy plant and it can be considered as the upstream part of the individual processor's value chain, from the producers and collectors supplying the processor dairy plant. According to Kenya national population census of 2019 (KNBS, 2019), the three milksheds considered in this study comprised counties that have most of the households keeping exotic breeds in Kenya. For instance, MWDL milkshed comprises

three counties Murang'a, Nyeri and Kirinyaga which account for 8.8 percent, 5.5 percent and 3.1 percent of the total 939,916 households who keeps exotic dairy breeds in Kenya; HCL comprises Nyandarua, Nakuru and Baringo county with 6.7 percent, 5.6 percent and 1.4 percent dairy farms with exotic breeds and NKCC Sotik milkshed hosting counties of Bomet, Kericho, Narok and Nyamira with 4.2 percent, 3.8 percent, 2.1 percent and 1.9 percent farmers keeping exotic dairy breeds (Figure 4.1).

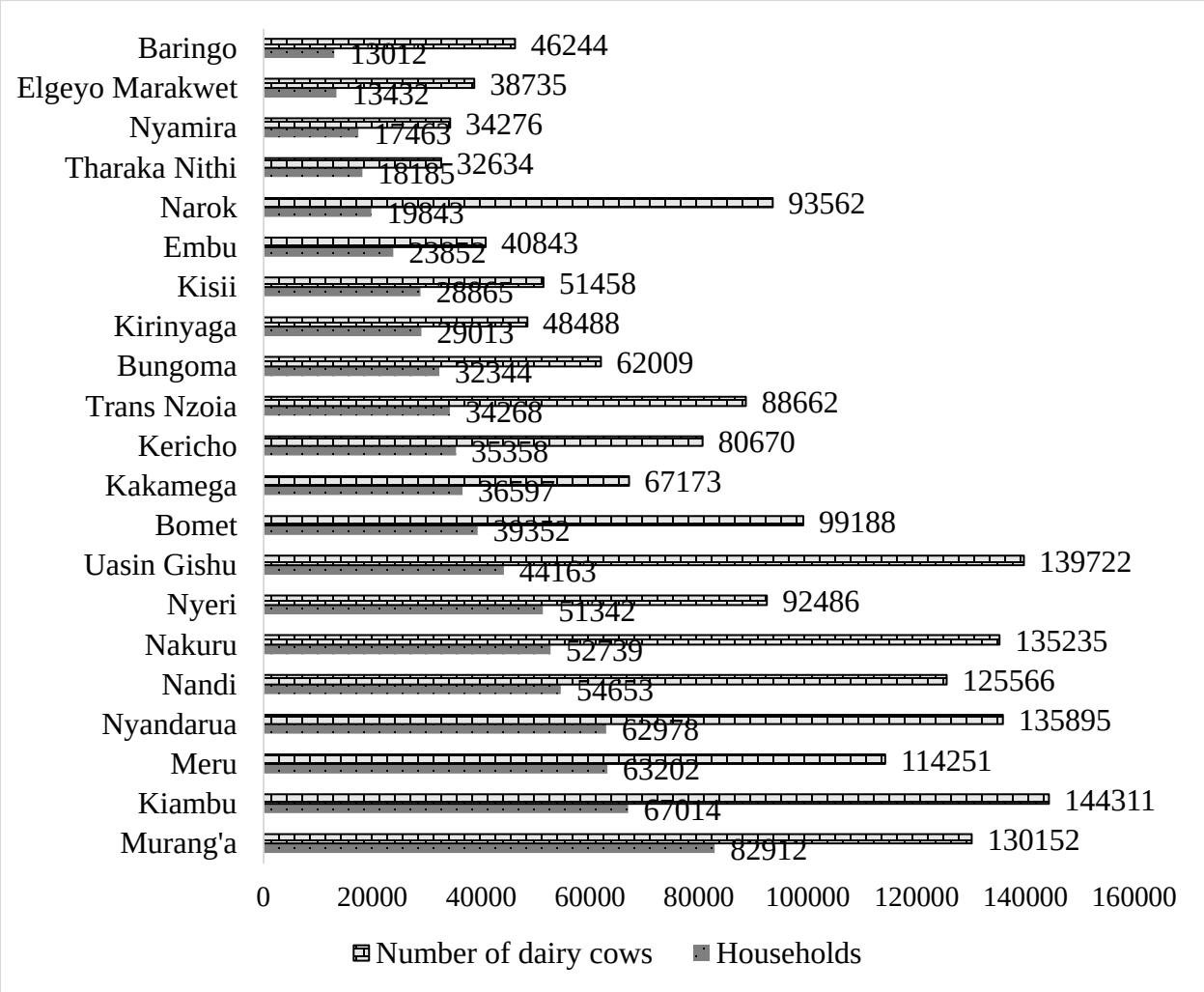


Figure 4. 1 Number of households keeping exotic dairy breeds in 23 counties

(Source: KNBS, 2019)

Unlike the present study that focused on three categories of dairy practices (technical, organizational and institutional), previous studies in these milksheds determined the contribution of one dairy practices that is aimed at increasing milk production and reducing the effect of seasonality. For example, studies by Richards *et al*. (2015) and Richards *et al*. (2019) focused on the effect of feeding high protein fodder trees and other nutritional management factors on the volume of milk sold by smallholder farmers or the impact of feeding minerals on reproductive efficiency on smallholder dairy farms, respectively. Both studies were conducted in the milkshed of MWDL. Another study by Kenduiwa *et al*. (2016) in Bomet county which is within the milkshed of NKCC Sotik, assessed the influence of smallholder dairy farmers' participation in microfinance on breed improvement, while past studies in the milkshed of HCL has revealed the importance of smallholder dairy farmer groups to facilitate transformation of new knowledge to action through collaboration between farmers, researchers, and field assistants (Restropo, 2018), and the significance of improved utilization of crop residues such as treating wheat with urea to maintain milk production during the dry season (Kashongwe *et al*., 2017). Additionally, a study by Nyokabi *et al*. (2018) in the same milkshed revealed that limited enforcement of formal contracts that prescribe the quality of raw milk to be supplied to processors and cooperatives, hinders the enhancement of milk quality.

Dairy practices' characterization is critical for improving their adoptability, identifying possible opportunities and obstacles to their adoption, proving avenues for learning and feedback, guaranteeing the preparation of policies as well as depicting the production categories that are

existing in a particular environment for appropriate introduction of improved technologies (Goswami *et al*., 2014; Kaouche-Adjlane *et al*., 2015; Dantas *et al*., 2016).

This paper characterizes the dairy practices adopted by farmers in the three milksheds. These included housing of cows, herd management practices, feeding, reproduction, animal health, milk hygiene, milk sale channels, access to credit and milk sale based on contracts. Since dairy farming is practiced in almost all agro-ecological zones in Kenya, characterizing the adopted dairy practices is an essential step to provide a practical guideline for the development of appropriate practice options and policy recommendations.

The remainder of this paper is organized as follows: Concept of dairy practices and theoretical background of the study, study area and data collection, methodology, results, discussion and conclusion.

4.2.1 The Concept of Innovation in Dairy Farming and Theoretical Background of the Study

Various authors have defined innovation to include scientific, technological, organizational, commercial and financial activities needed to produce, device, and sell improved products or processes (OECD, 1997; Hall *et al*., 2005). Sumberg (2005) argued that innovation involve science, technology , design and institutional innovation. Following these definitions, practices in the present study included technological, organizational and institutional practices.

Dairy technical practices included animal health care, improved feeding of dairy cows, housing management and reproduction management. Organizational practices, on the other hand, included building new milk collection or cooling centres, creating new private collectors or processing companies (or on the contrary setting up direct milk sales to consumers) and creating farmers' groups or cooperative societies. Institutional practices included changes in the formal and informal rules shaping the milk collection schemes and milk marketing channels, such as contractual arrangements between farmers and collectors or dairies, milk quality payment schemes, public milk quality regulations, loans programs or other financial devices.

Collectively, dairy practices have the potential to improve milk quality, increase milk quantity as well as improve the efficiency of the dairy value chain. For instance, technical practices have been considered likely to increase milk production, decrease seasonality, and improve microbial quality of milk (Wambugu *et al*., 2011). To ensure inclusivity and efficiency within the milksheds, organizational practices could stimulate milk production and reduce milk losses (Odero-Waitituh, 2017). Similarly, institutional practices are expected to encourage dairy farmers to improve their production practices (Holloway *et al*., 2000).

This study was informed by the theory of innovation first proposed by Schumpeter (1934) which explains the contribution of knowledge and technology in boosting productivity and economic development. The theory explores the various ways such as searching markets, combination of factors of production, sales policy and practices in which an entrepreneur can make profits vis-à-vis risk. Additionally, the concept of innovation covers five areas of development that involves new products and services such as production, market, source of raw materials and organization

of industry, all aimed at creating or breaking of a monopoly. These combinations are embODPed in unsold raw materials, new technologies, and idle productive capacity. The theory further recognizes credit and finance as key catalysts for innovation. This theory of innovation by Schumpeter (*ibid*) assumed private firms are important in the development of practices, market is competitive and financial markets are efficient such that they could support the production of new inventions. The theory specifies the role of knowledge in encouraging practices, enhancing new profitable opportunities and growth in the economy, and improvement in standard of life of the community.

The theory was however only applicable in countries with a democratic system. Over time, authors including Freeman (1982) advanced the Schumpeter theory, emphasized the role of design in innovation and viewed all economic development as the result of innovation. Whereas Schumpeter (1934) and Freeman (1982) particularly underlined the role of technological innovation, Van de Ven (1993) recognized that the success of technological practices is determined by institutional innovation representing the social, economic and political infrastructure required by any community to sustain its members.

Following the argument by Van de Ven (*ibid*), technical dairy practices are expected to be successful in the presence of developed infrastructure, including organizational practices. This study is therefore anchored on the theory of simultaneous technical practices on farms and organizational/institutional practices in milksheds in order to increase milk quantity and enhance milk quality.

4.3 Materials and Methods

4.3.1 Study Area

The study was carried out in the milksheds of Mukurweini Wakulima Dairy Limited (MWDL), Happy Cow Limited (HCL) and NKCC Sotik, which are part of the main milksheds in Kenya. The production system in MWDL comprising Nyeri county considered for this study, which is also part of Kenyan highlands is mainly cut and carry system (zero-grazing) (Odero-Waitituh, 2017). The HCL milkshed includes three counties: Nakuru, Nyandarua and Baringo, with the largest proportion of milk being sourced from Nakuru county. This study focused on part of the milkshed within Nakuru and Nyandarua counties where up to 70.5 percent and 16.4 percent respectively, of HCL milk was sourced. The majority of farmers practice semi-zero grazing, a system where cows are grazed during the day and are enclosed and offered supplementary feed at night. NKCC Sotik milkshed includes five counties, namely Bomet, Nyamira, Kisii, Narok and Nakuru. The study was carried out in two counties, Bomet and Nyamira, because up to 80 percent of milk of NKCC Sotik was sourced from these counties. The production system in this milkshed is mainly a free range grazing system where cows graze on natural and/or improved pastures using a paddocking or strip grazing approach, and are also supplemented with fodder.

4.3.2 Sampling Procedure and Data Collection

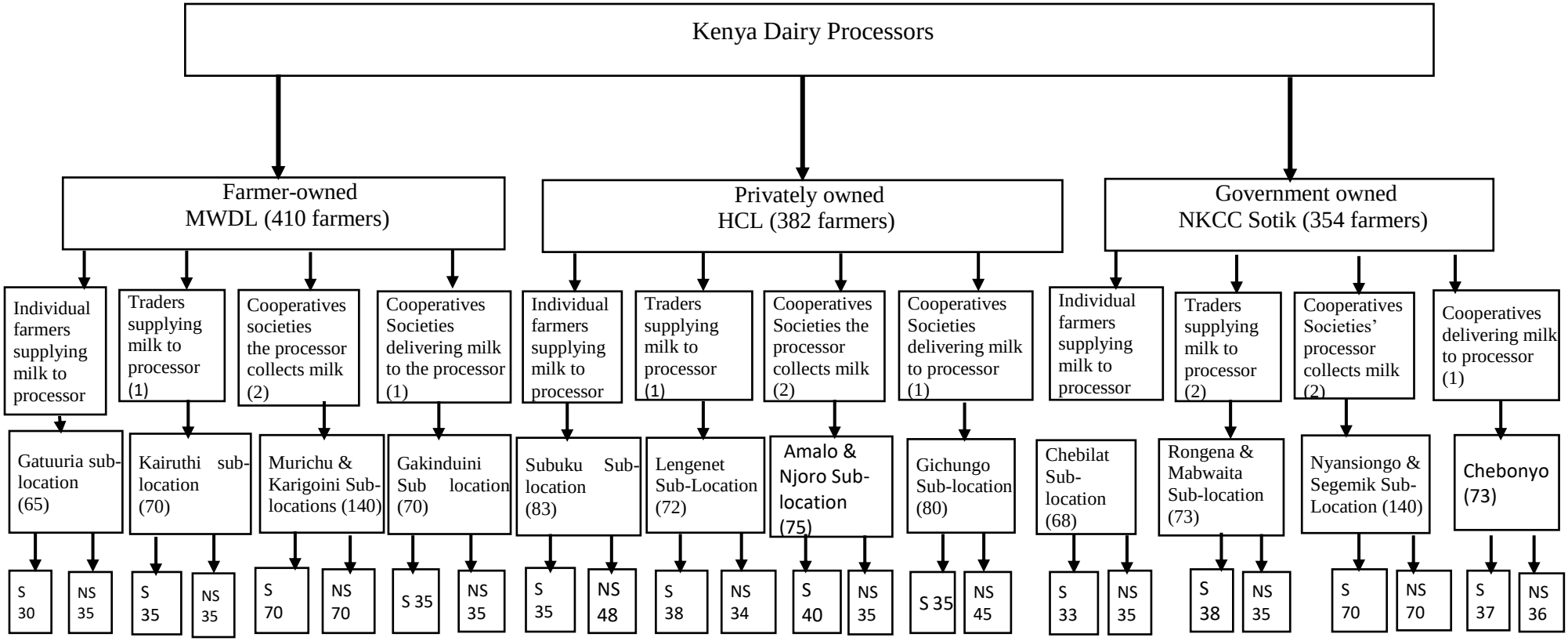
A multistage sampling technique was used to identify households for this study. In the first stage, three milksheds from which the three processors (MWDL, HCL and NKCC Sotik) operate were purposively sampled to represent three processor types: farmer-owned, privately-owned and state-owned, respectively. This selection aimed to clarify if the processor type affected the adoption of practices by its chain actors. The second stage involved sampling of common milk collection

systems across the three milksheds. This stage involved establishment of the criteria for selecting milk collection systems to be considered for the survey. The criteria included systems in which milk is collected and transported to the processor, possibility of aggregating milk before delivering to the processor, and quality aspects such as initial certification and cooling in cooling plants. Four milk collection systems were finally considered: i) individual farmers supplying milk directly to the processor (industry), ii) traders supplying milk to the processor, iii) cooperative societies where a processor collects milk and iv) cooperative societies delivering milk to the processors. The third stage involved purposive selection of the main production areas (Sub-locations) in each of the milkshed where the selected milk collection systems are located. An exhaustive list of dairy farmers from all villages within the main production areas (Sub-locations) of each milkshed was constituted by respective Sub-locations' administrators while the lists of milk suppliers were collected from processors, cooperative societies/self-help group, and traders. The fourth and the last stage involved a systematic random sampling of dairy farmers. In each of the milk collection systems, a total of 35 suppliers and non-suppliers were targeted. Milk suppliers were farmers delivering milk to the processors through sampled milk collection systems while non-suppliers were farmers selling their milk to other buyers.

To determine the specific respondents to participate in the study, regular intervals were chosen to ensure an adequate sample size. These intervals were determined by divIDPng the total number of respondents in both lists (milk suppliers and milk non-suppliers) with the target sample of 35. The value that was obtained was then used to determine the specific respondents in the list who were interviewed. To do this, from the two lists of milk suppliers and milk non-suppliers, the starting respondent of the sample was randomly chosen and the interval added to the random number and

the process of adding the interval continued until the required sample of 35 was achieved. During data collection from sampled respondents, in the event that the identified respondent was not available, replacement was done in which the immediate respondent in the list was interviewed.

With proportionate to size considerations, a total of 1146 dairy farmers comprising 410, 382 and 354 farmers from the milkshed of MWDL, HCL and NKCC Sotik, respectively, were sampled. The distribution of the sample by milkshed's main production areas (Sub-locations) is indicated in Figure 4.2.



Note: S means milk suppliers to the processor and NS means milk non-suppliers to the processor

Figure 4. 2 Sampling procedure used in the study

Dairy practices including cow housing, feeds and feeding, cow reproduction, cow health, milk hygiene, organizational structures and institutional factors were targeted in the data collection using a structured questionnaire designed in the Open Data Kit (ODK) software. The questionnaire was pretested and amended to ensure that all required data was collected for the analysis. Data collection was conducted between July and December 2019 with a reference period of the year 2018. Variables used in the analysis are presented in Table 4.1.

Table 4. 1 Variables used to run categorical principal component analysis

Variable category	Variable name	Variable description and measure
Cow housing	*COWHOUSED*	Whether cows are housed; 1=Yes; 0=No
	FHDRY	Housing frequency dry season; 1=All the time; 2=Night only; 3= when need arises (e.g mating, sick, rain); 4=Other specify
	FHWET	Housing frequency in wet season; 1=All the time; 2=Night only; 3=When need arises (e.g mating, sick, rain); 4=Other specify
	MODE_HOUSEDRY	Mode of cow housing; 1=Stable housing 2=Other types of housing
	MODE_HOUSEWET	Mode of cow housing; 1=Stable housing 2=Other types of housing
Feeds and feeding	*LAND_FODDER*	Area under fodder in acres
	STRFRGE	Store forage in 2018; 1=Yes; 0=No
	CONCENTFEED	Feed livestock with concentrates in 2018; 1= Yes; 0=No
	HME_RATIONS	Home-made rations; 1= Yes; 0=No
	MAINFEEDWET	The main system of feeding in wet season; 1=Only grazing; 2=Mainly grazing with some stall feeding;3= Mainly stall feeding with some grazing; 4= zero grazing)
	MAINFEEDDRY	The main system of feeding in dry season; 1=Only grazing; 2=Manly grazing with some stall feeding; 3= Mainly stall feeding with some grazing; 4= zero grazing
Cow Reproduction	*AI*	AI adoption; 1=A1; 2=Bull
	PRP_PURECOWS	Proportion of pure breeds in the herd; Ratio
Cow health	*DEWORMFR*	Deworming frequency; 1= Monthly; 2= 3 months; 3= 6 months
	DIPSPRAYFR	Frequency of dipping/spraying; 1= Weekly; 2=fortnight; 3=Monthly; 4=Three months
Milk hygiene	*CLEANTEATS*	Clean teats before milking 1=Yes; 0=No
	PREMIPDT	Use pre-milking products; 1=Yes; 0=No
	PSTMILK	Use post milking products; 1=Yes; 0=No
	STMKHR	Hours milk is stored at home before delivery at collection point
	HOURSCOOLER	Hours before milk get to the cooler
	CLEANEQUIPMENT	Cleaning the milking equipment before/after milking; 0=Simple water; 2= Soap and or disinfectant
	REFRIGERATE	Milk refrigerated at home; 1=Yes; 0=No
	DTCTMASTITIS	Detecting mastitis; 1=Yes; 0=No
	WAITDECISION	Decision of withdrawal after cows are treated 0= Arbitrarily; 1= According to product instructions or veterinary advice
	WGLOVES	Wear gloves while milking; 1=Yes; 0=No
	CONTANER_C	Containers closed during milk storage at home; 1= Yes; 0=No
Organizational structures	*MEMBERSHIP*	Group membership; 1=Yes; 0=No
	MILKCOOP	Selling milk through Groups; 1=Yes; 0=No
Institutions	*ACC_CREDIT*	Obtained credit; 1=Yes; 0=No
	LONG_TERMLOAN	Accessed long term loan for dairying; 1=Yes; 0=No
	CONTRCT	Written agreement (Contract) in selling milk; 1=Yes; 0=No
	RECORDS	keep dairy records; 1=Yes; 0=No

4.3.4 Methods of Data Analysis

This paper characterized dairy practices that are adopted by farmers both at the farm and at the milkshed level. The use of CATPCA and cluster analysis in this study was justified by its ability to reveal nonlinear relationships between the variables and jointly analyse numerical, ordinal and nominal variables through optimal quantification of values of categorical nature to numerical values (Linting *et al*., 2007; Mair & De Leeuw, 2010; Manisera *et al*., 2010; Linting & Van der Kooij, 2012). A CATPCA approach is also useful when two assumptions of PCA including linear relationship between variables and assumption that variables have to be scaled at the numeric level (interval or ratio scale of measurement) are not met. For instance, adoption of dairy practices may not be linear, given that dairy farmers operate in complex systems where they have to allocate their scarce resources across many enterprises.

Contrary to the previous studies that have used other methodologies including Principal Component Analysis and Cluster Analysis (Martínez-García *et al*., 2012; Kaouche-Adjlane *et al*., 2015; Martin-Collado *et al*., 2015; Todde *et al*., 2016), Factor Analysis (Dantas *et al*., 2016), to characterize dairy farm households based on adopted practices, socio economic characteristics and cow traits, this study used CATPCA. To add on, although the study has used similar methodology (CATPCA) with other studies (Abas *et al*., 2013; Castro *et al*., 2015; Deng *et al*., 2019) to characterize dairy practices at the farm level, this study has used CATPCA analysis to characterize dairy practices both at the farm and the milkshed level.

4.3.5 Empirical Method

The Non-Linear Principal Component Analysis (NLPCA) function in SPSS 21, also known as Categorical Principal Component Analysis (CATPCA) was used. The Eigen vector plots from PCA were employed to eliminate the highly interrelated variables. Assuming that we have

dimensions on *p* individual on *q* variables given with an *p* × q observed score matrix *L* where each variable is denoted by M_k, k=1…..*q* that is the k^{th} column of *L*, if the variables M_j are ordinal or nominal, then optimal scaling is essential where each observed score is converted into categorical quantification represented by *r* as shown in Equation 4.1 (Linting *et al*., 2007).

$$r_k = \varphi(M_k) \tag{4.1}$$

The analysis is estimated by minimizing the least-squares loss function in which the matrix *M* in Equation 1 is replaced by the matrix *R* (Equation 4.2*).*

$$L(R, A, S) = n^{-1} \sum_{i=1}^{m} tr(r_k a_k^T - S)^T (q_k a_k^T - S) \tag{4.2}$$

The symbol *tr* is the trace function representing any matrix. Assuming matrix A the trace function could be illustrated in Equation 4.3.

$$tr(A^T A) = \sum_i \sum_k a_{ik}^2 \tag{4.3}$$

Equation 4.4 shows the loss function that is subjected to some constraints aimed at homogenizing the changed variables to solve interdependence between r_k and a_j.

$$r_k^T r_k = p \tag{4.4}$$

This standardization indicates that r_k contains z-scores and produces component loadings in a_k reflecting correlations between the transformed variables and principal components.

The object scores are restricted by Equation 4.5

$$S^T S = nI \tag{4.5}$$

where, I is the identity matrix. The object scores are centered as indicated in Equation 6

$$1^T S = 0 \tag{4.6}$$

where 1 is a vector of one.

The software IBM SPSS Statistics 21 (SPSS, 2012) was used for data analysis. Up to 32 variables were selected from the dataset and the criteria for their selection was informed by

their anticipated capability to reveal major disparities that described dairy practices. The selected variables were cow feeds and feeding, cow housing, animal health, reproduction, milk hygiene, marketing of milk through cooperative societies, access to credit, and group shareholding among other factors. These variables were more condensed to a smaller group of uncorrelated components that represented most of the evidence found in the original variables (Meulman & Heiser, 2012). Using the generated components, a K-means clustering method was then used to characterize farm households with distinctive characteristics by grouping dairy farms that were similar. The K-means clustering method was preferred over two-step clustering and hierarchical clustering because the number of clusters was first specified using CATPCA and the data comprised more than 1000 cases (Dardac and Boitan, 2009).

44 Results

The CATPCA results presented in Table 4.2 yielded four (4) dimensions with Eigen values of 7.18, 2.33, 2.26 and 1.72. The Cronbach alpha coefficients for the overall model was 0.956 while for dimensions 1, 2, 3 and 4 were 0.889, 0.589, 0.575 and 0.433, respectively. The values of the Cronbach alpha coefficients were satisfactory meaning that the test for these samples of farms had a good reliability. The four Principal Components (PCs) combined explained 42.15 percent of the total variability in the dataset. The four PCs were described by variables with loadings of 0.5 and beyond (indicated in bold in Table 3.**2**) and they were termed like the to stated variables.

The first PC (technical capacity) explained 22.45 percent of the total variability in the dataset, with eight variables contributing to this dimension. It was strongly and positively associated with housing of dairy cows at night, and during dry and wet season, zero grazing as main grazing system and use of AI. The second PC (animal health management), which explained

additional 7.28 percent of the total variability was positively associated with only one variable, namely a low frequency of spraying or dipping cows. Regular spraying and dipping is an essential part of maintaining animal health and consequent milk production and common in semi intensive and extensive production systems to control tick and tick borne diseases is.

The third PC (organization capacity) explained an additional 7.05 percent of total variability and was strongly associated with two variables, including group membership and milk sale through this group. Whereas group membership had a positive correlation with this component, milk sale through the group had a negative effect. Group membership is vital in assuring a steady market for milk year round, reduction of transactions costs (e.g. transport costs, costs for negotiating of contracts, communication costs) and channelling higher investment into dairy farming. The fourth PC (milk hygiene) explained 5.38 percent of variability and was positively correlated with cleaning equipment with soap and closing container while storing milk at home. Milk hygiene is an important component in ensuring milk quality (Table 4.2).

Table 4. 2 Dimensions and component loadings for variables describing dairy practices (CATPCA results)

	Dimension			
Variables*	1	2	3	4
COWHOUSED	**0.905**	-0.323	-0.206	-0.127
FHDRY	**0.905**	-0.323	-0.206	-0.127
FHWET	**0.905**	-0.323	-0.206	-0.127
MODE_HOUSEDRY	**0.914**	-0.301	-0.206	-0.128
MODE_HOUSEWET	**0.914**	-0.302	-0.206	-0.128
MAINFEEDWET	**0.709**	0.492	-0.144	0.180
MAINFEEDDRY	**0.710**	0.491	-0.142	0.187
AI	**-0.591**	-0.248	0.048	-0.271
DIPSPRAYFR	0.490	**0.521**	-0.249	-0.012
MEMBERSHIP	0.405	0.391	**0.612**	-0.364
MILKCOOP	-0.405	-0.391	**-0.612**	0.364
CLEANEQUIPMENT	-0.134	-0.180	0.119	**0.566**
CONTANER_C	-0.102	-0.042	-0.005	**0.535**
LAND_FODDER	0.313	-0.020	0.126	0.283
CONCENTFEED	0.419	0.082	0.073	0.333
STRFRGE	-0.060	-0.380	0.139	-0.085
HME_RATIONS	0.168	0.054	0.072	0.029
DEWORMFR	-0.022	0.107	-0.162	-0.025
CLEANTEATS	0.162	0.003	0.029	0.237
WGLOVES	0.127	0.136	-0.008	-0.211
PREMIPDT	0.352	-0.185	0.406	0.088
PSTMILK	0.319	0.294	0.180	-0.029
HOURSCOOLER	0.313	-0.101	0.498	-0.022
STMKHR	-0.036	-0.384	0.320	-0.118
REFRIGERATE	0.113	-0.040	0.093	0.027
DTCTMASTITIS	0.091	-0.171	0.222	0.174
WAITDECISION	0.255	-0.272	0.241	0.286
ACC_CREDIT	0.388	-0.142	0.411	0.137
LONG_TERMLOAN	0.105	0.028	0.184	0.189
CONTRCT	0.145	0.031	0.274	0.044
RECORDS	0.258	-0.165	0.391	0.212
PRP_PURECOWS	0.306	0.248	-0.093	0.305
Cronbach's alpha	0.889	0.589	0.575	0.433
Eigen values	7.180	2.330	2.260	1.720
Variance accounted for (%)	22.450	7.280	7.050	5.380

* For abbreviations of variables refer to Table 3.1.

After running CATPCA, the K-means cluster analysis indicated that 365, 450, 196 and 135 farms were classified in cluster 1, cluster 2, cluster 3 and in cluster 4, respectively (Figure 3.2). The clusters were created based on the four dimensions yielded through the CATPCA. Overall,

most (39.3 percent) of respondents were in cluster 2. An analysis across the milksheds indicated that most farmers (65.0 percent and 55.8 percent) in milkshed of NKCC Sotik Factory and HCL were in cluster 1 and 2, respectively, while 40.2 percent and 25.1 percent of the farmers of MWDL milkshed were in cluster 3 and 4, respectively (Figure 4.3).

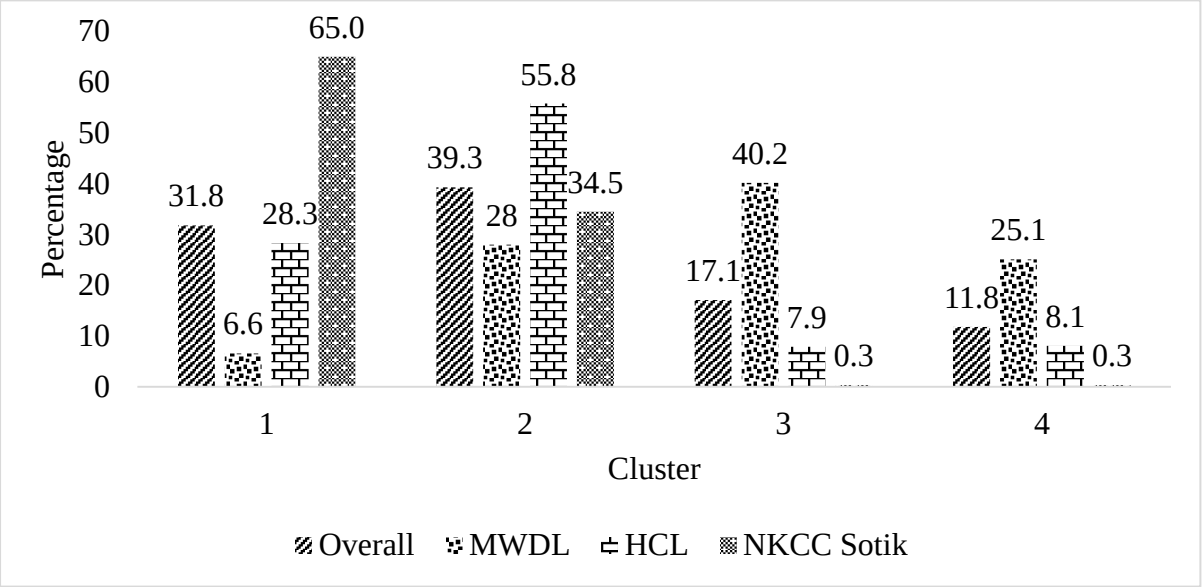


Figure 4. 3 K-means cluster analysis results in percentage by milkshed

The specific elements identifying the four clusters were determined by exploring the percentage of the variables containing the four PCs detailing the main dairy practices (Table 4.3). In cluster 1, it was uncommon to house cows at night (95.6 percent), both during dry and rainy season. The main feeding method during dry and rainy season was only grazing (free range) or tethering (60.8 percent). The bull was the main reproduction method used. Cows were sprayed weekly (66.6 percent) and most of the farmers (76.2 percent) were not member of a group. Accordingly, only 18.9 percent sold milk through groups. Use of soap to clean milking equipment and closing of containers while storing milk were common as indicated by 92.1 percent and 88.0 percent, respectively.

Table 4. 3 Analysis in percentages of four dimensions by clusters

PC 1	Clusters			
	1	2	3	4
Cows housed at night (Yes)	4.4	100.0	95.9	100.0
Frequency of penning dry				
1=All the time	3.8	23.8	86.7	96.3
2=Night only	0.5	73.3	8.7	3.7
3=Occasionally / when need arises (e.g.	0.0	2.9	0.5	0.0
Frequency of penning rainy				
1=All the time	4.1	24.4	87.8	95.6
2=Night only	0.3	72.7	7.7	4.4
3=Occasionally / when need arises (e.g.	0.0	2.9	0.5	0.0
Mode housing dry				
1= Open kraal	4.4	36.7	6.1	0.0
2= Kraal with roof	0.0	54.9	89.3	0.0
3= Brick walled	0.0	0.4	0.0	0.7
5= Stable with roof / no pen	0.0	6.2	0.5	94.8
6= In the house	0.0	1.8	0.0	3.7
Mode housing wet				
1= Open kraal	4.4	37.1	5.6	0.0
2= Kraal with roof	0.0	54.2	90.3	0.0
3= Brick walled	0.0	0.4	0.0	0.7
5= Stable with roof / no pen	0.0	6.2	0.0	94.8
6= In the house	0.0	1.8	0.0	3.7
Main feeding rainy & dry				
1 = Only grazing	60.8	26.9	1.5	.7
2 = Mainly grazing with some stall feeding	31.2	46.0	6.6	3.0
3 = Mainly stall feeding with some grazing	4.9	5.8	4.1	5.9
4 = Only stall feeding (zero grazing)	3.0	21.3	87.8	90.4
Reproduction method (AI)	34.0	67.1	92.9	96.3
PC 2				
Frequency of spraying/dipping				
1= Weekly	66.6	61.6	0	13.3
2= Fortnight	26.0	31.8	0	13.3
3= Monthly	3.8	5.8	20.9	19.3
4= Three months	1.4	.7	19.4	12.6
PC 3				
Group membership (Yes)	23.8	38.9	54.6	57.8
Milk sale through cooperative (Yes)	18.9	33.1	44.9	51.1
PC 4				
Clean milk equipment				
1= Simple water	5.5	9.1	11.2	38.5
2= Soap	92.1	83.6	84.2	55.6
3 =Disinfectant		.2	.5	5.2
Close container while storing milk (Yes)	88.5	81.6	91.8	63.7

Cluster 2 presents farms with cow housing at night (100 percent), with similar proportion during dry season (73.3 percent) and rainy season (72.7 percent). The main mode of housing is a kraal with roof (54.2 percent), and the main mode of feeding is grazing with some stall

feeding (46.0 percent both during dry and rainy seasons). Similar to cluster 1, spraying was done weekly (61.6 percent). Group membership stands at 38.9 percent, and 33.1 percent of respondents sold milk through the group.

In cluster 3, the majority of farmers housed their cows at night, with cow housing taking place at all times during dry and wet season. The main mode of housing is a kraal with roof, both during dry and wet season. Dipping and spraying of cows is uncommon among farmers in cluster 3. The use of AI is more common in cluster 3 as compared to clusters 1 and 2. Group membership is high among farmers and also milk sale through groups is highest in this cluster compared to other clusters. Cleaning of milking equipment is mainly done with soap and milk containers are closed while storing milk at home.

Cluster 4 was characterized by farmers who housed their cows at night (100 percent), all the time during dry and rainy seasons. The main type of housing during dry and rainy season (94.8 percent) is a stable with roof and main feeding type during dry and rainy season is stall feeding (zero grazing). Similar to cluster 3, AI is the main reproduction method used by farmers. Group membership and milk sale are common. Cleaning of milking equipment was practiced by 55.6 percent while closing of containers storing milk at home was done by 63.7percent of the sampled households.

4.5 Discussion

Results of CAPTCA and K-means cluster analysis revealed four categories of dairy practices that were adopted in the study area, including technical capacity (PC 1), animal health management (PC 2), organizational capacity (PC 3) and milk hygiene (PC 4). An analysis of the distribution of farmers among clusters across the three milksheds indicated that most (65.0

percent) farmers of NKCC Sotik (state-owned processor) were in cluster 1 which was characterized by not housing cows at night, use of bull as main method of reproduction, weekly spraying of cows and low proportion of farmers selling milk through groups. The reason for use of bull in reproduction could be as a result of farmers having large pieces of land to rear bulls (Mwanga *et al*., 2019), and farmers getting discouraged to use AI due to its high cost, and cases of repeated inseminations that further increase costs (Mburu *et al*., 2016). The finding of limited use of Artificial Insemination (AI) services was congruent with the findings of Kenduiwa *et al*. (2016) study in Bomet County on smallholder dairy farmers' membership in microfinance effect on cow breed upgrading.

Farmers could also prefer to graze their cows because they own large pieces of land. Spraying was also done because cows are exposed to tick borne related diseases while under free range grazing system unlike when animals are in zero-grazing management systems (Omunyin *et al*., 2014). The low group membership and milk sale through groups could be associated with low milk production in the milkshed which could be a result of keeping local breeds and limited adoption of AI services (Kenduiwa *et al*., 2016).

Regarding privately-owned processor's milkshed (HCL), most (55.8 percent) of the households were classified in cluster 2 which was characterized by grazing with some stall feeding, weekly spraying of cows, housing of cows at night and few farmers selling milk through groups. farmers could be discouraged to sell milk through cooperative societies because they offer lower prices than prices offered by the traders. The importance of group membership specifically cooperative society membership was however reported in this milkshed by Restrepo *et al*. (2018). Restrepo *et al*. (*ibid*) demonstrated that cooperative societies can be used as an avenue for collaborative learning among farmers, researchers and field assistants..

In MWDL milkshed (farmer owned processor), 40.2 percent of the farmers were in cluster 3 that was commonly associated with housing of cows all the time and zero grazing system, use of AI for reproduction, group membership , and selling of milk by farmers through groups. Farmers in this milkshed which is part of Central Kenya region, practice zero grazing due to their small pieces of land and hence limited land to graze their cows (Bebe *et al*., 2003). In addition, farmers with small pieces of land may decide to intensify their farming through genetic improvement such as AI (Didanna *et al*. 2018; Mwanga *et al*., 2019). Contrary, to the results of this study, size of grazing land was reported among the positive and significant factors that influenced smallholder dairy farmers adopt AI in Central Uganda (Mugisha *et al*., 2014).

Furthermore, small landholdings may explain why farmers adopt a zero grazing system. As a result of zero grazing, cows are not exposed to tick borne diseases as cows under free range grazing system and hence the cows are not sprayed. The reason for a larger percentage of farmers selling milk through groups unlike in other milksheds could be because farmers in this milkshed keep cow breeds of high genetic potential as represented by 53 percent, 32 percent and 10 percent of farmers rearing Friesian, Ayrshire and cross breeds respectively (Nyeri CIDP, 2018) and hence producing more milk that is sold through cooperatives. In addition, dairy farmers in this milkshed could be motivated to sell their milk MWDL (farmer-owned processor) because the processor provides financial services to farmers, including AI and animal health services, livestock feeds, credit for education fees and feedstuffs which members pay through a check off system (Van Leeuwen *et al*., 2012). This finding justifies the importance of milk sales through groups and cooperatives in providing an atmosphere appropriate for dairy intensification by enabling the diffusion of information on productivity and also offer milk selling services (Chagwiza *et al*., 2016).

4.6 Conclusion and Recommendations

According to the study results, adoption of dairy practices varied in the three milksheds. More households in MWDL adopted technical dairy practices such as AI and organizational practices including group membership and sale of milk through groups than farmers in the other two milksheds. Grounded on the results of this study, there is need to stimulate adoption of the three categories of dairy practices to boost sustainable milk production quantity and quality. Specifically, the county government in partnership with other development associates should support households particularly in facilitating the adoption of AI to improve on genetics. These efforts should target dairy farmers in milksheds of NKCC Sotik and HCL. To promote organizational practices, farmers in these two milksheds should be supported in forming farmer groups and also offer other services including AI services through a check off system.

This is a system in which farmers are offered services such as AI, feeds and health services on credit and the costs is later paid from the milk sale proceeds. Milk sale through groups will help farmers in ensuring milk market all year round. Regarding institutional dairy practices, the respective county governments and development partners in the three milksheds need to link farmers to financial service providers who can give farmers long term loans to improve their dairying enterprise including purchase of cows of high genetic potential and building houses for cows. Further, dairy farmers should be supported to engage into formal contracts with their buyers which should be based on milk quality and quantity to ensure access to market throughout the year.

CHAPTER FIVE: FACTORS AFFECTING ADOPTION OF TECHNICAL, ORGANIZATIONAL AND INSTITUTIONAL DAIRY PRACTICES IN SELECTED MILKSHEDS IN KENYA[2]

5.1 Abstract

Technical dairy practices (TDPs) including health management, improved cow feeding, and genetic improvement promote milk production while organizational and institutional dairy practices (OIDPs) such as milk sale through groups, access to feed and credit access could enhance efficiency in the dairy supply chain. We examined the determinants of TDPs and intensity of adoption of OIDPs. Data from 1146 farmers were analyzed using a double hurdle model. Our study revealed that access to dairy information positively influenced adoption of technical dairy practices in the three milksheds. Adoption of technical dairy practices across the milksheds was influenced by total dairy cows, dairy records, household head education and hired employees while extent of adoption of organizational and institutional dairy practices was affected by farm size, income, access to dairy information and keeping dairy records. The influence of these variables differed in magnitude and significance levels. Disseminating dairy information in the three milksheds by county government and dairy stakeholders could spur adoption of TDP. Across the milksheds, training farmers on dairy record keeping and access to dairy information, should be promoted to spur adoption of TDPs and OIDPs.

Keywords

Adoption of practices, D*airy farming*; *Dairy practices; adoption intensity; milkshed*

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5.2 Introduction

Dairy farming in Kenya is among the key economic enterprises, supporting an estimated 1.8 million smallholder farmers (KDB, 2020). Besides supporting smallholder farmers, the dairy value chain supports milk transporters, informal milk sellers, and processors as their source of livelihood. The sub-sector contributes 12 percent of the agricultural Gross Domestic Product (GDP) and more than 4 percent of Gross Domestic Product (KNBS, 2019a).

While the country's total milk consumption is growing at a rate of 4 percent per year (MoALF, 2019) the per capita consumption of milk (110 litres) remains the highest in Sub Saharan Africa (KDB, 2015). Often, the milk production is inadequate to satisfy the growing demand, especially during the dry periods. To meet the demand of milk consumers at the time of low milk production in the country, the country import powdered milk and fresh milk. For instance, the value of imported milk from Uganda increased from Kenya Shillings (KES) 19.3 billion in 2016, KES 42.0 billion in 2017 and KES 49.4 billion in 2018 (KNBS, 2018; 2019a).

The decrease in milk quantity has been attributed to several constraints faced by farmers, including limited quantity of feeds and poor quality feeds. Farmers are also discouraged from improving their dairy breeds because of high cost of Artificial Insemination (AI) and low success rates, while dairy cow diseases such as mastitis are becoming prevalent and a lack of access to credit affects milk productivity (Omunyin *et al*., 2014; Kibiego *et al*., 2015).

In response to farmer's constraints, the Kenyan government and the development partners have been supporting the sub-sector through TDPs and OIDPs. The TDPs are adopted at the farm level and aim to increase milk production. Mainly, they include feeding dairy cows, reproduction, animal health, milk hygiene, breeding, and cow housing. The ODPs, include

optimization of collection routes, establiment of collection centers, and introduction of cooling systems that could consist of more producers and reduce milk losses (Odero-Waitituh, 2017).

Changes in the formal and informal directions that regulate milk collection schemes and milk marketing channels, such as quality and seasonality-based payments and feed credit schemes, are examples of institutional dairy practices (IDPs) that are expected to encourage dairy farmers to improve their practices (Holloway *et al*., 2000; Ndambi *et al*., 2019). Among TDPs that the national and county governments have been supporting include developing disease-resistant fodder, on-farm feed production, silage making, and dairy infrastructure. Regarding ODPs, the two levels of government (national and county) focus have been operationalizing strategic milk reserves, procurement of milk coolers for counties, and encouraging milk sale through cooperatives (KDB, 2016; Rademaker *et al*., 2016).

The TDPs activities like local animal feed sourcing, improved cow nutrition, better health management and hygienic milking, reproductive management, and genetic enhancement have been shown to increase milk output quantity, minimize seasonality, and improve milk microbiological quality (Wambugu *et al*., 2011). To enhance the success of DPs adoption by farmers and increase milk quantity and enhancing quality, it is necessary to recognize the factors affecting their adoption. This is because farmers are the primary milk producers in the dairy value chain. Their adoption and continued use of DPs could positively impact the dairy value chain through increased milk supply and enhanced quality.

Past studies have revealed DPs adoption and intensity of use determinants to include farm and farmer characteristics, institutional and dairy innovation attributes. For example, Tebug *et al*. (2012) evaluated the adoption of common dairy practices in Malawi, including stall feeding,

milking practices, stable farm sanitation, farm record, breeding methods, sale of milk, protein supplement, and mineral supplement. On-farm visits by dairy extension workers were positively linked with the adoption of dairy practices. Mugisha *et al.* (2014) assessed factors that influence breeding services used by on smallholder dairy farms in Central Uganda. The findings of this study indicated that the use of AI was positively influenced by the size of grazing land, record keeping, and access to extension services, among others. Aksoy *et al*. (2011), while evaluating determinants of innovation adoption in dairy farms in Turkey, focused on six practices, including artificial insemination (AI), milking techniques, keeping farm records, silage making, cooling tank and a stable technique, and. The study indicated that younger farmers had higher levels of adoption of innovation than older farmers. Probability of benefiting from government support such as policies, animal breed and education of household head had a statistically significant positive influence on innovation adoption.

Still on TDPs, specifically breeding, Mwanga *et al*. (2019) focused on determinants of farmers' breeding decisions in Ethiopia, Kenya, Tanzania, and Uganda. The study revealed that farmer's experience, record-keeping by farmers, water and feeds availability were significantly and positively associated with AI adoption among dairy farmers with a small herd. On the contrary, farmers with large herd size and large farm acreage were not likely to use AI services. Further, the cost of Artificial Insemination (AI) services and the distance covered by the AI service provider reduced the probability of AI adoption as a breeding option.

Contrary to the past studies that focused on adoption determinants of one or several TDPs, this study determined both TDPs adoption determinants and OIDPs adoption intensity together. This is because the dairy value chain is complex and while determining factors affecting TDPs adoption, it is also important to consider OIDPs which compliments the adoption of TDPs.

Additionally, understanding the factors that influence adoption of the three types of DIs is important establishing relevant evidence-based strategies enhancing their uptake by farmers. Further, enhancing milk quantity and quality is important, especially in Kenya, where dairy farming largely contributes to the economy. Moreover, the study focused on MWDL (farmer-owned), HCL (privately-owned) and NKCC Sotik (state-owned). Most farmers in MWDL, practiced zero-grazing, in HCL farmers adopted semi-zero grazing with most farmers in NKCC Sotik practicing a free range-grazing system. Given the different processor types and production systems in these milksheds, dairy practices adoption could be influenced by different factors.

In recognition that farmers are among the main actors and specifically primary producers in the dairy value chain, understanding DPs adoption determinants at the farm and milkshed is important because it can increase milk quantity and enhance quality along the dairy value chain. In addition, few studies have sequentially analyzed different DIs adoption determinants. Therefore, this study contributes to the literature by sequentially modelling the adoption of DIs at the farm and milkshed by fitting double hurdle model. The model results give a broad measure of adoption determinants and intensity of adoption of the sampled dairy practices by dairy farmers practicing different production systems. The objective of this study was to assess the TDPs adoption determinants as well as the intensity of use of OIDPs.

5.3 Study Methods

5.3.1 Study Area

This study was conducted in three milksheds namely MWDL, HCL and NKCC Sotik. Although MWDL milkshed is composed of three counties: Nyeri, Murang'a and Kirinyaga, only Nyeri County was considered for this study because it hosts the processing plant. The milkshed of

HCL comprises three counties, namely Baringo, Nakuru and Nyandarua, and two of them Nakuru and Nyandarua were considered for the study where much of milk is sourced by the processor. NKCC Sotik milkshed comprises three counties Nyamira, Bomet and Narok and two of them Bomet and Nyamira were considered for the study where most milk is collected.

5.3.2 Sampling Procedure and Data Collection

A multistage sampling technique involving four stages was adopted to sample farm households for this study. Firstly, three processors including MWDL, HCL and NKCC representing farmer owned, privately owned and state owned were purposefully identified. Information was then sought from them on the counties they source their milk referred in this thesis as milksheds. This selection aimed to elucidate if the processor type affected the adoption of practices by its chain actors. Secondly, sampling of common milk collection systems across the three milksheds was done and it involved establishment of the criteria for selecting milk collection systems to be considered for the survey.

The criteria included systems in which milk is delivered to the processor, likelihood of aggregating milk before delivering to the processor, and quality aspects such as initial certification and cooling in cooling plants. Four milk collection systems were finally considered: i) individual farmers supplying milk directly to the processor, ii) traders supplying milk to the processor, iii) cooperative societies aggregating and cooling milk and a processor collects milk, and iv) cooperative societies delivering milk to the processors. Thirdly, the main production areas (Sub-locations) in each of the milkshed where the selected milk collection systems are located were sampled. A list of dairy farmers from all villages within sampled Sub-locations of each milkshed was created by respective Assistant chiefs (Sub-locations' administrators) and the lists of milk suppliers were collected from processors, cooperative

societies/self-help group, and traders. The fourth and the last stage involved a systematic random sampling of dairy farmers. In each of the milk collection systems, a total of 35 suppliers and non-suppliers were targeted. Milk suppliers were farmers delivering milk to the processors through sampled milk collection systems while non-suppliers were farmers selling their milk to other buyers. With proportionate to size considerations, a total of 1146 including 410, 382 and 354 farmers from the milkshed of MWDL, HCL and NKCC Sotik) dairy farmers, respectively, were interviewed.

5.3.3 Description of Variables Used in the Model

The dependent variable, *TECHINNOVAT* (TDPs adoption status of a household head at the farm) took values of 1 if a household had adopted at least 50 percent of TDPs or 0 if otherwise. Fifteen TDP were considered; keeping pure breeds, feeding cows with concentrates, use of AI, store fodder, housing of cows, use of aluminum milk can to store and deliver milk to collection centre, preparing home-made rations, growing fodder, observing withdrawal period after treating cows with antibiotics, deworming cows frequently after two weeks, cleaning cow teats before and after milking, detecting cows infected by mastitis, use of pre-milking products, use of post milking products and clean milking containers with water and soap.

The dependent variable, ORGINNO/INSTIT (ratio of number of OIDPs adopted by a farmer to the total number of possible OIDP available for adoption at the milkshed), was used to denote the OIDP intensity of use. Six OIDPs (three ODPs and three IDP) were considered. The ODPs were milk sale through cooperative, cooperative having a chilling plant and milk collection centre equipped with coolers while IDPs comprised access to long term loan, contractual arrangements in milk supply and cooperative society shareholding. The explanatory variables chosen for analysis are presented in Table 5.1 and were based on literature review findings.

Table 5. 1 Description, measurement and hypothesized effects of the variables in the model

Variable	Variable description & measure	Sign	Hypothesized effect
AGEHED	Household head age in years	+/-	Older farmers were expected to be more experienced in farming activities hence adopt DIs. To the contrary, older farmers could be risk averse and therefore less likely to adopt new technologies (Adesina & Baidu-Forson, 1995; Rahelizatovo & Gillespie, 2004).
EXPERIENCE	Years in dairying	+/-	More experience in farming help in understanding the attributes of practices and hence adoption. On the contrary, adoption of DIs could decrease with farm experience due to risk averse nature of older farmers (Kassie *et al*., 2013).
INCOME	Total annual household income in KES	+	High income enable farmers to access resources to invest in the dairy enterprise, such as acquiring dairy cows of high genetic potential.
GEDRHED	Household head gender; 1= Male; 2=Female	-	Females are expected to be risk averse to practices hence negative influence. Their risk averse nature could be associated with their limited access to resources and information than their male counterparts (Yesuf & Bluffstone, 2009).
HHEDUC	Years in formal education	+	More educated farmers are likely to be more confident in adapting to practices (Rao & Qaim, 2011; Abdulai & Huffman, 2014).
HHSIZE	Household size	+/-	Large family size, as a source of labour could positively affect adoption of TDP unlike hired labour that poses a moral hazard (Asfaw *et al*., 2012). Large household size is likely to result in family becoming financially constrained to engage in practices such as growing fodder.
TDCOWS	Total dairy cattle 2018	+	Large herd size is expected to affect DIs adoption positively particularly feed conservation technologies (Birhanu *et al*., 2017).
DAIRYINGINFOR	Access to dairying information; 1=Yes;0=No	+	Access to information can improve farmers' adoption ability by generating effective need for practices (Ayele *et al*., 2012).

FARMSIZE	Total farm area in acres	+/-	Large farms are likely to support many cows (Kabunga *et al*., 2017) hence positively influencing TDP such as growing of fodder. On the contrary, farmers with small farms may adopt intensive farming resulting in high productivity of their farms compared to farmers with large pieces of land (Chen *et al*., 2011) and hence opt to sell milk through cooperative due to an advantage of the economies of scale particularly transportation costs and market information search costs (Rao & Qaim, 2011).
EMPLOYEES	Number of employees	+	The large number of employees is positively associated with adoption of TDP and OIDP such as growing improved fodder and milk sale through cooperative respectively. Hired labour could result to efficient use of resources and consequent more milk production sold through cooperatives (Mburu *et al*., 2007).
RECORDS	Keep records; 1=Yes; 0=No	+	Keeping dairy records is expected to positively influence adoption of TDPs and OIDPs such as AI and credit respectively.
MILKPRICE	Milk price per litre in KES	+	As milk prices increases, farmers get resources to adopt OIDP such as milk sale through collective action like cooperative societies (Hernández-Espallardo *et al*., 2013).
YRCROSSBRED	Years household kept cross breed(s)	+	Rearing of cross-breeds has the potential of enhancing milk productivity (Wong & Kibirige, 2009; Wambugu, *et al*., 2011).
CREDIT_ACCESS	Access to credit 1=Yes; 0=No	+	Access to finances can positively affect adoption of agricultural technologies (Abdulai & Huffman, 2014). Dairy technologies that can be boosted by credit access include cross-breed cows' adoption (Abdulai & Huffman, 2005).

5.3.4. Analytical Framework

Dairy farmers are assumed to adopt a dairy practice (DP) when the utility of DP (P_k) surpasses the utility of a older technology (P_w). The utility gained from a DP is assumed to be a function of the vector of observed socio-economic aspects, supposed DP attributes (M_i), and a random disturbance term.

In an effort to maximize utility arising from adoption of an innovation, a farmer assesses the utility resulting from taking up various technologies and selects the one that is expected to offer higher satisfaction than the older technology (Adesina & Zinnah, 1993). If a farmer's value of accepting a DP in the case of this study TDP and OIDP is signified by P_k (M) and the choosing to adopt the older technology as P_w (M) then, adoption Equations of a DI and older technology are as indicated in Equation 5.1 and 5.2 respectively.

$$P_k(M) = M\beta_k + \varepsilon_k \tag{5.1}$$

$$P_w(M) = M\beta_w + \varepsilon_w \tag{5.2}$$

where βk, and ε_k, in Equation 5.1 of the adoption of DPs are factors and error terms in adoption of DIs and β_w and ε_w in Equation 5.2 adoption of traditional technology are the factors and error terms associated with the acceptance of traditional technologies. The probability of adopting a DP could be denoted by a dichotomous variable Y, value 1 for farmers willing to adopt a DP and zero otherwise. Function of M in Equation 5.3 indicate the probability that a given dairy farmer will adopt the DP.

$$\begin{aligned} L(Y=1) &= L(P_k > P_w) \\ &= L(M\beta_k + \varepsilon_k > M\beta_w + \varepsilon_w) \\ &= L[(M(\beta_k - \beta_w) > \varepsilon_k - \varepsilon_w] \\ &= L(M\beta > \varepsilon) \\ &= C(M\beta) \end{aligned} \tag{5.3}$$

where L is the probability function, $\beta = \beta_k - \beta_w$ represents a direction of unknown factors while $\varepsilon = \varepsilon_k - \varepsilon_w$ indicate the error term and $C(X\beta)$ is cumulative distribution function C assessed at $M\beta$ (Rahm and Huffman,1984). The variance between the expected utility production with the DP adoption and without the DP represents the possible factors influencing farmers' DPs adoption decision. These factors include socio-economic factors, physical capital, financial capital, milk price, access to information and village level factor.

5.3.5 Empirical Model

This study estimated a double hurdle model (DH) to evaluate the adoption of TDP and OIDP. The maximum likelihood parameter estimates, the unrestricted average partial effects (APE), and bootstrapping reproductions on each observation were done using the Craggit command in Stata (Burke, 2009). According to this author, the model estimate the observed coefficient, standard errors and the P-values showing the significance levels. Variance Inflation Factor (VIF) was used to test Multicollinearity test among the independent variables (Gujarati, 2004). The DH model was justified because, the dependent variable, (TDP) and decision to adopt OIDP are made sequentially conditions on adoption of TDP. The study assumed that milk productivity at the farm rely on both TDP adoption and intensity of OIDP use at the milkshed, and therefore it is imperative to consider determinants of both adoption and intensity of adoption of DPs.

According to DH model, adoption determinants and intensity of adoption are allowed to differ. In the context of adoption of DP analysis, those farmers who perceive low production due to seasonality in production, exclusion from the value chain and low milk quality decide to either adopt TDP and OIDP or not. The first hurdle of the DH model modelled the discrete choice of whether the farmer adopted 50 percent of the TDP or not, with a specification similar to that of the probit model while the second hurdle concerned the adoption intensity of OIDP at the milkshed. Both hurdles were conditioned by household demographic characteristics (e.g., household head education, household size, land size and age) and dairy practices attributes (distance to collection centres). The first equation in the DH model represents the decision to adopt TDP (*y*) and is expressed as indicated in Equation 5.4.

$$y_i = 1 if\ y_i^* > 0 and 0 if\ y_i^* \leq 0$$

$$y_i^* = M_i^* \alpha + \varepsilon_i \quad (5.4)$$

where y^* is underlying variable representing innovation adoption that represented by 1 if a household adopted at least half of TDP and 0 otherwise. Coefficient M is a vector of socio-economic characteristics and α is a vector of parameters. The second hurdle representing adoption intensity of OIDP is expressed in Equation 5.5:

$N_i = N_i^* \; if \; N_i^* > 0 \; and \; 0 if \; y_i^* \leq 0$

$N_i = 0$ for non- adoption

$$N_i^* = N_i^{'} \beta + \nu_i \quad (5.5)$$

where N_i represents the proportion of OIDP adopted expressed as a proportion of total OIDP adopted by the farmer. The $N_i^{'}$ is a vector of the farmer characteristics and β is a vector of parameters. The errors indicated by vi and ε_i are assumed to be independent and normally distributed. For both TDP and OIDP, multiple practices were considered. Empirically, the first hurdle (probit model) was estimated as shown in Equation 5.6 and second hurdle (Tobit) Equation 5.7.

$$\begin{aligned} TECHINNOVAT = {} & B_0 + \beta_1 AGEHED + \beta_2 EXPERENCE + \beta_3 INCOME + \\ & \beta_4 GEDRHED + \beta_5 HHEDUC + \beta_6 HHSIZE + \beta_7 TDCOWS + \\ & \beta_8 DAIRYINGIN FOR + \beta_9 FARMSIZE + \beta_{10} EMPLOYEES + \\ & \beta_{11} RECORDS + \beta_{12} MILKPRICE \\ & + \beta_{13} YRCROSSBRED + \beta_{14} ACESS\_CREDIT + \varepsilon_1 \end{aligned} \quad (5.6)$$

$$\begin{aligned} ORGINNO/INSTIT = {} & B_0 + \beta_1 AGEHED + \beta_2 EXPERENCE + \beta_3 INCOME + \\ & \beta_4 GEDRHED + \beta_5 HHEDUC + \beta_6 HHSIZE + \beta_7 TDCOWS + \\ & \beta_8 DAIRYINGIN FOR + \beta_9 FARMSIZE + \beta_{10} EMPLOYEES + \\ & \beta_{11} RECORDS + \beta_{12} MILKPRICE + \beta_{13} YRCROSSBRED + \\ & \beta_{14} ACESS\_CREDIT + \varepsilon_2 \end{aligned} \quad (5.7)$$

5.4 Results

5.4.1 Descriptive Statistics of Variables

Table 5.2 presents the summary statistics of variables used in this study. Farmers in MWDL milkshed were older, more experienced in dairy farming than farmers in the other milksheds while farmers in NKCC Sotik had the highest mean household size (Table 5.2).

Table 5. 2 Descriptive statistics

Variable	Full Sample	MWDL	HCL	NKCC Sotik	χ^2	Kruska Wallis
AGEHED (Mean)	56.12 (14.25)	60.88 (12.75)	56.79 (14.31)	49.87 (13.55)		117.30
EXPRNCE (Mean)	20.02 (14.63)	22.89 (14.75)	20.10 (14.16)	16.62 (14.29)		42.19**
INCOME (Mean)	187,236.44 (179,090.5)	186,372.47 (162,921.04)	202,604.91 (191,521.91)	172,230.74 (182,349.18)		12.08**
GEDRHED (%)	76.2	69.8	76.7	83.1	18.59***	
HHEDUC (mean)	10.47 (4.09)	10.24 (3.91)	10.58 (4.31)	10.64 (4.08)		2.58
HHSIZE (Mean)	4.22 (2.13)	3.20 (1.62)	4.57 (2.24)	5.01 (2.06)		163.87
TDCOWS (Mean)	1.81 (1.59)	1.57 (1.7)	1.79 (1.3)	2.09 (1.7)		55.72**
DAIRYINGINFOR (%)	36	46.3	33.5	26.8	32.95***	
FARMSIZE (Mean)	3.34 (3.017)	2.336 (2.085)	4.052 (3.345)	3.735 (3.257)		*89.68**
EMPLOYEES (Mean)	1.59 (1.14)	1.51 (0.96)	1.66 (1.34)	1.64 (1.10)		876
RECORDS (%)	25.8	27.8	24.6	24.9	1.31	
MILK_PRICE	32.28 (5.30)	32.60 (3.62	33.34 (6.54)	30.77 (5.14)		76.69**
YRCROSSBRED	18.40 (14.34)	20.46 (14.71)	18.33 (13.72)	16.01 (14.23)		30.23**
ACESS_CREDIT (%)	60.82	68.27	60.73	52.26	20.49***	

Note: Numbers in the parentheses are the standard deviations associated with the means for the variables indicated. ***, *mean significant at 1% probability levels.*
Source: Survey data, 2019.

Farmers' mean yearly total income was Kenya Shillings (KES) 187,236.00. There was a significant difference in total earnings between farmers in NKCC Sotik and MWDL and farmers in NKCC Sotik and HCL, all at 5 percent level. Farmers in the milkshed of HCL with the highest mean of KES 202,604.91. Most household heads (76.20 percent) were male and

comparative analysis across the milksheds indicated a significant difference at 1 percent level of gender distribution, with most respondents being male across the three milksheds. Overall, farmers had average years of formal education of 10.47 years. Farmers owned an average of 1.81dairy cows in 2018. About one third of farmers' accessed dairy information and there was a significant difference in information access with MWDL milkshed having the largest proportion of 46.30 percent. Farmers owned a mean of 3.34 acres of land, and farm sizes were larger in HCL (4.05 acres) compared to other two milksheds. Average farm size in MWDL was smaller and significant different to that of farmers in NKCC Sotik. There was however no significant difference in farm size in HCL and NKCC Sotik. Only one third and slightly above a quarter of the sample employed labourers in 2018 and kept dairy records respectively.

The dairy records kept by farmers included breeding, production, sales and purchase of cows and veterinary (treatment). Overall, the mean milk price was KES 32.28, with farmers in NKCC Sotik receiving the lowest mean price (KES 30.77) and farmers in HCL the highest (KES 33.34). On average, farmers had mean of 18.40 experience in keeping cross-breeds with farmers in MWDL with the highest mean of 20.46 and farmers in NKCC Sotik with the lowest mean (16.01 years).

5.4.2 Tests of Association between Independent Variables and Dependent Variables

Correlation analysis was also conducted on variables used in the double hurdle regression model, using Pearson correlations of numeric variables on intensity of adoption and Pearson chi-square for nominal independent variable with adoption. The results of these analyses are presented in Table 5.3.

Table 5. 3 Correlation analysis of independent variables and the dependent variables

Milkshed	**MWDL**		**HCL**		**NKCC**	
Variable	Correlation Coefficient	**P-value**	Correlation Coefficient	**P-value**	Correlation Coefficient	**P-value**
EXPRNCE	-0.0882	0.0746	0.0694	0.1759	**0.1125***	0.0343
INCOME	0.0031	0.9505	**0.2097***	0.000	**0.2755***	0.000
AGEHED	-0.0132	0.7905	-0.0143	0.7799	**0.1385***	0.0091
HHEDUC	**0.1556***	0.0016	**0.1781***	0.0005	0.0859	0.1066
HHSIZE	-0.0259	0.601	-0.0042	0.9349	0.078	0.1432
TDCOWS	**0.1098***	0.0262	**0.1683***	0.001	**0.2453***	0.000
YRCROSSBRED	**-0.2116***	0.000	0.0637	0.2138	0.0745	0.1618
FARMSIZE	-0.0054	0.9137	**0.2371***	0.000	**0.2243***	0.000
EMPLOYEES	**0.1574***	0.0014	0.0768	0.1342	**0.2244***	0.000
Milk_PRICE	-0.0865	0.0802	**-0.3172***	0.000	**-0.2424***	0.000
Variable	χ^2	P-	χ^2	P-value	χ^2	P-
GEDRHED	0.7978	0.372	0.4486	0.503	**4.0786***	0.043
DAIRYINGINFO	**5.1240***	0.024	**20.1609***	0.000	**13.3254***	0.000
RECORDS	0.1414	0.707	11.1238	0.001	**21.6263 ***	0.000
CREDIT_ACCES	**12.4018***	0.000	37.8560*	0.000	**39.7687***	0.000

In MWDL, household head education, total dairy cows owned and employed laborers had weak positive statistically significant correlation while experience in keeping cross-breed cows had a weak negative correlation with intensity of innovation adoption (Table 4.3). Household income, education, total dairy cows owned and, farm size had a weak positive correlation with adoption intensity while milk price had a weak negative correlation with innovation adoption intensity in HCL. The variables experience, income, age of household head, total dairy cows, farm size and employees had a weak positive correlation with intensity of innovation adoption while milk price had a weak negative correlation with of innovation adoption in NKCC Sotik. The results of Pearson chi-square results showed that, except access to dairy information variable that had a positive correlation with innovation adoption across the three milkshed, household head gender and keeping records had a significant positive correlation with adoption only in NKCC Sotik.

5.5 Factors Influencing TDP Adoption in the Three Milksheds

The VIF results ranged between 1.05 and 2.14 for MWDL, 1.06 to 7.15 for HCL and 1.03 and 8.64 for NKCC Sotik an indication of absence of multicollinearity among the continuous variables. Number of dairy cows, dairy information access and access to credit positively influenced TDP adoption, while farm size negatively influenced the adoption of TDP in MWDL. In HCL, access to dairy information, number of employees, dairy records and credit access positively and significantly influenced TDP adoption while milk price had a negative and significant influence. Moreover, the variables access to dairy information, total land, number of employees, access to credit and dairying records positively influenced adoption of TDP while milk price was significant and had a negative influence in NKCC Sotik (Table 5.4).

Table 5. 4 Factors influencing adoption of Technical dairy Practices by milkshed

VARIABLES	MWDL	HCL	NKCC
AGEHED	0.003(-0.0075)	-0.0016(-0.0066)	0.0091(-0.0077)
EXPRNCE	0.0001 (-0.0075)	-0.0062 (-0.0129)	0.0055(-0.0155)
INCOME	1.86e-07(3.04e-07)	5.24E-08(-2.12E-07)	2.90e-07(4.71e-07)
GEDRHED	-0.1691(-0.1703)	0.2622(-0.1874)	-0.0246(-0.2231)
HHEDUC	-0.0135(-0.0215)	-0.0107(-0.0175)	-0.0175(-0.0217)
HHSIZE	0.0515(-0.0503)	-0.0453(-0.0339)	0.0517(-0.0375)
TDCOWS	0.4133(-0.13) ***	0.0935 (-0.0683)	0.0414 (-0.0742)
DAIRYINGINFOR	0.4271(-0.1593) ***	0.2716(-0.1668)	0.3263 (-0.1884) *
FARMSIZE	-0.0634(-0.023) ***	-0.0074(-0.0178)	0.0453 (-0.0251) *
EMPLOYEES	0.08(-0.0903)	0.1992 (-0.0669) ***	0.2172 (-0.0922) **
RECORDS	0.2252(-0.1876)	0.3151 (0.1836) *	0.4295(-0.1966) **
MILK_PRICE	-0.0233(-0.0199)	-0.0624(0.0122) ***	-0.0860 (-0.0182)
YRCROSSBRED	-0.0119 (-0.0076)	0.007(-0.0125)	-0.007(-0.0158)
CREDIT_ACCESS	0.3058 (-0.1557) **	0.4469(-0.1552) ***	0.3859 (-0.167) **
_cons	-0.2496(-0.9094)	0.6118(-0.6475)	0.1651(-0.7587)
Observations	410	382	354
Log likelihood	-95.422452	-140.07215	-116.27777
Waldchi2(14)	41.26	61.7	68.07
Prob> chi2	0.0002	0.000	0.000

Note: ***, ** and * represent significant at 1%, 5% and 10% significant levels, respectively. Numbers in parenthesis are the standard errors
Source: Survey data, 2019.

5.6 Factors Affecting Intensity of Adoption of OIDP

Whereas household head education positively influenced intensity of adoption of OIDP in MWDL, household size, income and number of years that household kept cross-breed. Had a negative effect on intensity of adoption of OIDP. The APEs of total number of dairy cattle, dairy information, milk price and number of year's household kept cross-breed cows were significant. In HCL, income, farm size and access to credit were significant and positively influenced OIDP intensity of adoption, while the number of employees in the farm and milk price had a negative influence. The APEs of gender, dairy record and access to credit were positive and significant, while milk price APE was negative. Whereas household head age, income and dairy information access had a positive and significant effect on adoption of OIDP in NKCC Sotik, dairy records and milk price were significant and had a negative influence. The APEs of age, total income, dairy information, number of employees were positive and significant while APE of milk prices was negative and significant (Table 5.5).

Table 5. 5 Factors affecting intensity of ODPs and IDPs adoption

VARIABLES	MWDL	HCL	NKCC
AGEHED	0.003(-0.0075)	-0.0016(-0.0066)	0.0091(-0.0077)
EXPRNCE	0.0001 (-0.0075)	-0.0062 (-0.0129)	0.0055(-0.0155)
INCOME	1.86e-07(3.04e-07)	5.24E-08(-2.12E-07)	2.90e-07(4.71e-07)
GEDRHED	-0.1691(-0.1703)	0.2622(-0.1874)	-0.0246(-0.2231)
HHEDUC	-0.0135(-0.0215)	-0.0107(-0.0175)	-0.0175(-0.0217)
HHSIZE	0.0515(-0.0503)	-0.0453(-0.0339)	0.0517(-0.0375)
TDCOWS	0.4133 (-0.13) ***	0.0935 (-0.0683)	0.0414 (-0.0742)
DAIRYINGINFOR	0.4271 (-0.1593) ***	0.2716(-0.1668)	0.3263(-0.1884) *
FARMSIZE	-0.0634 (-0.023) ***	-0.0074(-0.0178)	0.0453(-0.0251) *
EMPLOYEES	0.08(-0.0903)	0.1992(0.0669) ***	0.2172(-0.0922) **
RECORDS	0.2252(-0.1876)	0.3151(-0.1836) *	0.4295(-0.1966) **
MILK_PRICE	-0.0233(-0.0199)	-0.0624(-0.0122)	-0.0860(-0.0182) ***
YRCROSSBRED	-0.0119 (-0.0076)	0.007(-0.0125)	-0.007(-0.0158)
CREDIT_ACCESS	0.3058(-0.1557) **	0.4469(-0.1552) ***	0.3859(-0.167) **
_cons	-0.2496(-0.9094)	0.6118	0.1651
Observations	410	382	354
Log likelihood	-95.422452	-140.07215	-116.27777
Waldchi2(14)	41.26	61.7	68.07
Prob> chi2	0.0002	0.000	0.000

Note: Numbers in parentheses are standard errors while ***, ** and * represent significant at 1%, 5% and 10% significant levels, respectively.

5.7 Discussion

5.7.1 Factors Influencing TDPAdoption in the three Milksheds

In the three milksheds, access to finances had a significant positive on TDP adoption, an indication that farmers who accessed credit were more likely to adopt TDP than those who did not. This variable's probability marginal effect (Average Partial Effect) was statistically significant in HCL only and indicated that TDP adoption in HCL increased with 10 percent with access to credit. This finding agrees with Abdulai and Huffman (2005) in Tanzania, who revealed a positive effect of access to credit and the adoption of crossbreed cows. Access to dairy information positively and significantly influenced adoption of TDP in MWDL and NKCC Sotik, an indication that farmers who accessed dairy information were more likely to adopt TDP than those who did not. The APE of this variable was statistically significant in the two milksheds with a higher significance level in MWDL than in NKCC Sotik. This variable's highly significance level in MWDL than in NKCC Sotik could be because most farmers in MWDL belongs to cooperative societies and groups where they are likely to access dairy information. As revealed by APEs, adoption of TDP increased by 5.95 percent and 7.14 percent with access to dairy information in MWDL and NKCC Sotik respectively. The finding agrees to those of other studies on adoption determinants of different agricultural technologies (Lapar & Ehui, 2003; Uaiene, 2011).

Farm size significantly and negatively influenced TDP adoption in MWDL and had a positive influence in NKCC Sotik. The negative sign of farm size on TDP adoption in MWDL could imply that farmers in this milkshed opt to use AI, one of TDP instead of keeping bulls due to limited land unlike farmers in NKCC Sotik who because of relatively large pieces of land could keep bulls and use them for reproduction. The finding in MWDL is consistent with Mwanga *et al*. (2019) findings, who reported a negative influence of land size on adoption of AI.

Number of employees was significant and positively influenced TDP adoption in HCL, implying that as farmers engage more employees, TDP adoption, such as the growing of fodder or improved feeds also increases. The APE of the variable for NKCC was positive and indicated that adoption of TDP increased by 2.77 percent as the number of employees increased by 1 person.

Keeping of dairy records such as reproduction, feed formulation and health records positively influenced adoption of TDP in HCL and NKCC Sotik. The APE of this coefficient in HCL indicated that adoption of TDP increased by 7.72 percent for farmers who kept records compared to those who did not. This finding corroborates Mugisha *et al.* (2014) in Uganda, which indicated a positive influence of record keeping on the use of AI.

Milk price negatively and significantly influenced TDP adoption in HCL and NKCC Sotik. This implies that farmer's decreased adoption of TDP as milk prices increased. The APE of this variable indicated that adoption of TDP dropped by 1.43 percent and 1.39 percent in HCL and NKCC Sotik respectively, when milk price increased by one Kenya shilling. The opposite influence of adoption of TDPand milk price can be explained by seasonal variability in milk production in the two milksheds. When the prices are high, milk production is also low due to limited feeds and therefore farmers are unlikely to adopt TDP.

Total dairy cattle owned positively influenced TDP adoption in MWDL. The APE of the variable revealed a probable increase of 3.11 percent TDP adoption, resulting from an increase of one dairy cow. An explanation could be that as the number of dairy cattle increases, TDP such as use of AI, health services, housing, feeding also increases. Other studies (Asfaw *et al*.,

2011; Shikur and Beshah, 2013) have also found a positive and significant relationship between technology adoption and herd size measured by total livestock units.

5.8 Factors Influencing the Intensity of Use of OIDP the Three Milksheds

Total income negatively influenced adoption of OIDP in MWDL, while the variable had a positive influence in OIDP adoption in HCL and NKCC Sotik. The finding implied that as income increased, farmers in MWDL were unlikely to join cooperative society while in HCL and NKCC Sotik, high income increased farmers' probability of joining cooperative societies. The reason could be that the extra income gained by the farmer from off-farm activity could be used to purchase dairy cows and engage employees to take care of them, and hence prefer to sell through a cooperative which already has a determined payment schedule at the end of the month. The finding agrees with Mburu *et al*. (2007) in Kenya that revealed that the probability of milk marketing through cooperative societies in Kenyan highlands increased if the household head engaged in off-farm work.

Household head education level positively influenced adoption of OIDP in MWDL only. An explanation is that farmers in MWDL who were more educated joined cooperative societies where they could adopt IDP such as credit access than those who were less educated. The reason could be more educated farmers are more likely to be more confident in adjusting to new practices (Rao & Qaim, 2011; Abdulai & Huffman, 2014). This finding corresponds with that of Ngeno (2018) who reported education level had a positive influence on participation in dairy hub by farmers in Kenya.

Household size negatively influenced adoption of OIDP in MWDL. This implied that as the number of persons in the household increased, the probability of the household adopting OIDP

reduced. The reason could be that, as size of household increases, the available land decreases, resulting in decreased milk production to be marketed through cooperative societies. Although this finding coincides with that of Ngeno (2018) in Kenya, who reported a significant negative effect of household on dairy hub participation and contradicts those of other studies which found positive and significant relationship between household size and market participation (Demissie *et al*., 2014; Chamboko *et al*., 2017).

The number of employees negatively influenced adoption of OIDP in HCL. The APE of this variable positive and statistically significant at 5 percent level in NKCC Sotik, indicating increase in the number of employees by one person, increased the probability of OIDP adoption with 2.8 percent. The results agrees with that of Mburu *et al*. (2007) in Kenya that reported a positive relationship between hired permanent labour and marketing milk through dairy cooperatives in Kenyan highlands. In HCL, only few farmers had joined cooperatives and groups engaged in milk selling, hence the negative effect.

Contrary to the expectation, farmers with more years with cross-breeds were unlikely to adopt OIDP in MWDL. Results indicate that, despite the farmers keeping cross-breed cows, there could be other factors such as inadequate feeding that could lead to low milk production, hindering farmers from selling milk through groups or cooperative society. The negative influence of farmers experience on adoption of OIDP such as milk sale through cooperatives is in line with the findings of Kuma *et al*. (2014) in Ethiopia.

Farm size positively influenced adoption of OIDP in HCL an indication that household with big land size can keep a large number of cows, resulting in increased milk production. The farmer may decide to sell the large volume of milk through cooperative societies, therefore

adopting ODP and access credit (IDP) than those with small pieces of land. These results contrast those of Kuma *et al*. (2014) in Ethiopia, who found a negative and significant effect of farm size on household milk market participation.

Keeping dairying records had a negative effect in NKCC Sotik. The implication could be that since most of the dairy records kept were on use of AI, a majority of farmers in NKCC Sotik used bulls for reproduction. Farmers who used AI produced more milk, and therefore they could sell it through cooperative societies. This possibility corresponds to Yeamkong *et al*. (2010) finding, who established that farms that kept records had higher milk yield per farm than those without records.

Milk price negatively influenced OIDP adoption in HCL and NKCC Sotik. This implies that due to low prices offered by cooperative societies in these two milksheds compared to prices offered by milk agents, farmers were unlikely to sell their milk through cooperatives or groups. The results corroborate to those of Mburu *et al*. (2007) in Kenya that revealed a negative relationship between average milk price (KES/kg) and milk marketing through dairy cooperative channel in Kenyan highlands. Similarly, other studies noted that cooperative dairy societies offered low prices compared to other milk marketing channels (Chagwiza *et al*., 2016; Laishram & Chauhan, 2019).

Access to dairy information positively influenced the OIDP adoption in NKCC Sotik, an indication that farmers who accessed dairy information were more likely to sell their milk through cooperative societies than those who did not. Similar findings in Kenya were reported by Mburu *et al*. (2007) who found that membership to dairy cooperative societies was a source of animal production information.

Farmers who accessed credit had a10.28 percent probability of adopting OIDP in HCL. An explanation could be that, access to finances could enhance access to artificial insemination, health services, and feeds resulting in increased milk production and income, farmers could be willing to sell their milk through cooperative societies one of OIDP.

5.9 Conclusion and Policy Implications

This study assessed the TDP adoption determinants, and intensity of use of OIDP in three milksheds of Kenya. The study contributes to existing dairy technology adoption literature by revealing dairy practices adopted by farmers practicing different production systems and selling milk to farmers, privately, and state-owned processors. The study further considered dairy practices and practices adopted at two levels-farm and milkshed. A low adoption of OIDP compared to TDP in the three milksheds was noted. Regarding the TDP adoption determinants, the study revealed that credit access is an important factor on adoption of TDP in the three milkshed. Further, TDP adoption and intensity of use of OIDP were influenced by different factors, which differed in magnitude and significance level across the three milksheds. The study, therefore, revealed varied interventions required to promote dairy practices across the three milksheds. To promote the adoption of TDP in MWDL, focus should be made on the provision of dairy information. The County government and dairy innovation promoters should develop extension approaches that would go toward disseminating dairy information. Regarding OIDP, promoters of these practices should target the large households, less educated and with higher income levels.

In HCL, Adoption of TDP can be boosted by the county government together with TDP and OIDP promoters by training farmers on dairy record keeping. The training should be tailored to reach young dairy farmers. Additionally, farmers should be encouraged to join groups

dealing with milk sale to enhance knowledge and information sharing and access to credit at reasonable interest rates to buy improved cow breeds and animal feeds. Group membership therefore can promote TDP and OIDP adoption. In NKCC Sotik, the county government should enhance access to dairy information and train farmers on dairy records keeping to enhance TDP and OIDP adoption. Efforts should target farmers with large farms and many employees.

CHAPTER SIX: IMPACT OF ADOPTION OF IMPROVED DAIRY PRACTICES ON POVERTY IN SELECTED MILKSHED IN KENYA

6.1 Abstract

Various studies assessing dairy practices adoption impact on poverty concentrated on adoption of a one dairy practices and therefore fails to consider the complementarity of dairy practices adopted at the farm and at the milkshed. This paper used the principal component analysis to create an asset index for each household and thereafter the ordered probit model to identify the impact of improved dairy practices grouped into technical, organizational, institutional and a combination of different dairy practices on poverty status in three milksheds in Kenya. Results indicated that adoption of technical dairy innovation reduced poverty in the three milksheds (Mukurweini Wakulima Dairy Limited, Happy Cow Limited and the New Kenya Cooperative Creameries Sotik) In Mukurweini Wakulima Dairy Limited (MWDL), the likelihood of households to remain poor decreased with the joint adoption of organizational and institutional dairy practices. The study conclude that the adoption of dairy practices at the farm and at the milkshed help in improving the welfare of dairy farmers, and as a result of low adoption rates particularly of organizational and institutional dairy practices, the study suggests that much more intervention by the dairy stakeholders like the development partners, national and county government to promote the adoption of the three types of dairy practices across the three milksheds in an effort to reduce poverty. Special focus should be to the female headed households, particularly in lower income level.

Keywords

Wealth index, Socio- economic status, Poverty status, Milkshed, Dairy practices

6.2 Introduction

Kenya is among the highest milk producing countries in Africa, including Ethiopia, South Africa, and Sudan (Dolecheck & Bewley, 2015). The importance of the dairy sub-sector in economic development and poverty reduction in the country is revealed by its contribution to Gross Domestic Products (GDP) as well as to the livelihoods of dairy farmers. The sub-sector contributes more than 4 percent to the total GDP and 12 percent and 44 percent to Kenyan agricultural sector and livestock GDPs respectively (KDB, 2016; KNBS, 2019). As a means of livelihood, the sub-sector supports about 1.8 million Kenyans and is growing at a rate of about 5 percent per year (MoALF, 2019). At the household level, dairy cow ownership can result in higher incomes, which are associated with increased milk production and sale (Nicholson *et al*., 2004). Moreover, it contributes to food and nutrition security and to rural livelihoods. Promotion of dairy sub-sector therefore, can go a long way in enhancing economic well-being of farmers such as reducing poverty and at the same time contributing to economic development of the country.

Despite the critical contribution of dairy sub-sector to the farmers' livelihood and the country economic development, the sub-sector is faced with low quantity of milk production, particularly in the event of drought. For instance, in the years which Kenya faced a drought like 1990-1991, 1995-1996, 1997-1998, 2006-2007, 2012-2013 and 2016-2017 total milk production declined from 2.74 to 2.50, 2.43 to 2.32, 2.49 to 2.44, 4.21 to 4.01, 4.89 to 4.48 and 5.28 to 4.76 respectively (KDB, 2021).

To reduce seasonality in the event of drought, increase milk production, enhance milk quality and boost dairy productivity which consequently result in increased income, food security and poverty reduction, adoption of dairy practices are important. These dairy practices include

technical dairy practices (TDPs) that are adopted at the farm level, and organizational dairy practices (ODPs) and institutional dairy practices (IDPs) both adopted at the milkshed. Technical dairy (TDPs) including local animal feed sourcing, improving cow feeding, and better health management and hygienic milking, reproduction management, and breed selection have been reported to result in increased milk production quantity, decreased seasonal fluctuations, and improved microbial quality in East Africa (Wambugu *et al*., 2011).

Further, adoption of improved cow breeds had statistically significant effect on increasing milk productivity and reduced household poverty in Uganda (Kabunga, 2014), dairy income and livestock income in Assam, India (Bayan & Dutta, 2017; Bayan, 2018). Improved cow feeding such as feeding cows on oat and vetch were found to increase milk production and milk quality in terms of butterfat, solid-non-fat, lactose and protein in central Kenya (Mwendia *et al*., 2018).

The impact of the ODPs including collective milk sales collectively through cooperative societies, setting up a cooling center, creating new private collector or processing companies on milk yield, farm income and poverty reduction has been reported by various studies (Alemu & Adesina, 2015; Rao *et al*., 2016; Bayan, 2018; Ngeno, 2018). Specifically, on milk sale through cooperatives, farmers' participation in dairy cooperatives impacted positively to milk yield and farm income in Ethiopia (Alemu & Adesina, 2015) and India (Bayan, 2018).

Similarly, farmers' participation in the dairy hub resulted in increased milk yield and milk income in Kenya (Ngeno, 2018). The positive effect of participation in dairy hubs was also reported in Kenya and Uganda where farmers who sold their milk through the dairy hub to the processors had a higher income than their counterparts who did not participate (Rao *et al*., 2016). This implied that milk sale through hub offered higher prices compared to that offered

by other buyers. On the contrary, dairy cooperatives were insignificant in improving milk yield and milk price in India (Kumar *et al*., 2011; Laishram & Chauhan, 2019). Cooperative societies were also found to largely facilitate technological transformations and commercialization although they offer low milk prices (Chagwiza *et al*., 2016).

On IDPs which includes milk sale through contracts, quality-based payment system and access to credit, studies have revealed lack of effect or positive effects on milk quality and quantity. For instance, milk sale contract had no effect on milk production and cow productivity in Ethiopia (Alemu & Adesina, 2015). Bonus payment was effective compared to sanctions in ensuring dairy farmers produce high quality milk in Vietnamese (Saenger *et al*., 2013). From the reviewed literature, existing studies on adoption of dairy practices have considered adoption of TDPs, ODPs and IDPs separately. There is therefore a dearth of information on the contribution of the three types of DIs including TDPs, ODPs and IDPs jointly on poverty status. Furthermore, there are limited studies on evaluation of effect of TDPs, ODPs and IDPs on household poverty status. This study therefore determined the contribution of the three categories of dairy practices and their combination in support of poverty alleviation.

Poverty can be categorized into either relative or absolute. Absolute poverty is also known as extreme poverty or abject poverty, and it involves the scarcity of basic food, clean water, health, shelter, premature death, ill-health, illiteracy, homelessness and lack of clothing (United Nations, 1996). On the other hand, relative poverty is when a person is regarded as poor in comparison to other persons living in the surrounding (Rigg, 2018). Understanding the relationship between dairy practices and absolute or relative nature of poverty is essential on informing on necessary interventions regarding dairy practices that can alleviate poverty among dairy farmers.

Understanding the effect of DP on either absolute or relative nature of poverty is important for three reasons: Firstly, milk quantity and quality is of a concern given the recent new Dairy Industry (Registration, Licensing, Cess and Levy) Regulations, 2021 proposed by Kenya Dairy Board that requires farmers to comply. The regulation stipulate that milk should be processed (preferably through industrial pasteurization process), chilled and transported using adequate transport means. It should also be traceable and subjected to milk safety and quality testing at different stages (Muunda *et al*., 2021). To comply with these regulations, farmers need to adopt some of the DPs geared towards enhancing milk quality. Secondly, the government of Kenya Vision 2030 outlined in its Medium Term Plan Three (MTP III) (GoK, 2018) and Big four Agenda its support for DPs.

Additionally, fostering practices among farmers has become the quality and quantity focus by some counties in Kenya including Nakuru. The County launched a Nakuru County Dairy Value Chain Strategic Plan (2019-2023) in 2020 and it seeks to increase milk production and improve safety and quality standards of dairy products to access regional markets (Nakuru County Dairy Value Chain Strategic Plan - 2019-2023). Thirdly, few studies exist that have assessed the effects of DIs on poverty. Moreover, the studies that have determined the effect of DIs on poverty have focused on single dairy practice, unlike in this paper which assessed several dairy practices adopted at the farm and at the milkshed. Using a single dairy practice as a proxy for adoption of dairy practices may provide a limited representation for the effect of dairy practices adoption on poverty.

6.2.1 Relationship Between Livestock, Dairy Practices and Poverty Reduction

In Kenya, although, the proportion of people living below the poverty line has been decreasing over time (from 52.3 percent in 1997/1998 to 46.8 percent in 2005/2006 and 36.1 percent in 2015/2016) (KIPPRA, 2020), the percentage of poor people is still high in rural areas at 70 percent (World Bank Group, 2018). This trend is similar to other smallholder farmers in rural Africa who face high levels of poverty (Radeny *et al*., 2012; Barrett *et al*., 2015). The high proportion of poor people in rural areas could be attributed to their reliance on the agriculture sector composed of crop and livestock systems as a source of livelihood. These systems are characterized by inefficient agricultural practices, rapid population growth, land fragmentation and limited access to markets which contribute to the high poverty levels (United Nations, 2015).

Promotion of dairy sub-sector is crucial in reducing poverty among households particularly in rural areas where poverty levels are still high at 40.0 percent compared to the national average of 36.1percent, peri-urban (27.5 percent) and core urban (29.4 percent) (KIPPRA, 2020). This is because first, the sub-sector is among the largest agriculture sub-sector after meat, horticulture and vegetable; and animal oil and fats (KIPPRA, 2018). Secondly, the sub-sector is a source of livelihood to 1.7 million Kenyans (MoALF, 2019) and hence its enhancement is likely to reduce poverty particularly among the poor households who primarily rely on livestock as a major asset, a source of income and high quality nutrients (Herrero *et al*., 2013).

Similar to other agricultural ventures, where practices have been identified as a key driver to productivity growth in agriculture (OECD, 2013), dairy sub-sector can be enhanced through promotion of dairy practices which are likely to spur productivity consequently leading to poverty reduction among the rural households. Dairy practices (DIs) can be categorized into

two namely those that are adopted at the farm (TDPs) and those that are adopted at the milkshed (ODPs and IDPs). The TDPs are aimed at increasing milk productivity, and they include adoption of Artificial Insemination (AI), rearing of crossbreed cows, improved feeding, cow housing and milking hygiene. These practices result in increased milk production and quality, decrease seasonality, improve microbial quality (Van der Lee *et al*., 2014).

Various studies have revealed the association of these DIs with reduced poverty. For instance, the effect of crossbreed cow ownership on poverty reduction was reported by Kabunga (2014) study, which examined the effects of improved cow-breeds on per-cow productivity and effects of adoption of improved dairy cows on the alleviation of poverty in Uganda. Results revealed that adopting improved dairy cows resulted in increased milk productivity and reduced household poverty. Related findings were also reported for Peruvian Andes of Peru by Kristjanson *et al*. (2007), using a binary logistic regression analysis. While determining factors associated with poverty status, the study found that intensification of livestock activities through improved breeds helped many households escape poverty. Regarding livestock disease control Perry and Rich (2007) study on poverty impacts of foot and mouth disease (FMD) and the poverty reduction implications of its control, revealed that FMD control was an important component of poverty reduction strategies for livestock enterprises.

Organizational dairy practices (ODPs) such as formation of cooperatives are capable of including more producers in the market by reducing transaction costs incurred by an individual producer (Holloway *et al*., 2000). Further, through collective action such as milk sale through cooperative societies, milk producers can access new markets where they can get better milk prices and consequently maintain market position (Lijia & Xuexi, 2014). Also, ODPs have the potential of reducing poverty of the households, given that they are primarily adopted to fight

exclusion and inefficiency within the milk supply chain. This implies that poor farmers can take part in collective marketing of milk which can lead to vertical integration that results in increased income. Two studies Cook (1995) and LeCren *et al*. (2009) revealed an association between collective action, vertical integration and increased smallholder farmers income. Similar findings were reported by Alemu and Adesina (2015) in Ethiopia where dairy farmers who sold their milk through cooperative society had higher incomes, higher milk production and better cow productivity than farmers who sold through the spot market.

Beyond ensuring inclusivity in milk supply chain and ensuring efficiency, ODPs have been found to positively influence milk production, farm income, employment, technology adoption and poverty reduction. For example, Bayan (2018) studied the impacts of dairy cooperatives in smallholder dairy production systems in India, and revealed that farmers' participation in dairy cooperatives had a positive impact on milk yield, farm income, and employment of farmers. Participation in cooperative society and specifically as a way of ensuring technological transformation and commercialization was highlighted in Ethiopia (Chagwiza *et al*., 2016). The findings of this study further indicated that cooperatives offered low milk prices. Another study on technological transformation, determined the effect of extension on the livelihood capital of smallholder dairy farmers and reported that the intervention increased production, and improved farmer-to-market linkage and maximised profit and income (Uddin *et al*., 2020). The study further reported that increased extension communication, milk production and higher income were among the main determinants of farmers' improved assets base.

Mhembwe and Debe (2017) study on the role of cooperatives in sustaining the livelihood of rural communities in Zimbabwe revealed that cooperative membership resulted in poverty reduction. Contrary to studies that reported positive effect of ODPs on milk quantity and

quality, Laishram and Chauhan (2019), indicated that dairy cooperatives were insignificant in improving milk yield and milk price in India.

Institutional dairy practices (IDPs) have been identified critical in encouraging dairy farmers to improve their dairy practices (Holloway *et al*., 2000). These IDPs include milk marketing through hubs, contractual arrangements between farmers and collectors, written contracts between farmers and dairies, milk quality payment schemes, public milk quality regulations, loans programs or other financial devices. Access to credit, one of the IDPs has been reported to support adoption of TDPs such as purchase of a cross-breed cow in Kenya (Kenduiwa *et al*., 2016). Also, a study by Omillo *et al*. (2013) on the role of microfinance institutions in Bunyala District, Western Kenya reported similar results that showed that availability of microfinance had a positive effect on the farmers' improvement of dairy breeds. Contrary to the expectations that use of contracts are likely to affect cow productivity, milk income and household income, Alemu and Adesina (2015) study in Ethiopia indicated contradicting results that milk sale contract had no effect on milk production and cow productivity.

6. 3 Methodology

6. 3.1 Study Site and Sampling

A multistage sampling technique was used to sample 1146 dairy households from three milksheds supplying milk to processors with different ownership status namely MWDL (farmer-owned), HCL (privately-owned) and NKCC (state owned) Sotik. The first stage involved selection of three processor's milkshed namely MWDL, HCL and NKCC. In the second stage, sampling of common milk collection systems across the three milksheds was done. Selection of the common milk collection was based on milk delivery method to the processor's, and it included i) individual farmers supplying milk directly to the processor, ii)

traders supplying milk to the processor, iii) cooperative societies aggregating and cooling milk and a processor collects milk, and iv) cooperative societies delivering milk to the processors. The third stage involved selection of the main milk production sub-locations. After identification and selection of the sub-locations, with the support of the respective assistant chiefs, the village elders prepared all the households in the sub-location and the lists of milk suppliers were collected from processors, cooperative societies/self-help group, and traders. In the fourth stage, a systematic random sampling of dairy farmers. In each of the milk collection systems, a total of 35 suppliers and non-suppliers were targeted. Milk suppliers were farmers delivering milk to the processors through sampled milk collection systems, while non-suppliers were farmers selling their milk to other buyers. With proportionate to size considerations, a total of 1146 including 410, 382 and 354 farmers from the milkshed of MWDL, HCL and NKCC Sotik dairy farmers, respectively, were interviewed.

6.3.2 Variables Measurements and Description

Dairy Practices (DIs) were categorized into technical dairy practices (TDPs), organizational dairy practices (ODPs) and institutional dairy practices (IDPs). Adoption of dairy practices (DIs) under each category was considered by summing up all practices adopted under each category. Fifteen TDPs were considered which included; keeping pure breeds, feeding cows with concentrates, use of AI, store fodder, housing of cows, use of aluminium milk cans to store and deliver milk to collection centre, preparing home-made rations, growing fodder, observing withdrawal period after treating cows with antibiotics, deworming cows frequently after two weeks, cleaning cow teats before and after milking, detecting cows infected by mastitis, use of pre-milking products, use of post milking products and clean milking containers with water and soap.The ODPs considered included adoption of milk sale through cooperative

societies, cooperative having a chilling plant and milk collection centre equipped with a cooling system.

The IDPs considered comprised access to long term loan, contractual arrangements in milk supply and cooperative society shareholding. The three dairy practices included in this study (Technical, organizational and institutional) and their combinations measured as interaction between these dairy practices are all expected to increase milk production and improve milk quality as well as reducing poverty among the households. The five variables (TDPs, ODPs, IDPs, TOC, OI) were then used as an independent variable in the determination of the effect of dairy practices effect on the poverty status of the household. These independent variables were postulated to positively or negatively influence the household poverty status.

6.3.3 Poverty Status Measurements

Poverty status was determined using asset ownership indicators by applying a principal component analysis (PCA) to the data to derive a social economic status (SES) index. The study used 32 asset variables, which were grouped into four categories. The first three variables were on ownership of communication assets (radio, television and phone/cell phone). Second, 13 variables were on buildings (livestock yards and pens for cattle, cattle stall, milking room, dairy and cheese factory, sheep and goat farms, forage sheds, hayloft, silage silo, well, drilling with pump, manure pits, biogas digester and solar panels). Third, six variables on transportation (bicycle, motorcycle-motorbike, tricycle, car, truck and cart). Fourth, 10 assets on significant farm tools, machines and equipment (tractor, plough/harrow, wheelbarrow, seeder/weeder, milking/milk storage equipment, machete, spraying knapsack, chaff cutter, baler and water pump). These variables were used to create a wealth index that classified household into SES.

To begin with, the selected variables were explored by running descriptive analysis, specifically a frequency of each variable. Variables that are capable of distinguishing relatively "wealthy" households and relatively "low income" ones were retained. To do this, variables that were owned by more than 95 percent or less than 5 percent of the sample were excluded from the analysis. Among the 13 variables that were excluded were ownership of phone, cheese factory, hayloft, silage silo, drilling with pump, biogas digester, tricycle, truck, cart, tractor, seeder, baler and water pump. For the remaining variables which were captured in categorical nature (yes/no) were recoded into scale variables where yes took a value of one (1) and no a value of zero (0). A principal component analysis was then used to create the wealth index.

The PCA approach was used to reduce the dimensionality of the data set and identify new meaningful underlying variables. The first principal component that explains the largest proportion of the total variance and was used as the wealth index (a continuous variable) to represent the household's wealth (Filmer & Pritchett, 1999). From the wealth index created, factor scores were obtained and cut-off points established to distinguish households into three broad SES categories. To establish the cut-off points, the study adopted the criteria used by Filmer and Pritchett (2001) that include the grouping categories of poverty index to low income, middle income and upper income. The factor scores showed the household with the most score and the least scores, meaning that the households with the highest score (from the possession of most weighted assets) were likely to be in the high SES and those with the lowest score due to owning less weighted assets fell into either low/middle SES.

6.3.4 Estimating the Impact of Dairy Practices on Poverty using Ordered Probit Model

Using the poverty index established using PCA, households were divided into three poverty categories: low income, middle income and high income. The study assumed that the poverty

categories can be ordered because poverty status was captured in three categories (low income, middle income and high income and therefore an ordered probit model was used. The ordered probit model evaluates the statistical significance and direction of the association of each inependent variable to each level of poverty. The marginal effects show the probabilities that a farmer falls in poverty level in the three groups given a set of farmer attributes and farm characteristics. The sign in the coefficient estimates and their statistical inference specifies the direction of the association (Verbeek, 2004).

An ordered probit model was appropriate because the dependent variable is ordered and it can identify factors influencing a dependent variable (poverty). An assumption of presence of a latent continuous metric underlying ordinal response was applied. Assuming a latent continuous variable say y^* , that is a linear combination of some predictions say x in addition to a an error term assumed to have a standard normal distribution ($\varepsilon_i \sim N(0,1), \forall_i = 1,\ldots N$). The ordered response variable (y) conditional on the explanatory variables (x) can be derived from the latent variable model. Assume that the latent variable y^* is determined as in Equation 6.1:

$$y^* = x\beta \mid + \varepsilon \mid x \sim \text{Normal } (0, 1) \qquad (6.1)$$

where β is a K × 1 and, for reasons x does not contain a constant. Given that in this study there are three categorical variables, there are two cut points. Given the standard normal distribution for

ε, the conditional distribution of y given x can be computed as in Equation 6.2

$$\begin{aligned} p(y=1 \mid x) &= p(y^* \le k_1 \mid x) = p(x\beta + \varepsilon \le k_1 \mid x = \phi(k_1 - x\beta) \\ p(y=2 \mid x) &= p(k_1 \le y^* \le k_2 \mid x) = p(x\beta + \varepsilon \le k_1 \mid x) = \phi(k_2 - x\beta) - \phi(k_1 - x\beta) \\ p(y=3 \mid x &= p(y^* \ge k_3 \mid x) = p(1 - \phi(k_3 - x\beta) \end{aligned} \qquad (6.2)$$

The parameters *k* and β can be estimated by maximum Likelihood. In this chapter, the interest is in how ceteris paribus changes in the elements of dairy practices adoption affect the response probabilities, $P(y = j|x), j = 1,2,..J)$.

The partial effects of the explanatory variables on the different categories can be computed as in Equation 3

$$\frac{\partial y_1(x)}{\partial x_k} = -\beta_k \phi(k_1 - x\beta), \frac{\partial p_j(x)}{\partial x_k} = \beta_k \phi(k_j - x\beta)$$
$$\frac{\partial y_j(x)}{\partial x_k} = \beta_k \phi[(k_{j-1} - x\beta) - (k_j - x\beta)], 1 < j < J \quad (6.3)$$

where y_i is the dependent variable (poverty), β' is a vector of estimated parameters and *x* is the vector of explanatory variables and Φ refers to cumulative distribution.

6.3.5 Data Analysis

Principle Component Analysis (PCA) and ordered probit regression analysis were conducted using Stata software (version 14). As a first step, descriptive analyses specifically frequencies for all the variables was conducted. Descriptive analysis informed on the variables to include in the analysis, and highlighted data management issues, such as cODPng of variables and missing values. A principal component analysis was then used to create the wealth index. Using the method of creating wealth index like in other studies (Filmer & Pritchett, 1999; Booysen *et al*., 2008; Lokosang *et al*., 2014; Habyarimana *et al*., 2015), households were classified into five quintiles as follows; first quintile (20 percent) as poorest, second quintile (20 percent) as poor, third quintile as middle (20 percent), fourth quintile (20 percent) as rich and the fifth quintile (20 percent) as richest (highest). Following this classification, this study used 10^{th} (lowest), 20^{th}, 40^{th}, 50^{th} and 80^{th} percentiles. Afterwards, the two lower quintile (poorest and poor) were combined and recoded as the lower income, the two middle (middle income and

upper income) were combined and recoded as middle income and the remaining was recoded as the upper income. Households were therefore assigned to low income 40, middle income 40, and upper income 20 percentiles. Using the three categories of poverty, an ordered probit model was then conducted on the data to determine the impact of dairy practices on poverty.

6.4 Results

6.4.1 Descriptive Results

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (0.681) was found to be satisfactory because it was above the recommended minimum acceptable value of 0.6 (WFP, 2017). The KMO measure the appropriateness of factor analysis in yielding distinct and reliable factors (Field, 2013). To test reliability of asset index for the 19 retained variables, PCA analysis scree plot (Figure 6.1) shows the cut-off points of the seven principal components with Eigen values of above 1.

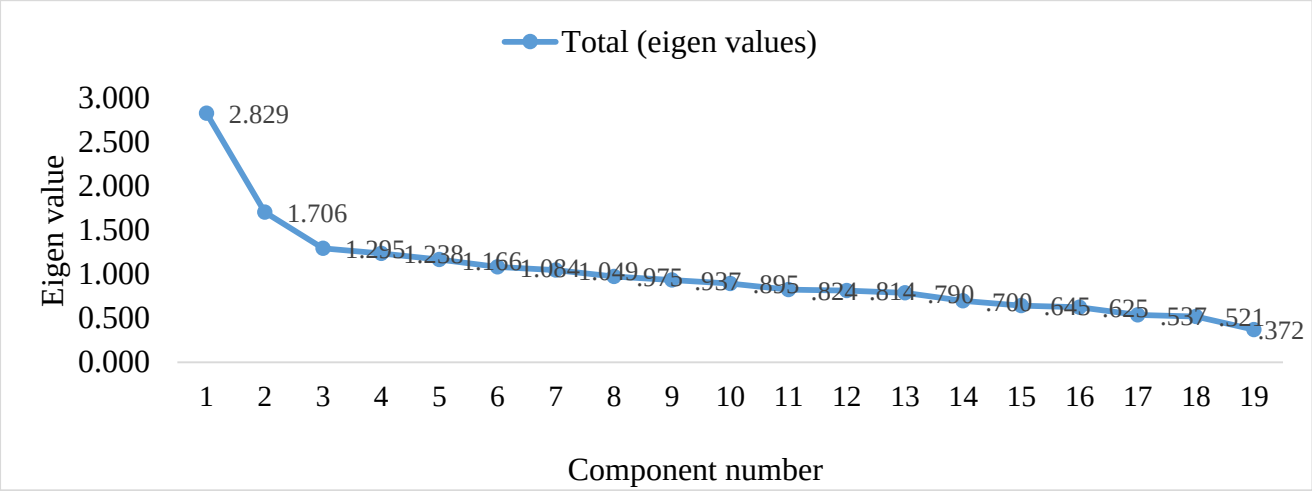

Figure 6. 1 Scree plot for Principal Component Analysis (PCA)

The internal coherence test is shown in Table 6.1, where the last three columns compare the average ownership of each asset across the low income, middle income and upper income households. Table 6.1 reports the scoring factors of 19 variables and their corresponding percentage in the wealth quantile.

Table 6. 1 Component scores and classification into wealth quintile for the overall sample

Asset name	Components score	Low income(40%)	Middle income (40%)	Upper income
Radio	0.239	68.1	95.9	100
TV	0.514	28.6	86.5	99.1
Livestock yard	0.276	34.9	48.8	65.9
Cattle stall	0.424	15.5	29.6	42.8
Milking room	0.376	11.1	24.8	22.3
Sheep-goat	0.522	3.9	6.1	14.0
Forage shed	0.370	9.6	24.0	17.0
Well	-0.241	11.6	10.2	2.6
Manure pit	0.128	5.9	9.6	3.5
Solar panel	-0.633	16.8	6.5	1.3
Bicycle	-0.054	12.4	12.9	5.7
Motorcycle	0.268	8.3	15.7	13.5
Car	0.519	4.6	10.7	10.9
Harrow plough	0.616	3.3	5.4	13.1
Wheel barrow	0.486	30.1	79.5	98.3
Milk storage	-0.058	95.2	91.7	82.1
Machete/panga	0.009	97.8	98.5	99.6
Knapsack	0.198	59.0	81.7	96.5
Chaff-cutter	0.542	7.9	20.7	35.4

Source: Survey data.

A variable with a positive factor score contributes to higher SES, and conversely a variable with a negative factor score weighs towards lower SES. The richest households (20 percent or fifth quintile) have assets with higher factor scores. For instance, for the overall sample, all the richest household (100 percent) owned a radio against 65 percent of the low income and 96 percent of middle income households. Up to 99 percent of upper income households have television set while 29, and 87 and 29 percent respectively of low income and middle income households owned the same respectively. Descriptive analysis of assets ownership across the poverty status in the three milksheds is shown in Table 6.2. In the three milksheds, more than 90 percent of the upper income households owned a radio, television, wheelbarrow, machete and knapsack sprayer.

Table 6. 2 Component scores and classification into wealth quintile for the three milksheds

	MWDL				HCL				NKCC Sotik			
	CS	LI 40%	MI 40%	UI 20%	CS	LI 40%	MI 40%	UI 20%	CS	LI 40%	MI 40%	UI 20%
Radio	0.4292	69.2	91.6	**100**	0.3795	74.4	98.8	**100**	-0.1909	64.3	99.0	**100**
Television	0.4857	52.1	90.6	**100**	0.5431	45.3	89.6	**98.0**	0.5204	7.6	74.0	**100**
Livestock yard	0.2647	57.3	48.2	55.9	0.4121	41.0	50.6	68.3	0.0657	20.1	47.1	96.2
Cattle stalls	0.3918	36.8	48.2	54.9	0.5721	17.1	20.1	38.6	0.0859	3.6	10.6	11.5
Milking room	0.2303	23.1	31.4	25.5	0.1610	18.8	25.6	20.8	0.4351	.9	11.5	15.4
Sheep/ goat farms	0.4437	7.7	5.2	8.8	0.5977	6.8	11.0	22.8	-0.9774	.4	0.0	0.0
Forage sheds	0.3532	17.1	25.7	14.7	0.4678	10.3	23.2	19.8	0.2284	5.4	22.1	15.4
Well	-0.1791	6.8	3.1	1.0	-0.2327	26.5	16.5	4.0	-0.2912	6.3	13.5	3.8
Manure pits	0.1310	17.9	19.4	4.9	.1011	4.3	4.3	1.0	0.1799	.4	0.0	7.7
Solar panels	-0.2103	7.7	3.7	0.0	-.5373	19.7	6.1	2.0	-0.8042	20.1	12.5	3.8
Bicycle	0.1998	7.7	8.4	2.0	.0643	24.8	21.3	9.9	-0.6107	8.5	7.7	3.8
Motorcycle	0.5545	3.4	9.4	9.8	.3340	12.8	21.3	14.9	-0.0385	8.5	18.3	23.1
Car	0.5283	6.0	8.9	9.8	.5218	11.1	14.0	14.9	0.4697	0.4	8.7	0.0
Plough harrow	0.8569	0.0	1.0	2.9	1.0973	2.6	6.1	21.8	0.0148	5.4	12.5	19.2
Wheel barrow	0.5116	40.2	81.2	**98.0**	.6083	35.0	75.0	**98.0**	0.2416	22.3	83.7	**100**
Milk equipment	0.2303	91.5	86.9	83.3	.1610	97.4	94.5	79.2	-0.5905	96.0	96.2	88.5
Machete/ Panga	0.2872	94.9	96.9	**100**	.2403	99.1	99.4	**99.0**	-0.5561	98.7	100	**100**
Knapsack	0.5034	36.8	68.1	**93.1**	.3991	61.5	87.8	**99.0**	-0.3174	69.2	97.1	**100**
Chaff-cutter	0.5211	16.2	25.7	40.2	.6838	6.8	19.5	32.7	0.2746	4.0	13.5	26.9

NB: CS= Represent Component Score; LI= low income, MI= middle income and UI= Upper income

Source: Survey data.

An analysis of distribution of poverty status indicated that overall, majority of respondents (40 percent were middle income). Across the milkshed, except in NKCC Sotik where majority were in low income, in the other two milkshed, the proportion of household who were in the middle income class were above 40 percent (Figure 6.2).

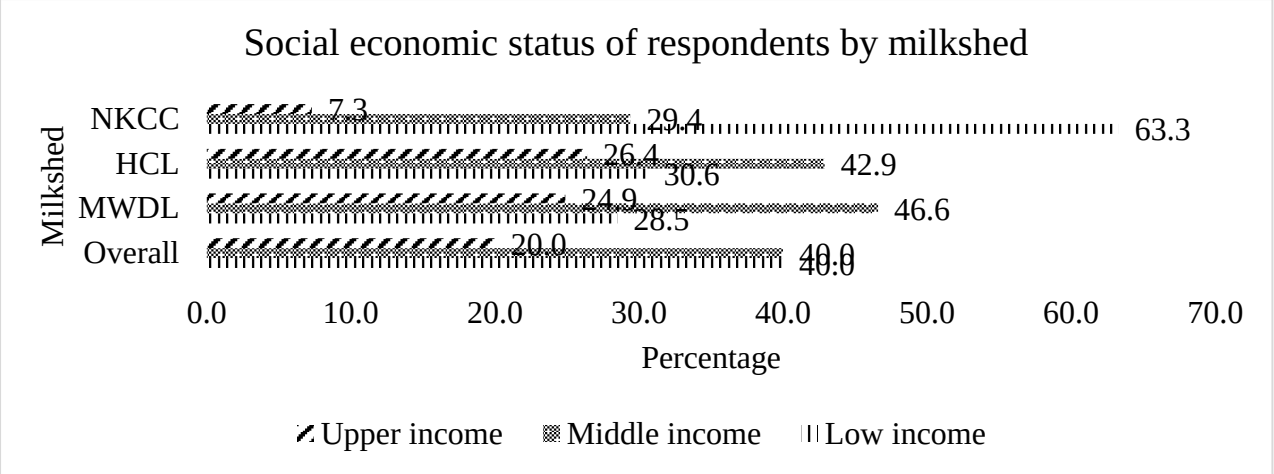

Figure 6. 2 Distribution of wealth index by milkshed
Source: Survey data

6.5 Ordered Probit Regression Results

This study used an ordered probit model to examine the impact of a single dairy practice category and their combinations on the different poverty categories, as well as model marginal effects. In MWDL, results indicated that adoption of TDPs, ODPs and IDPs and a combination of ODPs and IDPs significantly reduced likelihood of households being in low income category. The socio-economic characteristics that significantly influenced probability of households presence in the different poverty groups included gender of household head, age of the household head, and cultivated land. The likelihood of female headed households being in low income was at 11.0 percent and being in the high income reduced with 9.6 percent. A one-year increase in age of household head increased the likelihood of being in low income by 0.3 percent and reduced the likelihood of being in the high income category by 0.28 percent.

Technical dairy practices adoption reduced the possibility of being in low income by 2.8 percent and increased the likelihood of being in high income by 2.6 percent. The IDPs increased the possibility of being in low income by 1.4 percent and reduced the likelihood of being in high income by 13.6 percent. Adoption of a combination of ODPs and IDPs reduced the possibility of being in low income by 16.9 percent and increased the likelihood of being in high

income by 16.0 percent. An increase in cultivated land by one acre reduced the likelihood of household being in low income by 0.3 percent and increased the likelihood of being in high income by 0.3 percent (Table 6.3).

Table 6. 3 MWDL Ordered probit results and marginal effects

		Marginal effects		
Variables	Coefficient	Low	Middle	High income
	-0.3399**	**0.1099****	-0.0142	**-0.0957*****
GEDRHED (Female)	(0.1315)	(0.0436)	(0.0109)	(0.0353)
	-0.0094*	**0.0029***	-0.0002	**-0.0028***
AGEHED	(0.0057)	(0.0018)	(0.0002)	(0.0017)
	-0.0032	0.0010	0.0001	-0.0010
HHEDUC	(0.0151)	(0.0047)	(0.0003)	(0.0045)
	-0.0029	0.0009	0.0000	-0.0009
HHSIZE	(0.0391)	(0.0122)	(0.0007)	(0.0115)
	0.0568	-0.0177	0.0010	0.0167
INCOME	(0.0454)	(0.0141)	(0.0014)	(0.0133)
	-0.0094	0.0029	-0.0002	-0.0028
FARMSIZE	(0.0182)	(0.0057)	(0.0004)	(0.0053)
	0.0888***	**-0.0276*****	0.0015	**0.0261*****
TDP	(0.0301)	(0.0092)	(0.0018)	(0.0088)
	-0.1152	0.0358	-0.0020	-0.0339
ODP	(0.0902)	(0.0280)	(0.0027)	(0.0265)
	-0.4624*	**0.1438***	-0.0079	**-0.1359***
IDP	(0.2516)	(0.0776)	(0.0098)	(0.0739)
	0.0524	-0.0163	0.0009	0.0154
TOC	(0.2074)	(0.0645)	(0.0037)	(0.0610)
	0.5431*	**-0.1689***	0.0093	**0.1596***
OI	(0.3288)	(0.1016)	(0.0119)	(0.0966)
	-0.0303	0.0094	-0.0005	-0.0089
EXTENS	(0.0496)	(0.0154)	(0.0010)	(0.0146
	0.0098***	**-0.0031*****	0.0002	**0.0029*****
CULTIV	(0.0026)	(0.0008)	(0.0002)	(0.0008)
	0.0035	-0.0011	0.0001	0.0010
EXPRNCE	(0.0046)	(0.0014)	(0.0001)	(0.0014)
	0.0691	-0.0215	0.0012	0.0203
CREDIT_ACCES	(0.1323)	(0.0411)	(0.0026)	(0.0389)
LR chi2(15)	53.85			
Prob > chi2	0.000			
Pseudo R2	0.062			
Log likelihood	-407.59404			
N	410			
cut1	0.7916(0.7218)			
cut2	2.1491(0.7271)			

***Note**: Figures in parentheses are standard errors associated with the coefficients and marginal effects. ***P<0.01, **P<0.05, *P<0.10 mean significant at 1%, 5% and 10% probability levels, respectively.*

Household size, experience and technical dairy practices were the important factors that influenced poverty among the households in HCL. Household size increased the possibility of household being in low income and reduced the likelihood of being in high income. An increase with one family member in the household increased the probability of the household being in low income by 1.9 percent and decreased the likelihood of being in high income level by 1.8 percent. Adoption of TDPs reduced the likelihood of a household being in low income level by 4.3 percent and increased the likelihood of being in high income level by 4.0 percent. Experience in dairy reduced the likelihood of being in low income by 0.29 percent (Table 6.4).

Table 6. 4 HCL Ordered probit results and marginal effects

	Coefficient	Marginal effects		
Variables		Low	Middle income	High income
GEDRHED (Female)	-0.1867	0.0605	-0.0068	-0.0538
	(0.1549)	(0.0512)	(0.0087)	(0.0432)
AGEHED	0.0006	-0.0002	0.0000	0.0002
	(0.0055)	(0.0017)	(0.0001)	(0.0016)
HHEDUC	0.0133	-0.0042	0.0003	0.0039
	(0.0139)	(0.0044)	(0.0004)	(0.0041)
HHSIZE	**-0.0613****	**0.0194****	-0.0013	**-0.0182****
	(0.0288)	(0.0090)	(0.0013)	(0.0085)
INCOME	0.0321	-0.0102	0.0007	0.0095
	(0.0501)	(0.0159)	(0.0012)	(0.0148)
FARMSIZE	0.0016	-0.0005	0.0000	0.0005
	(0.0159)	(0.0050)	(0.0003)	(0.0047)
TDP	**0.1353*****	**-0.0429*****	0.0028	**0.0401*****
	(0.0297)	(0.0090)	(0.0025)	(0.0085)
ODP	0.0864	-0.0274	0.0018	0.0256
	(0.1048)	(0.0332)	(0.0026)	(0.0311)
IDP	0.0691	-0.0219	0.0014	0.0205
	(0.3078)	(0.0976)	(0.0065)	(0.0912)
TOC	-0.2261	0.0717	-0.0047	-0.0671
	(0.2338)	(0.0740)	(0.0063)	(0.0693)
OI	-0.3648	0.1157	-0.0075	-0.1082
	(0.4085)	(0.1294)	(0.0108)	(0.1209)
EXTENS	0.1705	-0.0541	0.0035	0.0506
	(0.1408)	(0.0446)	(0.0043)	(0.0416)
CULTIV	0.0001	0.0000	0.0000	0.0000
	(0.0019)	(0.0006)	(0.0000)	(0.0006)
EXPRNCE	**0.0091***	**-0.0029***	0.0002	0.0027
	(0.0055)	(0.0017)	(0.0002)	(0.0016)
CREDIT_ACCES	0.1674	-0.0531	0.0034	0.0496
	(0.1398)	(0.0442)	(0.0042)	(0.0414)
cut1	1.6369(0.7063)			
cut2	2.8942(0.7139)			
N	382			
LR chi2(15)	60.54			
Prob > chi2	0.000			
Pseudo R2	0.0736			
Log likelihood	-381.202822			

***Note**: Numbers in parentheses are standard errors*

****, **, * mean significant at 1%, 5% and 10% probability levels, respectively.*

In NKCC, except the household size that increased the possibility of household being in low income by 2.16 percent. Household head education, age of household head, income, adoption

of TDPs and cultivated land reduced the likelihood of household being in low income category (Table 6.5).

Table 6. 5 NKCC Ordered probit results and marginal effects

		Marginal effects		
Variables	Coefficient	Low income	Middle income	High income
GEDRHED (Female)	0.0742	-0.0213	0.0134	0.0079
	(0.2185)	(0.0631)	(0.0391)	(0.0240)
AGEHED	**0.0209*****	**-0.0060*****	**0.0038*****	**0.0022*****
	(0.0074)	(0.0021)	(0.0013)	(0.0008)
HHEDUC	**0.0939*****	**-0.0269*****	**0.0171*****	**0.0097*****
	(0.0194)	(0.0053)	(0.0036)	(0.0022)
HHSIZE	**-0.0753****	**0.0216****	**-0.0137****	**-0.0078****
	(0.0372)	(0.0105)	(0.0068)	(0.0040)
INCOME	0.1720*	-0.0492*	0.0314*	0.0178*
	(0.0911)	(0.0258)	(0.0164)	(0.0097)
FARMSIZE	-0.0173	0.0049	-0.0032	-0.0018
	(0.0180)	(0.0051)	(0.0033)	(0.0019)
TDP	**0.0726****	**-0.0208****	**0.0132****	**0.0075****
	(0.0330)	(0.0093)	(0.0060)	(0.0035)
ODP	0.0417	-0.0119	0.0076	0.0043
	(0.1556)	(0.0445)	(0.0284)	(0.0161)
IDP	-0.2797	0.0800	-0.0510	-0.0290
	(0.3476)	(0.0992)	(0.0632)	(0.0362)
TOC	0.0719	-0.0206	0.0131	0.0075
	(0.3608)	(0.1032)	(0.0658)	(0.0374)
OI	0.2921	-0.0836	0.0533	0.0303
	(0.4866)	(0.1390)	(0.0887)	(0.0506)
EXTENS	0.0098	-0.0028	0.0018	0.0010
	(0.1926)	(0.0551)	(0.0351)	(0.0200)
CULTIV	**0.0066*****	**-0.0019*****	**0.0012*****	**0.0007****
	(0.0026)	(0.0007)	(0.0005)	(0.0003)
EXPRNCE	0.0060	-0.0017	0.0011	0.0006
	(0.0064)	(0.0018)	(0.0012)	(0.0007)
CREDIT_ACCES	0.1000	-0.0286	0.0183	0.0104
	(0.1644)	(0.0469)	(0.0299)	(0.0171)
cut1	5.3793			
	(1.0692)			
cut2	6.8429			
	(1.0893)			
N	354			
LR chi2(15)	123.85			
Prob > chi2	0.000			
Pseudo R2	0.2079			
Log likelihood	-235.87222			

***Note**: Numbers in parentheses are standard errors*

***, **, * denote significant at 1%, 5% and 10% probability levels, respectively.

6.5 Discussion

In the three milksheds, adoption of technical dairy practices reduced the likelihood of households being in the low income category. The results imply that promotion of TDPs is a key factor in reducing poverty among the dairy farmers. This finding agrees with Kabunga (2014) who reported adoption of cross-breed cow as one of the TDP that reduced poverty in Uganda. Similarly, Wambugu *et al*. (2011) in Kenya reported that TDP including improved feeding, better animal health and hygiene increased milk production. Mwendia *et al*. (2018) study also observed that improved feeding increased milk quantity in Kenya. The increased milk production associated with TDP could result in increased income, which dairy farmers could use to invest and reduce their poverty level.

In MWDL, the results revealed that besides adoption of TDPs, a combination of ODPs and IDPs had a stronger effect in reducing the likelihood of the household being in low income category. Female headed households and older household head were likely to be in low income, unlike their counterparts' male headed households and younger household head. The positive association between female household head being in low income category (poor) coincided with the Kenya Continuous Household Survey (KCHS) conducted by the Kenya National Bureau of Statistics (KNBS) that revealed that female-led households in Kenya have a high poverty rate compared to those headed by men (KNBS, 2021). Other studies had similar findings (Kebede & Sharma, 2014; Teka *et al*., 2019; Tsehay & Bauer, 2012). The size of cultivated land reduced the likelihood of household being in the low income category. The results are in line with those of Shibru *et al*. (2013) in Ethiopia that found that the farm size had negative impacts on the likelihood of a household being poor. Similarly, farm size was positively related to the wellbeing of households in Mozambique (Kassie *et al*., 2014).

A combination of ODPs and IDPs reduced the probability of household being in the low income category. The positive influence could imply that farmers adopting ODPs such as cooperative

societies had cow breeds of high genetic potential, hence produced high milk and could access credit from those cooperative societies. This is in line with findings by Bayan (2020) who observed that cross-breed adopters with higher herd size had membership of dairy cooperative societies. Another explanation could be that given that IDPs such as quality and seasonality-based payments, and credit schemes for feed, are expected to encourage dairy producers to improve their dairy practices (Holloway *et al*., 2000), they are not by themselves independently sufficient in poverty reduction.

In HCL, adoption of TDPs and experience in dairy farming reduced the likelihood of households being in the low income category, while household size increased possibility of households being in low income category. To the contrary, adoption of ODPs, IDPs and their combination were not significant. This could be because, adoption of these practices were minimal and hence could not have a significant influence on household poverty status.

In NKCC, whereas household size increased the probability of household being in low income category, the household head age, household head education, income, and cultivated land reduced the likelihood of household falling in low income category. The positive effect of age in reducing poverty contradicts that of Kebede and Sharma (2014) in Ethiopia that reported a negative correlation between age and being poor. The positive effect of education in reducing poverty could be associated with improvement of agricultural productivity resulting from better understanding of improved farming practices among educated farmers (Rahman, 2013; Maiyo, 2015; Wanka & Rena, 2019).

6.6 Conclusion and Recommendations

The impact of dairy practices and their combinations on the three poverty categories (low income, middle income and higher income) in the three milksheds suggest that technical dairy practices contribute to poverty reduction. In MWDL, adoption of institutional dairy innovation

was a disincentive to poverty reduction. However, adoption of organizational and institutional dairy practices jointly contributed to poverty reduction and had the highest impact compared to other factors that were significant. Based on the findings, the study concludes that adoption of dairy practices individually and jointly improve the welfare of households irrespective of their poverty status (low income, middle income and higher income). The dairy value chain promoters should support farmers to adopt dairy practices at the farm and the milkshed.

CHAPTER SEVEN: ANALYSIS OF DAIRY FARMERS' PERCEPTION ON USE OF FARMER FIELD SCHOOLS TO IMPROVE DAIRY COWS' FEEDING AND NUTRITION IN SELECTED MILKSHEDS OF KENYA

7.1 Abstract

The Kenyan dairy sub-sector is characterized by low productivity per cow, mainly due to feed shortages. This paper analyzed farmers' perceptions on the farmer field school (FFS) role in improving dairy cow's feeding and nutrition. Data from 124 households and 11 key informants were collected. Stata Version 14 analyzed quantitative data using descriptive analysis and binary logit model, and Nvivo Version 12 analyzed qualitative data based on themes. Most farmers in Mukurweini Wakulima Dairy Limited (MWDL) perceived FFS as negative in improving dairy cow's feeding and nutrition compared to farmers in New Kenya Cooperative Creameries (NKCC). Cultivated land, minutes taken to agricultural extension offices and group membership positively influenced farmer's perception. In the two milksheds, the project implementers needed to link farmers with fodder seed sources. The study recommends strengthening group membership to boost farmers' perception of FFS in increasing milk quantity and improving milk quality.

Key words

Participatory approach, innovation platform, dairy technologies, extension approaches, farmer field schools

7.2 Introduction

The Kenyan dairy sub-sector plays a critical role as a source of livelihood supporting 1.8 million small-scale dairy farmers (KDB Strategic plan of 2017 to 2022). Although the dairy industry is fast-growing per year in terms of production, processing capacity and consumption rates average at 5.3 percent, 7.0 percent and 5.5 percent, respectively (GoK, 2015), the milk productivity per cow remain low at an average of 6 to 7 litres per day (Muraya *et al*., 2018).

The low milk productivity is attributed to among other reasons limited quantity of feeds and poor quality feeds, inadequate nutrition and low adoption of Artificial Insemination (Onono *et al*., 2013; Njarui *et al*., 2011). To address low milk productivity, dairy stakeholders including government, development partners and donor funded programmes support has been through promotion of dairy technologies, among them technological and organizational/ institutional at the household level and milkshed level respectively. Despite their efforts, adoption of these dairy technologies by farmers remains low (Omondi *et al*., 2017).

The possible reasons of low technologies' adoption could be associated with solving the problems by actors independently instead of collaboratively through participatory action research (PAR). At times, smallholder farmers are not involved in decision making regarding technologies and knowledge introduced to them by researchers (Chagunda *et al*., 2010). Failure to involve farmers in developing these technologies, experts may not understand how the farmers make decisions and the constraints under which they operate (Vanclay, 2004), resulting in farmers not adopting them.

The PAR together with collaborative learning have been reported to raise understanding and contextualization of practices to farmers' needs and priorities (Restrepo *et al*., 2016; Musvoto

et al., 2015). Still emphasizing on the need to involve owners of problems as co-owners of the process to solve them, stakeholders are likely to support solutions of a problem that they participate in solving (Neef & Neubert, 2011). Following these authors' arguments, involving dairy farmers in decision-making on the dairy technologies aimed at solving the challenges facing them is key. Innovation Platform (IP) could provide an appropriate avenue of convening stakeholders with an aim of solving a common problem affecting them.

According to Makini *et al*. (2013), an IP is a medium where various stakeholders facing similar problem can meet, exchange ideas and offer solution collectively. The process of solving common problem involve diagnosing the issue affecting stakeholders, assessing prospects and establishing the method of achieving them (Mulema & Mazur, 2015). In the dairy value chain context, actors include dairy producers, input suppliers (feed and supplements suppliers), business development services providers such as extension services, breeding services and veterinary services, processors and support services providers such as milk transporters.

To boost technologies adoption by farmers, the IP could be used to offer agricultural extension and advisory services through Farmer Field Schools (FFSs). The FFSs, emphasizes on a participatory, practical, and reflective learning aimed at improving capacity to solve problem of farmers, through support of trained coordinator working with farmers organized in a group (Larsen & Lilleor, 2014). Some reported impact of FFS include increase in farmers knowledge empowerment (Friis-Hansen & Duveskog, 2012), and agricultural income consisting of crop and livestock income (Davis *et al*., 2012).

In recognition of the importance of IP in solving farmers' problems through FFS, AfricaMilk project as of March 2022, had implemented two Dairy Innovation Platforms (DIPs) in two milksheds in Kenya namely Mukurweini Wakulima Dairy Limited (MWDL) and NKCC Sotik. The implementers of the project were the University of Nairobi in partnership with Wageningen University and Research and in collaboration with the NKCC Sotik and Agriculture Sector Development Support Programme of Nyeri County. One of the key objectives of the three year project running from 2018 to 2021 was to develop and test methodologies that could enhance milk quality and quantity sustainably.

This study is anchored on AfricaMilk Project and aim to establish farmers' perception on the use of FFSs in improving dairy cows' feeding and nutrition. This is because farmers are among the core stakeholders in the dairy industry, together with cooperative societies and milk processors in the formal milk value chain (Nyokabi *et al*., 2018) and increasing milk yield at farm level will translate to increased milk along the entire value chain. Additionally, given that a technology is likely to be adopted if the farmer perceives its relative advantage as positive (Tosakana *et al*., 2010), also a relationship between perception and adoption of agricultural technologies has been reported by various authors (Adesina & Zinnah, 1993; Rogers, 1995; Adesina & Baidu-Forson, 1995; Murage *et al*., 2015). Specifically on fodder adoption, Ndah *et al*. (2022) study in Tanzania noted a positive community attitude among the main determinants of adoption of improved forages. The study results will inform on the perception of farmers on use of FFS to stimulate dairy feeding and nutrition, important determinants influencing perception of FFS as a strategy to increase milk production, and the likelihood of farmers planting the fodder promoted in the demonstration plots.

7.3 Study Methods

7.3.1 The Study Area and Study Design

The study was conducted in the milksheds of MWDL and NKCC Sotik because that is where the FFS were established and were operating by March 2022 following the information from the baseline survey. The baseline study results revealed feeds and nutrition among the constraints faced by farmers in improving milk productivity, which informed establishment of FFS under Dairy Innovation Platform (DIP). A mixed-method approach- quantitative and qualitative research designs were employed. Whereas quantitative information was captured via semi-structured questionnaire digitized in Open Data Kit (ODK), qualitative data information were captured using the key informant interview (KII) guide. The KIIs were conducted with representatives from seven cooperative societies, owners of demonstration plots' land and DIP representatives.

7.3.2 Sampling Procedure and Sample Size Determination

A multistage sampling technique was adopted to select farmers to participate in the study. In the first stage, milksheds of two processors, NKCC Sotik and MWDL were targeted because that is where the DIPs were established and were in operation at the time of the survey and a baseline study was done which informed on challenges to be addressed through the DIP. The second stage involved purposive sampling of all cooperative societies having demonstration farms promoted by the DIPs. This stage involved selection of all the six cooperative societies, three in MWDL including Mathaita, Gakindu and Waraza and three namely, Olbutyo, Omonyenya and Matutu in NKCC Sotik milkshed.

Farmers' training attendance lists were sought from the cooperative societies in MWDL milkshed and in NKCC Sotik processor. The lists were sorted and one list per cooperative

society was prepared, comprising all participants who attended at least one training session. This was done because in some cooperatives, attendance was not consistent, and some farmers had attended only one session, with some attending all trainings. Additionally, in some instances, the household head attended some sessions and the spouse attended others. Concerning lists obtained from NKCC Sotik, for participants of Olbutyo cooperative, two lists with 59 and 84 participants were not considered while drawing the sample because those trainings were not entirely on feed and nutrition and not totally offered through the DIP.

The final one list per cooperative prepared included the name, phone number and the village of resident of the participants. In each of the village, simple random sampling was used to select the study participants, they were then visited in their homes or interviewed on phone. Based on the attendance lists, a total of 100 farmers and 119 farmers had attended at least one session in milksheds of MWDL and NKCC Sotik respectively. Overall, the trainings were spread into four sessions within four months. From the one compiled list per cooperative, in the case where the household head, the spouse and or a youth were included in the list, the household head was interviewed. Participants who attended the training because they were near the training venue, and they did not register their cell phone number at the time of training could not be traced at the time of interview and neither could the participants identify their residence. Therefore, after excluding them as well as the spouses in the event the head attended the training, a total of 160 participants who had attended at least one training in the two milkshed and were targeted for the interview. From the 160 participants, 124 participants were available for the survey.

The participants comprised members and non-members of cooperative society and dairy farmers and non-dairy farmers. The non-dairy farmers were particularly the youth and women who were invited to meet the criteria of inclusivity during training, or they were working near

the training venue, and they were therefore invited just before the training began. The third stage involved random sampling of farmers who attended trainings in the demonstration farms at least once since the project kicked off. The fourth and the last stage involved household visit to respondents who had attended training. Figure 7.1 shows the sampling procedure and sampled farmers by cooperative societies.

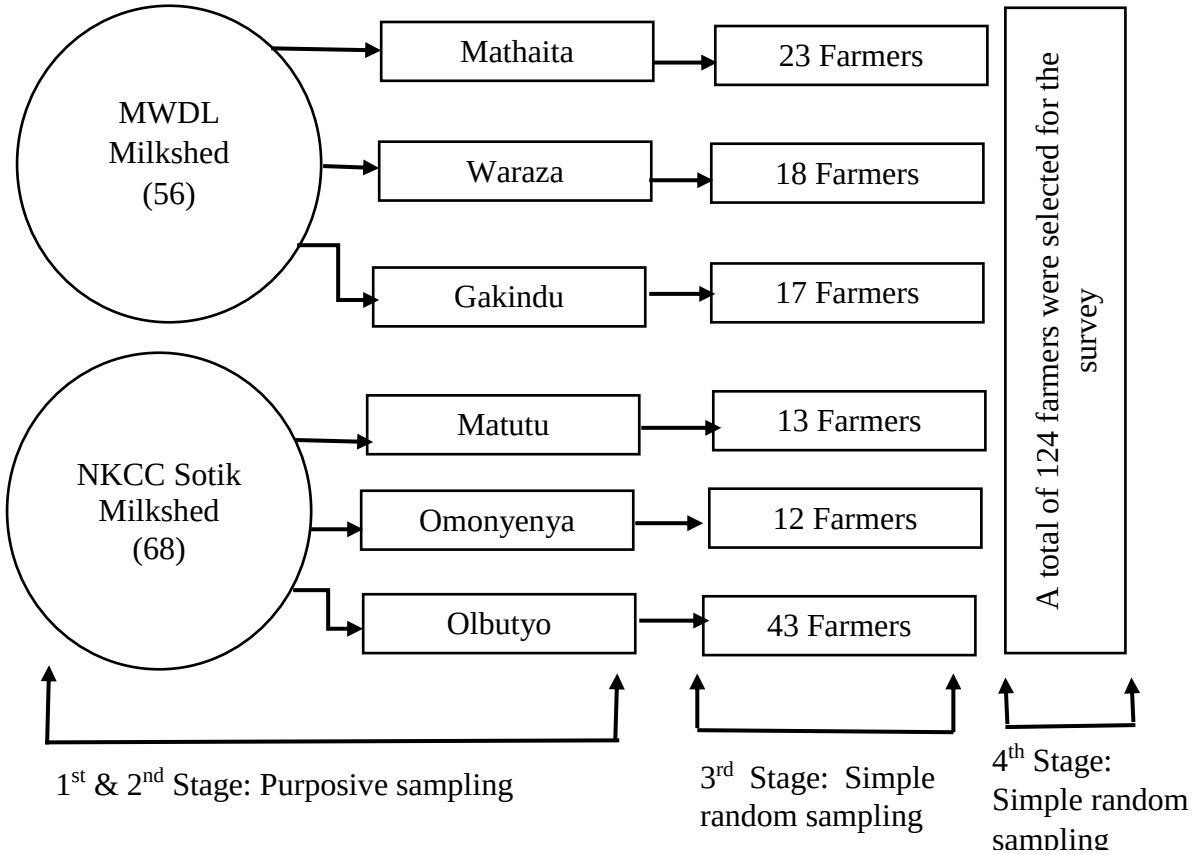

Figure 7. 1 Sampling procedure and sample size

Source: Authors compilation

7.3.3 Sample Size Determination for Qualitative Data

To gather qualitative information, a purposive sample was drawn including DIP representatives, cooperative societies' managers, and training consultants. Table 7.1 indicates the summary of the key informants contacted in each of the milkshed.

Table 7. 1 Distribution of key informants by category and milkshed

Category	MWDL	NKCC Sotik	Total
DIP representatives	1	1	2
Training consultants	1	1	2
Cooperative Society representatives	5	2	7
Total	7	4	11

7.3.4 Data

Data used in this study were from a survey conducted in February and March 2022. The major data collected were on farmers' perception towards several characteristics of FFS, and socio-economic and institutional factors including household head age, gender and education level, total land size owned by a household, distance in kilometres to the nearest village market, and income. In addition, data on the total labour force, farmer group membership were also collected. The qualitative information gathered included the number of farmers participating in FFS, number of DIP members, the status of farmers attending trainings (members or non-members of cooperative societies implementing FFS), criteria of participation in training, access to information about DIP, inclusivity (men, women and youth) in DIP and trainings, members who have been attending trainings, reasons why some members' attendance is not consistent, topics participants are trained on, people involved in implementation of DIP and their roles, challenges faced in training at FFSs, recommendations, and experience of feeding cows with tested fodder. Farmers were also asked to rank six characteristics of FFS in a 3 point (1=Not important, 2=Important; 3=Very Important) likert scale on how they considered them and rate the extent to which the FFSs was meeting their needs in a 3 point likert (1=Poor; 2=Good; 3=Very good).

7.3.5 Data Analysis

STATA version 14 was used to analyze quantitative data producing frequencies, percentages, means and standard deviations, test statistics for independence such as independent sample t

test and chi-square test, and binary logistic regression. These outputs were used to describe the households' farming characteristics and their influence on farmers' perception. The KIIs, were recorded, transcribed and thematic analysis performed using NVIVO version 12 for windows and results were presented based on themes and quotes.

7.3.5.1 Binary Logistic Regression to Determine Farmers' Perception on FFS and Underlying Perception Determinants

The study used Binary logistic regression, the appropriate model for a dependent variable that is of dichotomous outcome variable. The dependent variable in this study, perception of FFS, is dichotomous, the value 0 was assigned to negative perception and 1 was assigned to positive perception in the econometric model. Following Gujarati 1995 the functional form of the logit model is specified as follows:

$$P_i = E\left(Y = \frac{1}{xi}\right) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_1)}} \quad (7.1)$$

The equation 1 can be simplified as follows:

$$P_i = \frac{1}{1 + e^{-zi}} \quad (7.2)$$

The probability of the farmer having a positive perception is expressed by equation 7.2 while the probability of a farmers having a negative perception is shown in equation 7.3.

$$1 - P_i = \frac{1}{1 + e^{zi}} \quad (7.3)$$

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{zi}}{1 + e^{-zi}} \quad (7.4)$$

$\left(\frac{P_i}{1-P_i}\right)$ is the odds ratio in favour of positive perception. The ratio of probability that a farmer will have a positive perception to the likelihood that he/she will have a positive perception. Taking a natural log of equation 4 we obtain equation 7.5.

$$L_i = In\left(\frac{P_i}{1-P_i}\right) = zi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...\beta_n X_n \quad (7.5)$$

Where P_i is a probability of having a positive perception which ranges from 0 to 1; zi is a function of n explanatory variables (x), which are also expressed as:

$$zi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...\beta_n X_n \quad (7.6)$$

β_0 is an intercept , β_1, β_2, β_3,…….β_n, are slopes of equation in the model, Li is the log of odds ratio which is linear in xi and linear in the parameters and xi is the vector of relevant farmer's characteristics. The binary logistic regression, indicate the effect of explanatory variable on the response variable.

The empirical model is as follows:

$$\begin{aligned} Perception = {} & \beta_0 + \beta_1 Genderhhed + \beta_2 Agehhed + \beta_3 Educhhed + \beta_4 Experiencd + \\ & \beta_5 jTotalacres + \beta_6 Cultiacres + \beta_7 labourfrc + \beta_8 Awaredip + \\ & \beta_9 Mindem + \beta_{10} Minmr + \beta_{11} Minnmkt + \beta_{12} Mindelers + \\ & \beta_{13} Minagext + + \beta_{14} nodcows + \beta_{15} Othergrp + \varepsilon_1 \end{aligned} \quad \textbf{(7.7)}$$

7.4 Results and Discussion

7.4.1 Overview of Farmers Served by the DIP Through FFS

Overall, a low turn-out of farmers during the four training sessions was noted and was attributed to unclear communication made by implementing team and the consultants as revealed by the interviewed respondents.

"*The first training, 12 participants attended and established 12 sections with different forage varieties in the demonstration plot, later on, a communication was done that women and youth were needed to be included and they were invited to the training*" (MWJ1)

"*But there was a reason for low turnout, the consultant did a mistake from day one which seriously affected us, because the communication that was made, we thought farmers who planted were the only ones to be trained*" (NMJ1)

"The communication from Dairy Innovation Platform was that at least 20 and at most 30 farmers should attend the trainings" (GCD1)

Participants of FFS were both members and non-members of cooperative societies implementing the demonstration plots. The non-members were mainly the youth who attended the trainings.

"*The two youth were deliberately invited on behalf of their parents to learn and represent other youth" (MWJ2)*

The KII findings revealed that the criteria for FFS's participants' selection was not clear and differed in the two milksheds. In MWDL, respondents indicated that at the beginning, the criteria for FFS's participation included being a member of a cooperative society. The consultant also communicated that participants were not to exceed 20. Later on, a communication was done by the implementing team that non-members could attend. In NKCC Sotik, the criteria for participation was dairy farmers who were near the demonstration plots. In the two milksheds, induction meeting was done at the DIP level. At the cooperative society level, there was no planning meeting and members were informed about the FFS by the cooperative society chairmen in MWDL while in NKCC Sotik communication to cooperative societies was done by the DIP representatives, extension representative and milk transporters.

Communication of the training sessions also differed across the cooperative societies, particularly in MWDL as reported by KII respondents.

"*So in short at the demonstration farm with feeds and feeding consultant we were trained for three days,* (MWJ1)

"*When the consultant came to train the second time, she said we covered two lessons in day one*" (MWJ2)

"*We were told the training was to take about 4 months, and we will be learning once per month*" (GJD)

7.4.2 Decision on Location of the Demonstration Farm

The decision on demonstration plot location differed in the two milkshed. Whereas in MWDL, the location was informed by milk production quantity of smallholder farmers, in NKCC Sotik was informed by convenient location in terms of accessibility by cooperative society members as noted by KII respondent.

"*In the cooperative, they said they want a smallholder farmer who is performing well, they did not want a large scale farmer because, if you go for a training to a rich farmer, like if you go for a training to Slopes dairy, a smallholder farmer can lose hope, because when you compare yourself with them you can be discouraged. So they said they want smallholder farmer they walk with her/him. That is why I was chosen, and then in the cooperative, the smallholder farmer with a passion and when they checked the milk production sold, I was selected because of my good performance".* (GJD1).

7.4.3 Inclusivity of Women and Youth in the FFS

In MWDL, with an average attendance of 20 participants per training session, only two youth attended at least one session in each of the three cooperative societies considered. The youth who attended did not have cows, and they were deliberately invited for to represent their

parents, have a youth representation and some of them were working at the demonstration plot. Similar to MWDL, in NKCC Sotik, the two youth who attended trainings were invited because they were farming near the demonstration plot. In both milkshed, the proportion of women who participated in training ranged between 50 percent and 75 percent while youth proportion ranged between 3 percent and 10 percent. According to the KII, the reasons of low participation of youth in the training included that most of them have ventured in motorcycle (*Boda Boda in Swahili*) business that give instant money and that they have few responsibilities such as not paying schools fees and lack families to take care of and therefore may not engage in farming. Other reasons included that most of the youth keep chicken because of low investment cost and therefore lack capital to engage in dairy farming. Therefore, dairy farming is done by old generation who may not adopt the promoted technologies despite their participation in the training. To add on, these old and skilled people come back to farming when they are worn out after retirement and hence may not have adequate energy to maximize production as reported by a KII respondent:

"*Youth in rural areas are among the ones rejected by capital city and they do not own a farm nor a cow. Old people on the other hand do not like disturbance for example, a case of an old women we visited and inquired why she was not having a high milk producing cow and she said,* "*You are telling me to buy a cow that is producing 40 liters of milk per day and when the employee who attend it and does milking resign, I start crying because I do not have energy to milk and milk all the milk, then cow gets mastitis? I better remain with this low producing cow which I have energy to milk and milk all the milk*" (*MWJ2*)

7.4.4 Stakeholders Involved in the Dips Activities

In MWDL, AfricaMilk team, ProDairy consultant, Agriculture Sector Development Support Programme (ASDSP) and cooperative society members were involved. AfricaMilk milk

contribution included purchase of fodder seeds, funding DIP and paying consultants. Whereas the consultant trained farmers, cooperative society's representatives mobilized farmers to participate in the training. The ASDSP provided a platform where farmers to participate in DIP formation were be identified. In NKCC Sotik, besides the AfricaMilk team role similar to that in MWDL, NKCC Sotik extension department and cooperative society not only mobilized farmers to participate in the training but also provided farmers with refreshments, catered for irrigation costs, purchased some fodder seeds that were also tested in the demonstration plots and sold some to farmers who paid through a check-off system (payment paid from milk proceeds). In addition, all the NKCC Sotik DIP committee attended training particularly during planting which was not the case in MWDL where farmers revealed that except the secretary of DIP committee who attended some sessions, the other DIP committee members had not attended any session.

7.4.5 Tested Fodder Varieties in the two Milksheds

Twelve and 20 fodder varieties were tested in MWDL and NKCC Sotik respectively. Common fodders in the two milksheds included Brachiaria Sabia, Panicum maximum CV Sabmera, Rye grass (Annual Rye Ribeye), Oats Cv wizard, Chicory CV Commander, Green leaf DesmODPum, Lucerne (Alfalfa mIDPcago sativa), Sunn Hemp CV, Panicum maximum cv saimbasa, Branchiaria Cayman, Brachiaria Mulato II, Dolichos lablab cv Rongai. Additionally, in NKCC Sotik, Super napier, Sweet potatoes vines, Kikuyu grass, Edible cana, Russian comfrey, Improved sorghum (sugar grace), Nutrifeed (improved millet), and Sweet Lupin were also tested.

7.4.6 Basic costs for platform events

In MWDL, whereas no cost was involved in two cooperative societies, in one the cooperative society's chairperson paid for ploughing the demonstration plot while costs of irrigation and

tendering the plots were raised through cost sharing by the 12 members who established the demonstration plots. The DIP committee gave owners of demonstration plots a token of KES 5000.00 once the trainings were over and reimbursed transport reimbursement of a range of KES 1200.00 and 1500.00 to farmers who attended DIP meetings. In NKCC Sotik, the DIP paid for weeding of the demonstration plots and transport cost of KES 2000.00 for members of DIP any time they attended a meeting.

7.4.7 Challenges Faced by Farmers

In the two milksheds, challenges reported included lack of access to fodder seeds being tested in demonstration plots for farmers to test in their farms, inadequate finances at the DIP, lack of transport by participants, delayed soil test results which were availed late after planting, and location of demonstration plots being far from most of the farmers' homestead. In NKCC Sotik, only one demonstration plot in which super napier did not do well due to inadequate rainfall. Challenges faced by farmers of MWDL included unfavourable training condition such as learning in open ground under hot sun due to lack of money to rent a tent and chairs, lack of refreshments, wild animals (antelope) and pests (aphids, leave minors, white flies) were a threat to lucern, and Dolichos. Other challenges included bright, high cost of irrigation, unclear communication on number of participants to attend training, rigid training dates that were not convenient to farmers, limited rainfall and lack of money to cater for irrigation costs hence some fodder varieties did not germinate and not growing to maturity as reported by KII informant.

"*The DIP could not afford to do piping for irrigation because of limited finances*" (NDR1)

7.4.8 Farmers Experience with Feeding Tested Fodder to their Cows and Attending Training

Two farmers of NKCC Sotik, one fed his cow with Rye Siambasa, Chicory and DesmODPum which resulted in increased milk production with the other one feeding his calf on lucerne. The respondent explained that people in the area believed that feeding a cow on lucerne could kill it. He then promised to share the experience and show the fellow farmers the calf was still alive after feeding it with lucerne.

7.4.9 Recommendations for Improvement across Milksheds

In MWDL, farmers recommended a need for demonstration plots to be located at central place close to farmers, farmers be linked to fodder seeds sources, cooperative society to acquire fodder seeds, animal feeds, supplements, health services such veterinary, deworming and advance them to farmers on a checkoff system. Additionally, farmers recommended involvement of youth in dairy by the development partners. This could be done by selecting youth groups who keep dairy cows, establish demonstration plots close to them, have leaders, monitor, and supervise them. In NKCC Sotik, farmers suggested cooperative societies to acquire fodder seeds and advance them to farmers on a checkoff system, farmers to be trained on animal diseases and breeding and the processor to upscale the demonstration plots close to farmers.

7.4.10 Process of DIP Formation in the two Milksheds

The process of DIP formation differed across the two milksheds. A participatory action research approach was used in NKCC Sotik, involving NKCC processors, representatives of cooperative societies and a veterinary officer. The process began with a baseline survey at farm level that revealed challenges faced by farmers in increasing milk production and aimed at

informing on establishment of a local Dairy Innovation Platform. The baseline survey findings were presented to the above-mentioned representatives and the challenges regarding milk production and collection were identified, validated, and prioritized. Participants discussed the causes and consequences associated with the challenges stated by dairy farmers and possible

s Approach used l challer Main activities o inform draft resea Outcome

i sh e 7
approach in NKCC Sotik.

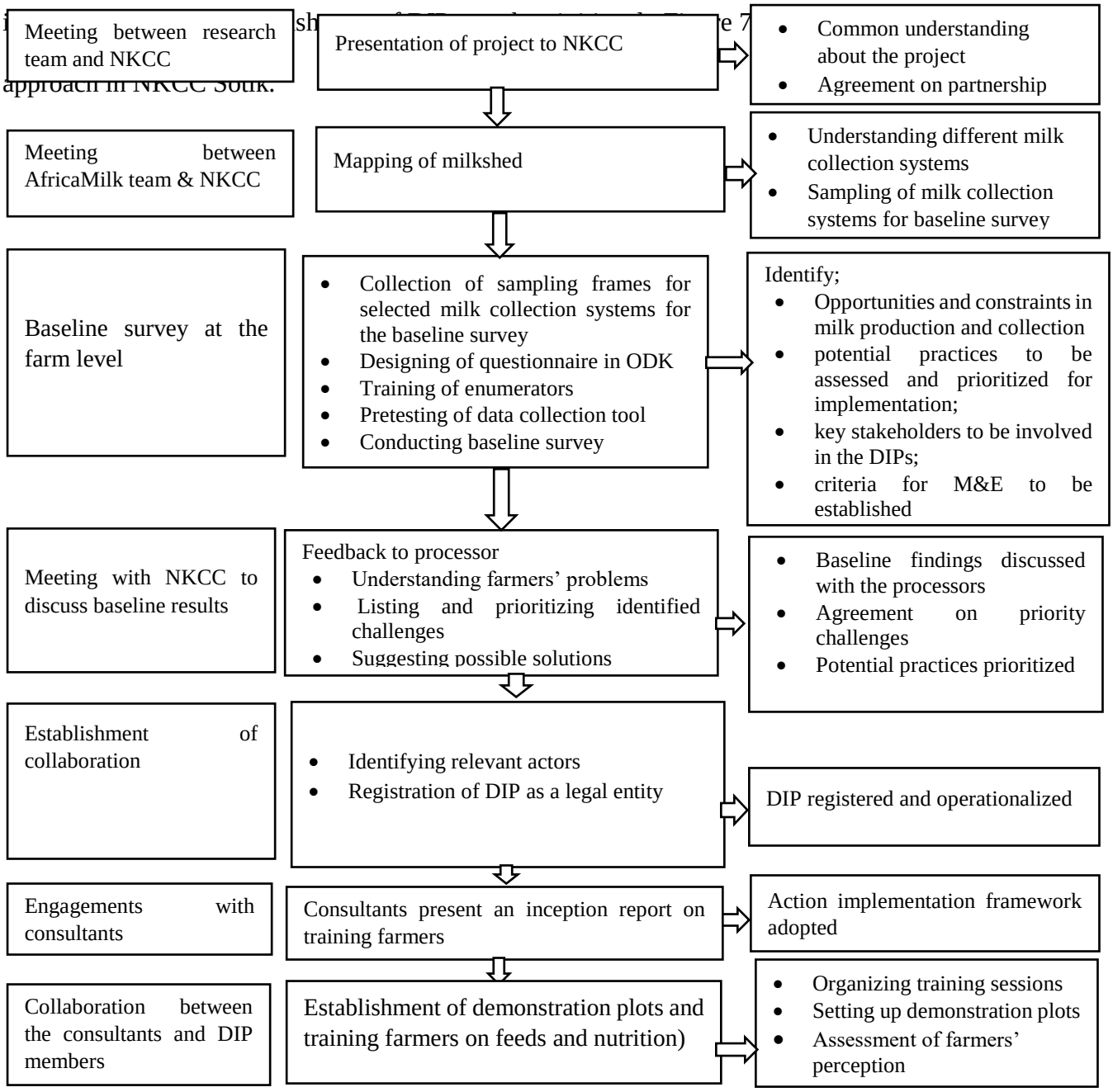

Figure 7. 2 Process of DIP formation in NKCC Sotik

In MWDL, AfricaMilk team communicated about the DIP at a forum organized by Agriculture Sector Development Support Programme (ASDSP) held in Nyeri town. The ASDSP was a five years (2017-2022) programme implemented by the Ministry of Agriculture, Livestock, Fisheries and Cooperatives and 47 county governments to address food and nutrition security, and promote manufacturing. Other ASDSP' stakeholders included cooperative societies, farmer groups, women groups, agricultural officers and dairy processors. The programme aimed to enhance the capacity of different priority value chain actors at different levels to tackle the problems that hinder commercialization of Agriculture.

The DIP idea was discussed and a DIP comprising 30 members, representing the entire Nyeri County, was registered in September 2021. The MWDL processor, who was the entry point of AfricaMilk in Nyeri County, participated in DIP as a member. This was contrary to the expectation, following the initial project's objective to be implemented through processors. Leaders of DIP were lead farmers from three sub-counties of Nyeri namely Tetu, Othaya and Kieni West. Areas covered by DIP included Othaya, Mukurweini, Tetu, Kieni East and Kieni West.

Following the communication by AfricaMilk team, the DIP targeted four cooperative societies and therefore voting was done to identify them. Initially, three cooperatives were identified that were working with ASDSP, and they included Waraza farmers' cooperative Society, Slopes and Gakindu cooperative Society. Mathaita cooperative was not represented in the meeting and was later contacted and included following AfricaMilk team communication to DIP representatives. AfricaMilk team then engaged consultants to train on feeds and nutrition as well as quality and also purchased the fodder seeds. Unlike in NKCC where DIP activities

were informed by baseline survey results, that was not a case in MWDL as reported by the KII respondents.

"*The DIP idea was totally a new idea and not informed by any baseline survey*, we discussed the *issue in a ASDSP meeting and we were asked to ensure it is registration overnight, we did it in three days*" (NDR1).

"*And to tell you and I felt a bit bitter, I don't know what went wrong because they had picked three societies, I don't know how Waraza was picked yet it was not considered during baseline, so they started with the ones that were not part of baseline survey and we were forgotten for a month, we felt that Mathaita was not considered first for the implementation of the project because all the activities started in November 2021 while it had started in October 2021 in other cooperatives. The project also considered other cooperatives that were not considered in the baseline survey like Waraza farmers' cooperative society. We felt like in Mathaita ours was treated like a crush program" (MWJ).*

6.4.11 Descriptive Analysis of Households' Characteristics

Overall, three-quarter of the household heads were male with an average age above 50 years, considerable years of experience in dairy farming, and attained primary. Farmers in milkshed of MWDL were mostly male headed household, older, aware of existence of DIP, allocated large land sizes to fodder, and planted fodder promoted by DIP than those in NKCC Sotik. Farmers in NKCC Sotik had low education level with some not having formal education, received low annual income and took much time in minutes to source fodder seeds and access motorable roads than those in MWDL (Table 7.2).

Table 7. 2 Descriptive analysis and test statistics across the two milksheds

Variables	Overall	MWDL	NKCC	Test statistic	
Household characteristics	Mean/Frequency & %	Mean/Frequency & %	Mean/Frequency & %	t-Value	$\chi 2$
Gender male (Frequency & %)	93(75)	48(85.7)	45(66.2)		**6.252****
Age household head in years)	53.27(13.3)	56.5(12.5)	50.6(13.4)	**2.54****	
Experience in dairy in (years)	17.86(12.23)	16.96(12.82)	18.60(11.76)	-0.735	
Years in cooperative society	8.92(8.74)	8.31(8.01)	8.79(7.91)	0.236	
Other group membership (Yes Freq. & %)	43(34.7)	22(51.2)	21(48.8)		0.957
Education					
No education (Frequency & %)	6(4.8)	0(0.00)	6(8.82)		**17.456****
Primary (Frequency and %)	50(40.3)	17(30.36)	33(48.53)		
Secondary (Frequency and %)	48(38.7)	25(44.46)	23(33.82)		
College (Frequency & %)	16(12.9)	13(23.21)	3(4.41)		
University (Frequency & %)	4(3.2)	1(1.79)	3(4.41)		
Income per year in Kenya shillings					
10000-50000 (Frequency & %)	23(18.5)	7(12.5)	16(23.5)		**7.125***
51000-100000 (Frequency & %)	43(34.7)	17(30.4)	26(38.2)		
101000-150000 (Frequency & %)	25(20.2)	11(19.6)	14(20.6)		
150000-5000000 (Frequency & %)	33(26.6)	21(37.5)	12(17.6)		
Dairy income in Kenya Shillings per year					
<=50000 (Frequency and %)	44(35.5)	15(26.8)	29(42.6)		5.967
51000-100000 (Frequency and %)	44(35.5)	19(33.9)	25(36.8)		
101000-150000 (Frequency and %)	16(12.9)	10(17.9)	6(8.8)		
150000-5000000 (Frequency and %)	20(16.1)	12(21.4)	8(11.8)		
Farm characteristics					
Total owned land acres	2.82(2.37)	2.67(2.48)	2.93(2.30)	1.451	
Cultivated land acres	1.73(1.67)	1.65(1.52)	1.54(1.34)	1.570	
Land under fodder acres	0.575(0.53)	0.63(0.59)	0.54(0.49)	**2.548***	
Adoption fodder promoted by DIP (Yes, frequency and %)	19(15.3)	14(73.70)	5(26.30)		**7.371****
Awareness of DIP (Frequency and %)	18(14.5)	16(88.9)	2(11.10)		**16.257****
number of dairy	2.65(1.57)	2.75(1.77)	2.57(1.40)	0.588	
Labour force	2.23(1.36)	2.09(1.53)	2.31(1.23)	-0.718	
Minutes to the nearest motorable road?	5.66(9.11)	3.30(3.23)	4.91(4.04)	**-2.43****	
Walking minutes to the nearest village market?	30.91(21.75)	32.61(26.63)	29.51(16.80)	0.754	
Walking minutes to the nearest source of seed dealers (fodder seeds)?	36.10(33.36)	20.29(8.74)	30.76(17.48)	**1.85***	
Walking minutes to the nearest agricultural extension office	54.21(41.17)	57.77(44.34)	51.28(38.46)	0.860	
Walking minutes to the nearest demonstration meeting venue	24.90(20.43)	26.05(23.69)	24.18(18.21)	0.442	

, **, and * denote significance at 10%, 5%, and 1%, respectively*

7.4.12 Farmers' Perception on the Importance of DIP Characteristics

Farmers' judgement on the importance of the attributes of FFS to them (very important, important, not so important) revealed that all characteristic were considered very important (Table 7.3).

Table 7. 3 Perception of farmers rating the importance of DIP characteristics

Characteristics (%)		Capital requirement	Labour requirement	Milk quality &quantity	Forage affordability	Forage seeds availability	Milk yield
Overall	Not important	4.0	6.5	2.4	0.0	4.0	0.8
	Important	10.5	34.7	2.4	5.6	3.2	0.8
	Very important	85.5	58.9	95.2	94.4	92.7	98.4
MWDL	Not important	1.8	7.1	3.6		8.9	1.8
	Important	8.9	32.1	3.6	10.7	5.4	1.8
	Very important	89.3	60.7	92.9	89.3	85.7	96.4
NKCC	Not important	5.9	5.9	1.5	0.0	0.0	0.0
	Important	11.8	36.8	1.5	1.5	1.5	0.0
	Very important	82.4	57.4	97.1	98.5	98.5	100

Farmers judgement on the quality of the attribute being supplied through FFS (very good, good, poor) revealed that, overall, more than half of farmers perceived the FFS capability of addressing challenges of capital requirement, labour requirement, forage affordability and forage availability as poor. Most farmers in MWDL perceived FFS as poor in all the six characteristics than those in NKCC Sotik (Table 7.4).

Table 7. 4 DIP rating in meeting farmer's needs

	Overall (%)			MWDL (%)			NKCC (%)		
Characteristics	Poor	Good	Very good	Poor	Good	Very good	Poor	Good	Very good
Capital	78.2	15.3	6.5	80.4	14.3	5.4	76.5	16.2	7.4
Labour	66.9	30.6	2.4	78.6	17.9	3.6	57.4	41.2	1.5
Quality & quantity	33.1	28.2	38.7	37.5	35.7	26.8	29.4	22.1	48.5
Forage	53.2	25.8	21.0	69.6	21.4	8.9	39.7	29.4	30.9
Forage availability	54.8	37.1	8.1	71.4	25.0	3.6	41.2	47.1	11.8
Milk yield	40.3	24.2	35.5	46.4	33.9	19.6	35.3	16.2	48.5

The negative perception of FFS in MWDL compared to NKCC Sotik can be explained by the fact that NKCC supported the DIP through contribution such as supporting irrigation of demonstration plot, provision of refreshments and purchase of fodder seeds, supports that were not available in MWDL. In addition, all the eight DIP committee members of NKCC, participated in planting in all demonstration plots an act that could boost farmers' confidence in FFS. To the contrary, farmers of two cooperative societies in MWDL did not have an opportunity to see the fodder grow to maturity and hence their negative perception towards FFS in addressing their challenges as revealed by a farmer.

"I am not convinced that the trial fodder can perform well in our location" (Farmer in MWDL).

7.5 Binary Logistic Regression Model Results and Discussion

Table 7.5, shows the binary logistic coefficient for each independent variable. The probability of the Chi-square model (73.83) with significant ($p < 0.0000$), demonstrate that the likelihood ratio statistics are highly significant, suggesting the model has the power to reliably explain behavior that leads to farmers' FFS perception in improving dairy cow's feeding and nutrition.

A binary logit model employed for perception analysed 15 explanatory variables. The model overall goodness of fit parameters predicted and chi-square tests show that the overall goodness

of fit model was 78.83 and statistically significant at less than 1 percent. The binary logit model highlights the factors that influenced the perception of farmers on use of Farmer Field School in increasing milk quantity and improving milk quality. Fifteen characteristics were identified as factors influencing the decision perception on FFS. According to Table 7.5, the household head education level, minutes taken to demonstration farm, minutes taken to agrodealers land cultivated in acres, minutes taken to agricultural extension offices, and group membership were all important variables in the model.

Education of household head was significant at 10 percent significance level, with a negative influence on perception of FFS in increasing milk and improving milk quality. As the education of household head increases, the perception of FFS on increasing milk quantity and quality decreased by 0.538. It implied that farmers with higher education levels perceived FFS as ineffective in boosting milk quality and quantity compared to those who had lower education levels. The results corroborate those of Al-Zahrani *et al*. (2019) which revealed a negative and significant effect of education and perceived effectiveness of extension services in promoting modern technologies in Pakistan.

Time taken from farmer's homestead to demonstration farm was significant at 10 percent level and had a negative impact on the perception of FFS. The results implied that increasing the time taken to get to the demonstration plot by one minute reduced the likelihood of having a positive perception on FFS in increasing milk production and quality of milk by 0.985. Time taken from farmer's homestead to agrodealers was significant at 10 percent level and had a negative impact on the perception of FFS. Compared to farmers in close proximity and hence took short time to get to the demonstration plot, the likelihood of having a positive perception on FFS in increasing milk production and quality of milk was reduced by 0.941.

Land cultivated in acres was significant at a 1 percent level, positively influencing the FFS perception. Compared to farmers who had a negative perception on FFS in improving milk quantity and quality, the likelihood of perceiving FFS as positive increased by 1.590. In contrast to this study findings, Maake & Antwi (2022) reported a negative and significant correlation of farm size with perceived effectiveness of extension services in South Africa.

The results show that group membership had a 1 percent significance level, and positively influenced FFS perception. Compared to farmers who had a negative perception on use of FFS in increasing milk quantity and increasing milk quality, the likelihood of perceiving FFS as positive increased by 14.604. Membership to groups had the highest effect, implying that farmers could be receiving information on fodder from other groups, and hence the positive perception. This corroborates Lugandu (2017) study results in Tanzania, who noted that farmers' perceptions may be influenced by the information available to them. Minutes taken to agricultural extension was significant at a 1 percent level, positively influencing the perception of FFS. Compared to farmers who had a negative perception to FFS in improving milk quantity and quality, the likelihood of perceiving FFS positive in increasing milk quantity and improving milk quality increased by 1.058. As a result, at a significance level of less than 1 percent, the minutes taken to agricultural extension and FFS perception were positively related. The significance and positive effect of time taken to walk to government extension office on rating by farmers as positive, indicate that although FFS is one of extension approach, the information about its existence could also be received from agricultural officers irrespective of whether they were not involved in it implementation of the project.

Table 7. 5 Factors influencing farmers' perception on Farmer Field School

Vaariables	Estimated coefficients	Odds ratio (exp(B))
Genderhhed (female)	-0.930 (0.678)	0.394 (0.267)
Agehhed	-0.008 (0.027)	0.992 (0.027)
Educhhed	**-0.619*** **(0.362)**	**0.538*** **(0.195)**
Experienced	0.006 (0.029)	1.006 (0.030)
No_dcows	-0.058 (0.063)	0.944 (0.059)
Total_acres	-0.137 (0.093)	0.872 (0.081)
Culti_acres	**0.464*** **(0.247)**	**1.590*** **(0.392)**
Labour_frc	0.234 (0.304)	1.263 (0.384)
Minmr	0.044 (0.051)	1.045 (0.053)
Minnmkt	0.027 (0.029)	1.027 (0.030)
Mindelers	**-0.060*** **(0.032)**	**0.941*** **(0.030**)
Minagext	**0.056***** **(0.017)**	**1.058***** **(0.018)**
Mindem	**-0.015*** **(0.009)**	**0.985*** **(0.008)**
AwareDIP (Yes)	-0.215 (0.996)	0.807 (0.803)
Other_grp (Yes)	**2.681***** **(0.646)**	**14.604***** **(9.432)**
Constant	0.109 (1.582)	1.115 (1.764)
Observations		124
LR chi2(15)		73.83
Prob> chi2		0.000
Log likelihood		-47.998241
Pseudo R2		0.4348

, **, and * denote significance at 10%, 5%, and 1%, respectively; standard errors in parentheses.* (source: own survey, 2022).

7.6 Conclusions and Policy Implication

Assessing farmers' perception on dissemination of agricultural technologies through FFS is important in informing on possibility of adoption of technologies. The study sought to provide

information into the perceived perception of FFS by dairy farmers on improving feeding and nutrition to inform efforts targeting adoption of different fodder varieties. In both milkshed, a higher proportion of farmers perceived FFS could not address the challenge of capital requirement and labour requirement. Further, a higher percentage of farmers in MWDL perceived FFS incapable of enhancing forage seeds affordability and availability, which contradicts findings in NKCC Sotik. The different perception across the milkshed can be linked to financial support and DIP implementation. Whereas in NKCC Sotik, the DIP and extension department provided refreshments, financed weeding of demonstration plots and ensured growth of tested forages to maturity through irrigation and hence positive perception, this was not the case in MWDL. To improve farmers' perception on FFS, there is a need to invest in demonstration plots through irrigation of forages. This will boost perception of farmers and could increase the adoption of forages promoted at the demonstration plots, particularly in MWDL. To boost perception of FFS in the two milkshed, group membership is key. The study recommends another study on adoption of fodder seeds by farmers across the milkshed obtained either from demonstration farms or purchased to inform whether FFS had effect on land allocated under fodder and milk yield.

CHAPTER EIGHT: GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

8.1 Discussion

This study characterized dairy practices, determined factors influencing their adoption by farmers, as well as their effect on poverty status representing three processor' milksheds in Kenya namely Happy Cow Limited (HCL), New Kenya Cooperative Creameries (NKCC) Sotik, and Mukurweini Wakulima Dairy Limited (MWDL) representing one private, state and farmer-owned processor, respectively. The study further analysed the perception of dairy farmers on use of farmer's field schools in improving cow feeding and nutrition in MWDL and NKCC Sotik. The study used a baseline survey data of 1146 households collected between June and December 2019 and after AfricaMilk project implementation, data from 124 farmers and 11 key informant interviews in MWDL and NKCC Sotik. For the baseline survey, milk suppliers and non-suppliers of sampled processors were interviewed, while data collected after project implementation were from farmers who had been trained through the farmer field school extension approach.

The first objective of the study characterized the dairy practices adopted by farmers both at the farm referred here in as technical dairy practices /technical dairy practices and at the milkshed referred to as organizational and institutional dairy practices/ organizational and institutional dairy practices. The dairy practices at the farm are meant at increasing milk productivity, while those adopted at the milkshed aim at enhancing milk marketing efficiency and inclusivity along the dairy value chain. This objective was achieved using a Categorical Principal Component Analysis (CATPCA) and the results revealed that most smallholder farmers adopted technical dairy practices than organizational and institutional dairy practices.

Using a double hurdle model, the second objective then sought to understand factors that influence adoption of technical dairy practices and intensity of use of organizational and institutional dairy practices. The results indicated that, to boost adoption of technical dairy practices, access to dairy information, keeping dairy records are key while household head education, income, farm size, dairy records and access to information are necessary for adoption of organizational and institutional dairy practices.

The third objective focused on whether dairy practices would influence the farmers' poverty status, since literature suggests adoption of dairy practices can alleviate poverty. The objective, therefore, focused on the effects of dairy practices on poverty status (measured using an asset-based index). The quantile regression results revealed a positive effects of technical dairy practices on poverty status. The study further revealed that an interaction of organizational and institutional dairy practices is likely to reduce poverty among the poor farmers.

The fourth objective analysed farmers' perception on farmer field schools in enhancing dairy cow's feeding and nutrition. While applying Multinomial Logit Model, the objective further established factors that influenced farmers' perception. This objective revealed that farmers perceived FFS as poor in improving the dairy cow's feeding and nutrition. Some of their reasons of rating FFS as poor included that farmers did not access fodder seeds to try in their farm, training session of four months was short, in some demonstration farms fodder did not grow to maturity due to lack of rain, and the training environment was not conducive. Factors such as household head age, income and group membership positively influenced farmer's perception.

The results of the four objectives addressed by the study differed across the milksheds. Objective one that characterized dairy practices adopted by farmers showed that more farmers in the milkshed of MWDL adopted technical and organizational dairy practices such as use of artificial insemination and milk sale through groups, respectively, than farmers in milkshed of NKCC Sotik and HCL. The study therefore concluded that there is low adoption of the three categories of dairy practices (technical, organizational and institutional) in milkshed of NKCC Sotik and Happy Cow Limited.

Objective two that determined the factors influencing adoption of technical dairy practices and the intensity of use of organizational and institutional dairy practices revealed that access to dairy information positively influenced adoption of technical dairy practices in the three milksheds. Further, the study showed that adoption of technical dairy practices across the milksheds was influenced by hired employees, dairy records, total dairy cows and household head education while extent of adoption of organizational and institutional dairy practices was influenced by income, farm size, keeping dairy records, income, access to dairy information.

Objective three determined the effect of technical, organizational and institutional dairy practices on farmers' poverty status. A principal component analysis (PCA) was used to create an asset index for each household and thereafter the quantile regression model to identify the effects of DPs including technical dairy practices (TDPs), organizational dairy practices (ODPs), institutional dairy practices (IDPs) and an interaction between ODPs and IDPs on poverty status in the three milksheds supplying milk to MWDL, HCL and NKCC Sotik. The study found that TDPs had a positive and significant effect on poverty reduction in the three milksheds. Except for HCL where ODPs and IDPs had no effect on poverty status, in MWDL,

both ODPs and IDPs negatively influenced household poverty status. In NKCC Sotik, ODPs and interaction of ODPs and IDPs positively influenced poverty status.

Objective four analysed farmers' perception on farmer field schools in enhancing dairy cow's feeding and nutrition. Most farmers in Mukurweini Wakulima Dairy Limited (MWDL) perceived FFS as poor in improving dairy cow's feeding and nutrition than in New Kenya Cooperative Creameries (NKCC). Household head age, income and group membership positively influenced farmer's perception.

8.2 Conclusions

8.2.1 Characterize the Technical, Organizational and Institutional Dairy Practices that are Adopted by Farmers in Kenya

More of technical dairy practices were adopted in the three milkshed than the organizational and institutional dairy practices. Farmers in MWDL however adopted technical dairy practices such as AI and organizational practices including group membership and sale of milk through groups than farmers in the other two milksheds.

8.2.2 Evaluate the Factors that Influence Intensity of Adoption of Technical, Organizational and Institutional Dairy Practices in Kenya

Adoption of TDP and intensity of adoption OIDP were influenced by different factors and therefore require varied interventions to promote dairy practices across the three milksheds. Access to dairy information is a key driver to adoption of TDPs and intensity of adoption of ODPs and IDPs in the three milksheds. Additionally, credit access, access to dairy information were the main drivers of adoption of TDPs while adoption of ODPs and IDPs were access to dairy information, income, household size, record keeping and number of employees in the three milksheds.

8.2.3 Assess the Effects of Dairy Technical, Organizational and Institutional Dairy Practices on Dairy Farmers' Poverty Status

The findings presented in this paper suggested that the adoption of TDPs contribute to poverty reductionmong households across the three milksheds. In MWDL, adoption of organizational and institutional dairy practices jointly contributed to poverty reduction. The study concludes that adoption of dairy practices individually and jointly improve the welfare of households irrespective of their poverty status.

8.2.4 Analysis of Dairy Farmers' Perception on Use of Farmer Field Schools to Improve Dairy Cows' Feeding and Nutrition in Selected Milksheds of Kenya

The findings of this study revealed that although FFS is a way of disseminating information and gives farmers an opportunity to test the technologies trained while attending FFS, farmer's perception of FFS role in improving dairy feeding and nutrition was negative. Size of land cultivated, group membership and time taken to walk to agricultural extension offices boosted perception of FSSs. Time taken in minutes to demonstration plots and education level had a negative influence on perception.

8.3 Recommendations

8.3.1 Characterize the Technical, Organizational and Institutional Dairy Practices that are Adopted by Farmers

Based on the findings of this study, there is need to promote the three types of dairy practices to enhance sustainable milk production quantity and quality. Specifically, the county government in collaboration with other development partners should support farmers,

particularly in promoting the adoption of AI to improve on genetics. These efforts should target dairy farmers in milksheds of NKCC Sotik and HCL. This could be possible by the county governments in the counties under the two milkshed coming up with policies targeting subsIDPzing of Artificial Insemination (AI) and animal health services. To promote organizational practices, farmers in these two milksheds should be supported in forming farmer groups and also offer other services including AI services through a check off system. This is a system in which farmers are offered services such as AI, feeds and health services on credit and the costs are later paid from the milk sale proceeds. Milk sale through groups will help farmers in ensuring milk market all year round. Regarding institutional dairy practices, the respective county governments and development partners in the three milksheds need to link farmers to financial service providers who can give farmers long term loans to improve their dairying enterprise, including purchase of cows of high genetic potential and building houses for cows. Further, dairy farmers should be supported to engage into formal contracts with their buyers, which should be based on milk quality and quantity to ensure access to market throughout the year.

8.3.2 Evaluate the factors that influence intensity of use of technical, organizational and institutional dairy practices that support inclusive and efficient milk collection systems.

The study revealed different strategies are necessary to promote dairy practices across the three milksheds. To promote the adoption of TDP in MWDL, focus should be made on the provision of dairy information. Regarding OIDP, dairy value chain promoters (county government and development patners) of these practices should target the large households, less educated and with higher income levels. In HCL, Adoption of TDP can be boosted by the county government together with TDP and OIDP promoters training farmers on dairy record keeping. The training

should be tailored to reach young dairy farmers. In addition, farmers should be encouraged to join groups dealing with milk sale to enhance information, knowledge sharing and access to credit at affordable interest rates to buy improved cow breeds and animal feeds. In NKCC Sotik, the county government should enhance access to dairy information and train farmers on how to keep dairy records to enhance TDP and OIDP adoption. Efforts should target farmers with large farms and many employees.

8.3.3 Assess The Effects Of Dairy Technical, Organizational and Institutional Dairy Practices on Dairy Farmers' Poverty Status.

Objective three results recommends dairy stakeholders including national and county government to promote the adoption of TDPs, ODPs and IDPs across the three milksheds in an effort to reduce poverty among the dairy farmers. Promotion of local fodder production is one of the technical dairy innovation that could result in increased milk production, consequent increase in income from milk sale and hence reduced poverty status. To support local fodder production, the government (national and county) should come up with institutional and regulatory framework governing production, processing and marketing of fodder support which is underdeveloped, leaving farmers vulnerable to unscrupulous market actors who sell feeds of low quality.

8.3.4 Analysis of Dairy Farmers' Perception on Use of Farmer Field Schools to Improve Dairy Cows' Feeding And Nutrition in Selected Milksheds of Kenya

To improve farmers perception on FFS contribution in increasing milk quantity and enhancing milk quality, which could result in adoption of technologies learned, group membership is key where farmers can gain knowledge on dairy farming. Additionally, linking farmers to sources

of fodder could be important to allow them increase land under fodder and also to test them in their farms. The study recommends another study on adoption of fodder seeds by farmers across the milkshed obtained either from demonstration farms or purchased to inform whether FFS had effect on land allocated under fodder and milk yield.

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APPENDICES

Appendix 1: Household survey questionnaire

Topic: An analysis of technical, organizational and institutional innovation in fostering efficient and inclusive milk supply by smallholders' and medium dairy farmers in Kenya

INSTRUCTIONS FOR ENUMERATORS:

1. Only those who consent should be interviewed. *2. Always read carefully, the instruction given in bold/per question before you ask a question* *3. Do not read responses/options unless instructed to do so* *4. Ensure questionnaires are complete for those consenting to the assessment*	
1. Questionnaire code	
2. Date of survey (DD/MM/YYYY)	_____ / _____ / _____
3. County name	1= Nyeri; 2=Nakuru; 3=Bomet
4. County code	Nyeri=019; Nakuru=032;Bomet=036;
5. Village	
6. Enumerator name	
7. Time: starting interview	
8. Time: ending interview	
A: SOCIO-ECONOMICATTRIBUTES	
A.1 Full name of the respondent	
A.2 Gender of the respondent	1= Male; 2=Female
A.3 Gender of household head	1= Male; 2=Female
A.4 Age of the household head in years	
A.5 Level of education of the household head (codes)	Level of education codes:1 = Illiterate 2 = Elementary school; 3 = Middle School; 4 = High school; 5 = University; 6 = Koranic school; 7 = Other
A.6 How many people are in this household?	
A.7 Farm size of household in acres in 2018	
A.8 Rented in farm in acres in 2018	
A.9 Rented out land in acres in 2018	
A.10 Land size in acres under fodder and grazing	
A.11 Did you use any **community/ public land** for	1=Yes; 2=No

B Household financial resources

(*Rank the **different sources of income** to the household and provide an estimate of the amount of YEARLY income by source in 2018*)

Sources of income	**RANK (codes)**	**Income in local currency/year**	**Income managed by adult males**	**Income managed by adult females**
B.1 Income from dairy (milk, cattle, feed and manure)				
B.2 Income from other livestock activities (specify)----------				
B.3 Income from all crop activities				
B.4 Income from other farm activities (including bee keeping, brew making, draft animal rental, machinery and equipment rental, etc.)				
B.5 Income from wages/salaries/rentals/non-farm, pension and business activities not related to agriculture				
B.6 Income from remittances from absent family members and other external income				
B.7 Income from other sources (specify): /----------/				
Ranking codes: 1= Main source of income source, etc..	2 = 2nd source		3 = 3rd	

B.8 Do you have access to credit? [___] = YES [___] = NO (tick)

B.9 . If yes, provide details in the following Table:

Main source of current loan (codes)	**Amount borrowed (local currency)**	**What was the interest rate for the loan (%)**	**Main Purpose of Loan (codes)**

Source of loan codes:	Purpose of loan codes:
1 = Micro-finance institution 2 = Commercial banks 3 = Cooperatives 4 = NGOs 5 = Government credit schemes 6 = Agricultural Finance Corporation 7 = Local money lender 8 = Group/Table banking 9 = Family and friends 10 = Contractual outgrower arrangements	1 = Purchase farm inputs (e.g. seeds, fertilizers etc.) 2 = Buy livestock 3 = For marketing and value addition activities 4 = Buy land 5 = Construction of farm structures 6 = Buy machinery and equipment 7 = Payment of labor costs 8 = Irrigation facilities

SECTION C. LIVESTOCK INVENTORY & MANAGMENT

B.1. Livestock Inventory

C. 1. Indicate the **heads of cattle** kept on the farm in 2018 including those kept but not owned:

Breeds (codes)	**Animal type (codes)**	**Owned and kept on the farm (number)**	**Owned but kept out of the farm (number)**	**Kept on farm but not owned (number)**

Animal types codes:	3 = Immature males (< 3 yrs)	6 = Pre-weaning males
1 = Bulls (>3 yrs.)	4 = Cows (calved at least once)	7 = Pre-weaning females
2 = Castrated adult males (oxen>3 yrs)	5 = Heifers	
Breed codes (Kenya):		
1 = Holstein-Friesian (pure)	**5 = Jersey (pure)**	**9 = Sahiwal**
2 = Holstein-Friesian (cross)	6 = Jersey (cross)	10 = Boran
3 = Ayrshire (pure)	7 = Guernsey (pure)	11 = Local zebu
4 = Ayrshire (cross)	8 = Guernsey (cross	

C.2. Indicate the **numbers of animals** for the different species kept on the farm in 2018

Type of animal	**Number kept on farm in 2018**
Goats	
Sheep	
Poultry	
Rabbits	
Donkeys	
Horses	
Pigs	
Others (specify):	

SECTION D. DAIRY COWS' MANAGEMENT

D.1. Dairy cows' characteristics and milk production in 2018

D.1. How many **total dairy cows** did you have in 2018? /_____/

D.2 Did you produce milk in 2018? 1=Yes; 0=No

D.3. If Yes, Please provide estimates of daily milk production and sales in 2018:

Months	**Jan 2018**	**Feb 2018**	**March 2018**	**April 2018**	**May 2018**	**June 2018**	**July 2018**	**Aug 2018**	**Sept 2018**	**Oct 2018**	**Nov 2018**	**Dec 2018**
Daily number of												
Average milk												
Number calve births												
Daily milk production												
Daily milk household												
Daily milk sales												

Average price per												

D.4. Do you **plan to increase the amount of milk** you produce? [___] = YES [___] = NO (tick)

D.5. If **yes**, **how** do you plan to do it? First method [___] Second method [___] (codes)

1 = Improve the grade of animals 2 = Produce more feed	3 = Buy more feed 4 = Increase number of dairy cows	5 = Increase number of dairy goats 6 = Spend more on controlling animal disease	7 = Depends on extensionist's advice 8 = Other better management and feeding practices	9 = I don't know 10 = Other specify

D.6. If you do want to increase the amount of milk you produce, what are the constraints or what are the limitations? Main constraint [___] Second constraint [___] (codes)

1 = My animals cannot produce more	7 = Not enough feed available to increase production
2 = Lack of credit to buy animals	8 = Buying more feed would be too expensive
3 = Lack of credit to buy feed	9 = Dairy animals have poor health
4 = I cannot use more milk	10 = No buyer/ dairy cooperative
5 = The price of milk is too low	11= There is not enough reliable water available
6 = Lack of labour	12= Other specify: _____

D.7 Did you store fodder or crop residues in 2018? 1=Yes; 0=No

D.8. If no, indicate reasons for not conserving (codes)

E.4. Dairy cow's reproduction and genetic

Reproduction

E.1. Between AI, bull and other, **which method of serving female cows do you prefer** for your cattle?

[__] = AI [__] = Bull [__] = Other (sexed semen, synchronized estrus etc.?)

E.2. Why do you prefer the above choice (codes)? [____] [____] [____] [____]

Reasons for service preference codes:	
1 = Its more affordable	4 = Breed variety
2 = Its easily accessible	5 = Other, specify
3 = Few or no repeats	

E.3. Have you **used AI in the last 5 years**? [___] = YES [___] = NO (tick)

E.4. If **yes**, who was the main provider of the service? (tick):

Private inseminator	
Government organization	
Research station personnel	
Project or NGO's	
Other (specify)	

E.5. The **cost of AI service** currently is: _____ (Local currency)

E.6. The **cost of bull service** currently is: _____ (Local currency)

Genetic

F. Indicate which of the following **breeding strategies you have used** (tick any number of boxes):

Breeding strategies	**Has ever used**	**Used in 2018**
Controlled mating – best male to best female		
Controlled mating – to avoid mating of close relatives		
Controlled mating – other (e.g. corrective)		
Use best males from own herd		
Gift / loan of high quality breeding male		
Exchange of high quality breeding male		
Purchase of high quality breeding male		
Artificial insemination		
Purchase of high quality breeding female(s)		
Use female from neighboring farmers		
Use female from multiplier association		
Castrate non-productive males		
Culled/sold non-productive males		
Culled/sold non-productive females		
Cross-breeding with?		
Other (specify):_____		
Other (specify):_____		

G.6. Dairy inputs in 2018

G.1. How do you source your inputs and services for your dairy cows?:

Inputs and services	**Model of sourcing inputs and**	**Why do you choose this**
Concentrates & minerals		
Animal health		
Artificial insemination		
Extension		
Loans		
Other (specify)		

Model codes: 1 = Purchase directly from private service providers 2 = Cooperative owned agrovets through check off system 3 = Private Service providers contracted by processor	Reason of choose codes: 1 = Variety of product and/or services offered 2 = Offer lower price 3 = Offer goods on credit 4 = Less distance to the source 5 = Quality inputs and services 6= Inputs delivered to me during milk collection 7= other (specify)

G.2. Has anyone in the household ever **obtained long term credit (loans)** for your dairying activities? [___] = YES [___] = NO (tick)

G.3. If **yes** indicate, **amount**, for **which needs** credit was obtained, and from **what credit source**? (List each loan separately):

Value or amount	Credit needs (codes)	Source of credit (codes)

Credit needs codes: 1 = To purchase improved dairy animals 2 = For purchase of feed 3 = For veterinary services 4 = For AI services 5 = Other (specify)	Source of credit codes: 1 = Government bank/agency 2 = Commercial bank 3 = Informal lenders 4 = Co-operative	5 = Project / NGO 6 = Self Help group or savings club 7= Relatives 8 = Other (specify):_____

4.4. If **no credit was obtained**, why not? [____] (codes)

1 = Credit required but didn't get 2 = Credit not available 3 = Credit was too costly 4 = Lack of collateral ("mortgage")	5 = Didn't know / not aware / do not have such information or advice 6 = Fear of being unable to pay	7 = Never thought of it 8 = Does not need credit 9 = Other (specify) _____

SECTION H. MARKETING, FARM MILK NETWORK, SOURCES OF INFORMATION

H. Household milk self-consumption, milk transformation & milk marketing in 2018

H.1. Do your household consume milk or dairy products? [___] = YES [___] = NO (tick)

H.2. If **yes,** what is the **quantity** of these products? (consider average during the last month):

Milk products	Per day/ week/ month (codes)	Unit (codes)	Quantity (number of units)
Raw milk (unpasteurised milk)			
Pasteurised milk			
Sour milk - yogurt			
Cheeses			
Butter & cream			
Milk powder - condensed milk			
Other Specify_____			
Other Specify_____			

Frequency codes: 1 = Daily 2 = Per week 3 = Per month 4 = Other (specify)	Units codes: 1= Liter 2= Kg 3= Grams 4= Other (specify)

H.3. Do you make **milk products (other than fresh milk)**? [___] = YES [___] = NO (tick)

H.4. If **yes**, please fill in the table:

Milk Product	Do you make? 1=Yes 2=No	Quantity Units (codes)	Quantity produced in 2018	Quantity sold in 2018	Buyer type (code)	Price outlet (in local currency/ unit)
Sour						
Butter						
Cream						
Cheese						
Other						

Milk unit codes: 1 = Liter; 2 = Kg; 3 = Other(specify)	Types of buyers codes: 1 = Individual customers ; 2 = Private milk; 3 = Relatives; 4 = Dairy co-operative collection center 5 = Other (specify)

H.5. When did you first start selling milk? [___ __ __] (Year)

H.6. Did you sell milk in 2018? **[___] = YES** **[___] = NO (tick)**

H.7. If yes, give more details about fresh milk you sold to different types of buyers in 2018?

Buyer types (codes)	**Number of buyers of this type? (average)**	**Time of the day (codes)**	**Quantity per day (Litres)**	**Price/Litre (local currency)**	**How is price determined? (codes)**	**Who receives the money? (codes)**	**Do you have a formal contract (1 = Yes ; 0 = No)**	**Nature of milk payment (codes)**	**Other arrangement (codes)**	**Distance to selling point (km)**	**Who transported? (code)**	**Transport mode (code)**	**Cost of transport (local currency)**	**Type of milk test (codes)**

Milk buyer codes:	How is price determined? (codes):	Nature of payment codes:	Who transported? (codes):	Type of milk test codes:
1 = Individual customers 2 = Private milk-traders 3 = Dairy co-op. collection center 4 = Chilling plants 5 = Other (specify) Time of the day codes: 1 = Morning 2 = Evening 3 = Both	1 = Market price 2 = Seller decides 3 = Buyer decides 4 = Buyer and seller agree and fix price based on quality Who receives the money? (codes): 1 = Husband 2 = Spouse 3 = Household (All) 4 = Other (specify	1 = Buyer pays cash 2 = Buyer pays end of month, verbal contract 3 = Buyer pays end of month, written contract 4 = Buyer pays in advance, verbal contract 5 = buyer pays in advance, written contract 6 = Other (specify) Other arrangements codes: 0= No other arrangement 1 = Buyer provides feeds on credit 2 = Buyer provides AI on credit 3 = Buyer provides loans 4 = Buyer gives deposit 5 = Other (specify)	1 = Farmer 2 = Buyer 3 = Hired transport (farmer paid) 4 = Hired transport (buyer paid) 5 = Other (specify) Transport mode codes: 1 = On-foot 2 = Draft animals / carts 3 = Bicycle 4 = Motorcycle 5 = Public vehicle/ bus 6 = Private pick-up, van, truck 7 = Other (specify)	1 = Not tested 2 = Lactometer 3 = Smear test 4 = Flavor/Visual test 5 = Other (specify

H.8. Do you experience delays in getting paid for milk sold in 2018? [____] = YES [____] = NO (tick)

H.9. In 2018, have you **searched for new** milk buyers? [___] = YES [___] = NO (tick)

H.10. If **yes**, why? [_____] [_____] [_____] (codes)

1 = Find a better price 2 = Find a single buyer of larger quantity	3 = Want more buyers 4 = Find a more reliable buyer	5 = Buyers stopped buying 6 = Other (specify) _____

I. Farm milk network

G.1. Do you have any member of the household registered as a member of a **dairy co-op** or **self-help group or** dairy **innovative platform (DIP)** that collects milk? 1= Dairy co-op; 2= Self-help group; 3= DIP; 4= Not member

I.2. If **yes**, since when? [_____] (year)

I.3. What is the **name of the co-op or group or DIP**?
[_____]

I.4. And **who is registered as a member?** [_____]

1 = Head		4 = head's father	6 = Son	8 = Other joint (specify):_____
2 = Spouse	3 = Household (All)	5 = head's mother	7 = Daughter	11= Other (specify):_____

I.5. Is the **member holding an elected or appointed leadership position**? [____] = YES [____] = NO (tick)

I.6. Is the household **currently delivering milk to that co-op or group or DIP**? [____] = YES [____] = NO

I.7. If not currently delivering milk to diary co-ops, please explain **why not**? [____][____][____] (code)

1 = Immature cows	4 = Cows died	7 = Dairy co-op collapsed / not taking milk any more
2 = Dry cows	5 = Selling milk elsewhere at a better price	8 = Delayed payments
3 = Sold all cows	6 = Consuming all the milk	9 = Other (specify) _____

I.8. Does this co-operative/group/DIP own a chilling plant? [____] = YES [____] = NO (tick)

I.9. If **yes,** has the **household member bought any shares in this chilling plant**? [___] = YES [___] = NO

I.10. If **yes,** how much: [___ ___ ___ ___ ___] (KES)

I.11. If household would become a member of a **dairy co-op** or **self-help group,** what **services** of the dairy co-op/Self Help Group **do you use?** Indicate with ticks:

Services	**M**	**Veterina**	**Selling**	**Provider**	**Credit**	**Credit**	**Insuran**	**Others**
Dairy co-op								
Self Help Group								

I.12. Are you **willing to contribute for the set up/expansion of a (an existing) chilling plant**? 1 = YES; 0= NO (tick)

I.13. If **Yes,** how much would you be willing to pay for shares (KES)? [_____]

J.3. Access to information

J.1. Do you access **information on dairy cows breeding**? [___] = YES [___] = NO (tick).

J.2. If **yes**, indicate for each type of information, **source and how you access information:**

The type of information (codes)	The two mains sources of information (codes)		How did you access information? (codes)	
Feeds				
Concentrate feeding				
Fodder and forage feeding				
Grazing management				
Fodder establishment				
Fodder harvesting & processing				
Fodder conservation				
Feeds ration formulation				
Calf nutrition				
Cattle management				
Cattle housing				
Cattle breeding				
Cattle reproduction				
Health and diseases management				
Manure management				
Milk management & marketing				
Milk prices				
New milk outlets				
Milk hygiene management				
Milk quality standard				
Others				
Financial services (loans)				
Livestock training schemes				
Other specify: /_____/				

Source of information codes:
1 = Government ministries
2 = Farmer/ self-help farmer groups
3 = Private entrepreneurs/sector
4 = NGOs, Specify
5 = Cooperative societies
6 = A research organization, specify
7 = A learning institution
8 = Ongoing projects, Specify
9 = Other (specify)

Method of access to information codes:
1 = Farmer/group to farmer
2 = Extension briefs
3 = Producer trainers to farmers/groups
4 = Extension agents to farmers/ groups
5 = NGOs to farmers/groups
6 = Media (Radio, Print, TV etc)
7 = Field days, demos, barazas etc.
8 = Training workshops, seminars etc
9 = Churches/Religious organisation
10= Poster/Banners

K. Awareness on environmental impact

What measures do you take in your dairy cow rearing practices to preserve the environment or to limit the impact of your activity on the environment?

K.1. Avoid overgrazing and under-grazing [____] = YES [____] = NO (tick)

K.2. Avoid pruning trees [____] = YES [____] = NO (tick)

K.3. Reduce the use of industrial imported concentrates feeds [____] = YES [____] = NO (tick)

K.4. Reduce the use of chemical fertilizers and pesticides [____] = YES [____] = NO (tick)

K.5. Feed cows with digestible feeds to reduce methane production [____] = YES [____] = NO

K.6. Good management of animal manure (composting) [____] = YES [____] = NO (tick)

K.7. Practice forage cultivation [____] = YES [____] = NO (tick)

K.8. Integrate legumes into crop rotations [____] = YES [____] = NO (tick)

K.9. Planting trees for various uses (fodder, hedges, medicinal plants, wildlife corridors, etc.) 1=YES; 2=NO (tick)

K.10. Use of alternative medicine or eco-pathology [____] = YES [____] = NO (tick)
K.11. Other (please specify): _____
K.12. Other (please specify): _____

L. Institutional innovation

Contractual arrangements

L.1 Is the agreement/relation formalized (written and signed) guIDPng your milk supply?	**[1]** = Written **[2]** = Not Written but Verbal, [3] = None
L.2 Who initiated the Agreement?	**[1]** = The producer(Farmer), **[2]** = The buyer, **[3]** = an intermediary,
L.3 What are the content of the agreements (*See copies if available) see requirements of buyers/intermediaries*?	
L.4 How long does your arrangement run?	_____ Years
L.5 How were the various aspects in arrangement arrived at?	[1] Mutually agreed with the farmer/group leaders [2] Guided by a
L.6 How frequently are adjustments made in the arrangement?	[1] Weekly [2] Monthly [3] Half year[4] Yearly [5] When necessary
L.7 Who initiates the adjustments?	[1] = The producer(Farmer), [2] = The buyer, [3] = an intermediary,
L.8 How often would you like the adjustments?	[1] Weekly [2] Monthly [3] Half year[4] Yearly [5] When necessary
L.9 Is the frequency of adjustments favorable to you?	[1] = Yes, [0] = No
L.10 If the agreements are not written, How long has it been going on?	_____Years
L.11 How do you enforce the various aspects in the trade arrangement to ensure compliance?	
L.12 Would you consider changing to another selling arrangement if made possible?	[1] = Yes, [0] = No
L.13 If yes, which selling arrangement will you change to?	[1] Sell to the nearby spot markets, [2] = Sell to intermediaries/brokers,
L.14 Why do you want to change to that selling arrangement mentioned in L.1 above?	

L.15 What challenges do you face in this selling arrangement	
L.16 how do you cope with these challenges?	
L.17 Do buyers always honor their payment obligations?	**[1]** = Yes, **[0]**= No
L.18 If No, are there sanctions/rules do you have to support compliance?	**[1]** = Yes, **[0]**= No
L.19 Who enforces the penalties to ensure compliance?	(1)=Farmers (2)=Traders (3)= Police (4)= Group committee (5)= Local
L.20 Who do the penalties favor most?	**[1]** = The buyers, **[2]** = The sellers,
L.21 Please give reasons for the response in L.20. on penalties	
L.22 In cases of total breach, what arrangements are there to allow enforceability of breached aspects in the trade	

M. Quality based payment system

M.1 What is the average **distance in Kilometres** from most of milk producers home who supply milk to this dairy to collection centres?

M.2 On average, how many **minutes do** most of you take while walking to the milk collection centre?

M.3 What is the main type of road that milk producers in this area use while transporting their milk to the collection centres? *(1=Paved (all weather) road; 2= Earthen (seasonal) road 3=Other specify? _____)*

M.4 Which are some of the quality tests that the milk is subjected to at the collection centres? (1=Density; 2=Alcohol test 3=Other specify_____)

M.5 Is there quality /standard of milk that have been defined and enforced? How?_____

M.6 Describe the milk quality that is delivered to the collection centre? ____ (1= Poor; 2=Average; 3=Good; 4=Very good)

M.7 Are there instances when your milk is rejected at the collection centres? (1=Yes; 0=No)

M.8 If yes, what are the reasons why the milk is rejected? (1=Density; 2=Fails to pass alcohol test; 3=Anti biotic residues; 4=Organic matter; 5= other specify_____)

M.9 What proportion in percentage of milk is lost during collection?

M.10 Does your dairy cooperative have an incentive system (additional payment) paid to farmers who have better quality of milk? _____ (1=Yes; 0=No)

M.11 If yes in M10, have you ever received the incentive? ____ (1= Yes; 0=No)

M.12. If yes in M11, how many times have you received a bonus? _____

M.13. If yes in M10 how much in total bonus have you received so far in Kenya Shillings (KES) ____

M.14 Are you satisfied with the bonus paid? (1= Yes; 0=No)

M.15. If not satisfied, why? _____

M.16. Is your milk collection centres equipped with a cooling system? (1=Yes; 0=No)

M.17 In your own opinion, are there policies that need to be put in place to boast the production and marketing of milk from small scale farmers? Please mention.

Questionnaire on perception for objective four

APPEDIX 1: QUESTIONNAIRE

An analysis of dairy farmers' perception on use of innovation platform to improve cows' feeding, nutrition and milk quality: A case of selected milksheds in Kenya

Introductions and consent to participate in the study

My name is _____, and I am supporting Edith Wairimu, a PhD student at the University of Nairobi in carrying out a survey to complete her academics. She is conducting a survey in these areas on the farmer's perception on Dairy Innovation Platforms (DIP) in enhancing cow's feeding nutrition and milk quality. You have been selected to participate in this survey because you are a member of a cooperative society that is implementing the DIP. Participation in the survey is voluntary and the information that you will give will be handled with confidentiality. The survey will take approximately 40 minutes.

PART 1: IDENTIFICATION

1.	Questionnaire number	
2.	Date of interview	
3.	Enumerators name	
4.	Milkshed	1=MWDL; 2=NKCC Sotik
5.	County	1= Nyeri; 2=Bomet; 3=Nyamira; 4=Nakuru; 5=Narok

PART 2: SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLD HEAD

1. Respondent name? _____
2. Are you the household head? (1=Yes; 0=No)
3. If no in question 2, indicate the household head name? _____
4. Household head gender?_____ (1=male; 2=Female)
5. Household head education level? _____ (1=no education; 2=Primary; 3=Secondary; 4=college; 5=University)
6. Age of household head in years? _____
7. Households head farming experience in years? _____

8. Household's total land size in acres……. acres
9. Household's total cultivated land…….acre
10. Household's land under fodder in ……..acres
11. Number of dairy cows owned? …….
12. Household labour force (members in the age of 18-65 years)_____
13. What is the average household income in Kenya shillings per year? _____

PART 3: SOCIAL CAPITAL AND NETWORKS (PARTICIPATION IN RURAL INSTITUTIONS)

1. Are you or member of your household a member of the DIP (Cooperative implementing this DIP?_____ (1=Yes; 0=No)
2. How long in years have you been a member of the DIP (Cooperative implementing this DIP)? _____
3. Which are some of the services provided in DIP?_____ (1=Training on fodder production; 2=Extension reinforcement; 3= Milk sale through formal contracts; 4=Other specify)
4. Indicate the frequency of attendance in DIP monthly? _____
5. Indicate how much you input in decision making in the DIP? _____ (1=No input; 2=input into very few decisions; 3=input into some decisions; 4=input into most decisions; 5=input into all decisions)
6. Besides being a member of the DIP (Cooperative implementing this DIP), which other group or a cooperative society are you a member to?_____(1=Savings and credit; 2=merry go round; 3=crops/seed production; 4=crop marketing; 5=women's group; 6=youth association; 7=Church/mosque; 8=Development group; 9=input supply group; 10=Other specify)
7. How long in years have you been in that group/cooperative society? _____
8. Indicate the frequency of attendance in the group/cooperative society annually? _____
9. How much do you input in decision making in the group/cooperative society? _____ (1=No input; 2=input into very few decisions; 3=input into some decisions; 4=input into most decisions; 5=input into all decisions)
10. Are you growing fodder which are promoted in DIP? 1=Yes; 0=No

11. If no in question 10, why? _____

i. Reason 1_____

ii. Reason 2_____

iii. Reason 3_____

PART 4: INFRASTRUCTURE

1. Indicate in the walking minutes the time taken from the point of residence to the nearest motor able road? _____
2. Indicate in the walking minutes the time taken from the point of residence to the nearest village market? _____
3. Indicate in the walking minutes the time taken from the point of residence to the nearest source of seed dealers (fodder seeds)? _____
4. Indicate in the walking minutes the time taken from the point of residence to the nearest agricultural extension office? _____
5. Indicate in the walking minutes the time taken from the point of residence to the nearest DIP meeting venue? _____

PART 5: DIP FUNCTIONING AND PROCESS

1. What are the three main activities conducted in DIP? _____

i. _____

ii. _____

iii. _____

2. Are DIPs inclusive (women, youth etc) _____ (1=Yes; 0=No)

PART 6: FARMERS' PERCEPTION ON USE DIP IN IMPROVING FEEDING AND MILK QUALITY CONTROL COMPARED TO CONVENTIONAL METHODS (DIRECT MILK SALE OR MILK SALE THROUGH COOPERATIVE SOCIETIES)

No.	**Interventions characteristics**	How important is the characteristic to the farmer? (3=very important 2=important 1=Not important)	How does the DIP (address) the characteristic to the farmer? (1= poor; 2=Good 1= very good)
1	Capital requirement to take up the interventions		
2	Labour required (in man days)		
3	Effectiveness in increasing milk productivity and enhancing milk quality		
4	Affordability of forage seeds and milk quality test equipment/materials		
5	Availability of forage seeds		
6	milk yield potential in Kgs of the proposed practices		
7	Others specify		

PART 7: ACCESS TO INFORMATION

1. Indicate the type of information on dairying you received in 2021?_____ (1=feeds; 2=cattle management; 3=milk management and marketing; 4=Other specify)
2. If information you received in 2021 is feeding which ones? _____ (1=Concentrate feeding; 2=Fodder and forage feeding; 3=Grazing management; 4=Fodder establishment; 5=fodder harvesting and processing; 6=fodder conservation; 7=Feeds ration formulation; 8=calf nutrition)
3. Indicate the source of feeds information? _____(1=Government ministries; 2=Farmer/self-help group; 3=Private entrepreneurs/sector; 4=NGO specify; 5=Cooperative societies/DIP; 6= A research organization specify; 7=A learning institution specify; 8=Ongoing project/program specify; 9=Other specify)
4. Frequency of access to extension services and advisory services on feeds? _____
5. Method you accessed extension services and advisory services on feeds?_____(1=Extension brief; 2=media(radio; print, TV); 3=field days, demos, Barraza's etc; 4=training workshops and seminars; 5=poster/banners)

6. If information you received in 2021 is on cattle management which ones? _____(1=cattle housing; 2=cattle breeding; 3=cattle reproduction; 4=health and diseases management; 5=manure management)

7. Indicate the source of cattle management information? _____(1=Government ministries; 2=Farmer/self-help group; 3=Private entrepreneurs/sector; 4=NGO specify; 5=Cooperative societies/DIP; 6= A research organization specify; 7=A learning institution specify; 8=Ongoing project/program specify; 9=Other specify)
8. Frequency of access to extension services and advisory services on cattle management? _____
9. Method you accessed extension services and advisory services on cattle management?_____(1=Extension brief; 2=media(radio; print, TV); 3=field days, demos, Barraza's etc; 4=training workshops and seminars; 5=poster/banners)

10. If the information received in 2021 is on milk management and marketing which ones? _____ (1=Milk price; 2=New milk outlets (contracts); 3=milk hygiene management; 4=milk quality standard
11. Indicate the source of milk management and marketing information? _____(1=Government ministries; 2=Farmer/self-help group; 3=Private entrepreneurs/sector; 4=NGO specify; 5=Cooperative societies/DIP; 6= A research organization specify; 7=A learning institution specify; 8=Ongoing project/program specify; 9=Other specify)
12. Frequency of access to extension services and advisory services on milk management and marketing information? _____
13. Method you accessed extension services and advisory services on milk management marketing ?_____(1=Extension brief; 2=media(radio; print, TV); 3=field days, demos, Barraza's etc; 4=training workshops and seminars; 5=poster/banners)

14. If the information received in 2021 is on other services, which ones?_____(1=Financial services (loans); 2=livestock training schemes; 3=Other specify)

15. Indicate the source of other information? _____(1=Government ministries; 2=Farmer/self-help group; 3=Private entrepreneurs/sector; 4=NGO specify; 5=Cooperative societies/DIP; 6= A research organization specify; 7=A learning institution specify; 8=Ongoing project/program specify; 9=Other specify)
16. Frequency of access to extension services and advisory services on other services? _____
17. Method you accessed extension services and advisory services on other services?_____(1=Extension brief; 2=media(radio; print, TV); 3=field days, demos, *Baraza's* etc; 4=training workshops and seminars; 5=poster/banners)

PART 8: EFFECT OF DIP ON ACCESS TO INFORMATION

1. How has the information needs on dairy production been after introduction of DIP? (1=Decreased; 2=Remained the same; 3=Increased)
2. Indicate the how information sources used has been after introduction of DIP (1=Decreased; 2=Remained the same; 3=Increased)

3. Change in range of input markets has?_____ (1=Decreased; 2=Remained the same; 3=Increased)
4. Change in range of input markets has?_____ (1=Decreased; 2=Remained the same; 3=Increased)
5. Change in range of milk buyers has?_____ (1=Decreased; 2=Remained the same; 3=Increased)
6. Change in milk purchase process is now (1= much more difficult; 2=more difficult; 3=The same; 4==easier; 5=much easier)
7. Change in land under fodder?_____(1=Decreased; 2=Remained the same; 3=Increased)
8. Change in use of concentrates? _____ **(**1=Decreased; 2=Remained the same; 3=Increased)
9. Change in practices meant to enhance milk quality such as observing withdrawal period after treating cows with antibiotics? _____ **(**1=Decreased; 2=Remained the same; 3=Increased)
10. Change in milk sale arrangements such as having a formal contractual agreement?_____(1=Decreased; 2=Remained the same; 3=Increased)

PART 9: LIVESTOCK OWNERSHIP (To help compute Tropical Livestock Unit- TLU)

1. Indicate the livestock owned by your household and the number owned

Livestock owned	Current number owned
Pure breed cow	
Pure breed bull	
Pure breed calve	
Cross-breed cow	
Cross-breed bull	
Local breed cow	
Local breed bull	
Local breed calve	
Goats	
Sheep	
Chicken improved	
Chicken indigenous	
Donkey	
Other specify	

THE END

APPEDIX 2: KEY INFORMANT INTERVIEW

1. How many farmers are served by this innovation platform? _____
2. Are there members who attend trainings offered in DIPs and are not members of cooperatives implementing DIP? What are the criteria for participating in DIPs training? did members of DIP go through induction? Who informed them about DIP and DIPs activities?
3. Describe the inclusivity of women and youth in the DIPs? _____
4. What is the proportion (percentage) of women in the DIP membership? _____
5. What is the proportion (percentage) of youth in the DIPs? _____
6. Do you have set rules that govern conflict resolution, membership and decision making? Explain?
7. Which are some of the issues prioritized in the DIPs_____
   i. Priority 1
   ii. Priority 2
   iii. Priority 3
8. How many training sessions have been conducted in this DIP? _____
9. On average how many members have attended all the sessions? for the members who have not attended all the training sessions, what are the reasons?
10. Which are some of the topics that members of DIP were trained on? _____
11. Who are the people involved in the activities of the DIP(involvement of national level policy actors and county national policy makers etc)
12. Does the mandate of your cooperative involve quantity and milk quality control? What are the mandates?Are your structures sensitive to changes?
13. What are procedures and funding mechanisms in your cooperative society?
14. How is the facilitation of interactions (championing, brokerage, boundary spanning, promoting) e,g researchers, other stakeholders in innovation platform
15. How do you collaborate in DIP activities and how are power dynamics and actions addressed?
16. What are the amounts of basic costs for platform events?
    i. coordination of meetings of intervention actors, reflection and preparation for meetings_____
    ii. Theme-specific costs for conducting trials, provIDPng training, data collection_____
17. Is the funding adequate for innovation platform implementation?
    i). Staff costs in Kenya shillings,
    ii) Number of innovation platform members (farmers involved in the platform)
    iii) The level of platform support functions required?
    - facilitator,
    - documentation
    - Meeting costs included renting the meeting venue and lunch or transport refunds for participants such as farmers or government officials,