FACTORS AFFECTING ADOPTION OF DAIRY CATTLE MILK PRODUCTION TECHNOLOGIES BY SMALLHOLDER DAIRY FARMERS IN MOSOP SUB COUNTY, NANDI COUNTY, KENYA

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DECLARATION AND APPROVAL

Declaration

This thesis is my original work and has not been presented for the conferment of a degree or for the award of a diploma in this or any other University: -

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DEDICATION

I dedicate this thesis to my late mother, Rose Mutai, my wife Belinda Kosgei, my children June, Sharon, Lynne and Gideon and to the others whose wonderful minds and hearts worked very hard in guiding me throughout the process of proposal development and thesis writing.

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ABSTRACT

Dairy industry plays a key role in the development of the Kenyan economy. The development of this sector is viewed as a means of uplifting the rural economy, achieving national self-reliance and ensuring food security in milk and milk products. However, the dairy industry has not thrived well because of poor adoption of dairy milk production technologies. Therefore, this study sought to investigate the factors influencing the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya. The objectives of the study were to analyse socio-demographic, technological, economic and institutional factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County. This study was grounded by the Innovation Diffusion Theory (IDT) and descriptive and statistical research designs were used to guide the study. The target population was 21,534 smallholder dairy farmers and a sample size of 199 smallholder dairy farmers was drawn from the target population through stratified random sampling technique and used in data analysis. Closed and open ended questionnaire was used to collect primary data while descriptive and inferential statistics was used to analyse the data. The collected data was analysed using multivariate probit regression model with the aid of STATA version 14 software. Descriptive results show that the mean age of smallholder dairy farmers was 49 years with 10 years of experience. Multivariate probit regression results revealed that the education level of the household head had a positive and significance marginal effect at 5% level of significance on the adoption of milk equipment technologies. A unit increase in the education level of the household head, increased the marginal effect of using the milking equipment by 7.5 percentage points. The relevance of dairy cattle technology was positive and had a positive effect on the adoption of AI at 1 % significance level. A unit increase in the relevance of technology would result in an increase in the marginal probability of adopting AI by 244 percentage points. The results further revealed that land size had a positive and significant marginal effect at 1% significant level on the adoption of AI. A one-unit increase in land size increases the marginal probability of adopting AI by 40 percentage points. The marginal effects result on milk chilling plants revealed that there was a positive relationship with the adoption of dairy cattle milk production technologies at 1% significant level. A unit increase in the number of milk chilling plants leads to a marginal increase in the probability of adopting dairy cattle milk production technologies by 65 percentage points. The study concluded that dairy farmers adopted technologies which were relevant depending on benefits derive out of it. It is further concluded that market distance determines the availability of the market for dairy produce and products and hence affecting the adoption of cattle milk production technologies. Further, extension services play a critical role in the adoption of cattle milk production technologies as it enhances the uptake and continued use of technologies. The study recommends that the county government should strengthen and revamp the extension service in order to aid dissemination of dairy cattle milk production technologies and continued use of the same by the farmers. It is also recommended that policies and initiatives that would go towards empowering farmers economically.

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LIST OF ABBREVIATIONS AND ACRONYMS

AI	**---**	Artificial Insemination
ADT	--	Innovation Diffusion Theory
AMS	--	Automatic Milking System
ASDSP	**--**	Agricultural Sector Development Support Programme
CCF	--	Contingency Coefficient Factor
CIDP	--	County Integrated Development Plan
EADD	--	East Africa Dairy Development
ET	**--**	Embryo Transfer
EU	--	European Union
FAO	**--**	Food and Agricultural Organization
GDP	--	Gross Domestic Product
IDT	**--**	Innovation Diffusion Theory
ILRI	--	International Livestock Research Institute
KALRO	--	Kenya Agriculture and Livestock Research Organization
KCC	**--**	Kenya cooperative creameries
KDB	**--**	Kenya Dairy Board
KM	--	Kilometres
KNBS	--	Kenya National Bureau of Statistics
MOAL & F	**--**	Ministry of Agriculture, Livestock and Fisheries
NACOSTI	--	National Commission for Science, Technology and Innovation
NKCC	--	New Kenya Cooperative Creameries
NGOs	**--**	Non-Governmental Organizations
SS	**--**	Sexed Semen
UK	-	United Kingdom

US	-	United States
USA	--	United States of America
VIF	**--**	Variance Inflation Factor

DEFINITION OF TERMS

Adoption – It is the ability of a dairy farmer to take up dairy technologies. In the study, it meant practicing a combination of various technologies (feed establishment and fodder conservation, silage making, use of artificial insemination, mobile phone platforms, use milk parlours) by the dairy cattle farmers to increase milk production.

Dairy production- It is an agricultural activity of keeping dairy cattle for milk production while in this research, dairy production refers to the engagement of farmers in keeping dairy cattle to solely produce milk.

Economic factors- these are factors such as capital, land, labour, income, government policies, taxes, interest rates and management which determines the adoption of cattle milk production technologies. In this research, it meant that one or a combination of productive factors (capital, land, labour and income) which the dairy cattle milk producers used to decide on the adoption of various technologies.

Institutional factors: - this relates to organizations in the society, which include among others things routines, rules and norms that guides the way the individuals in the society behave and the processes can exist within an organization which may be part of the culture in particular. In this study, it was used to refer to farmer's organizations that were formed by farmers to assist them in resource mobilization, bulking, marketing and in offering other essential services to the members.

Technological factors: - these are effects that have bearing on how an organization functions and are correlated with the use of equipments within the organization's environment. They are also used for evaluating the alternatives with regard to technological capacities. In the study technological factors have been used to refer to access and use of technologies like milking cans, milking machines, mobile phones, computers, artificial insemination, forage harvesters and hay balers.

Milk production technologies-. In this study, it was used to refer to forage, sweet potatoes, sunflower, Boma Rhodes, lucerns and nappier grass establishment and conservation of hay, maize stovers, breeding, dairy management techniques, use of mobile phone platform and computer applications.

Smallholder Dairy Farmer –In this study, it was used to refer to farmer with less than ten dairy cattle irrespective of the breeds.

Socio-demographics- these are nothing more than characteristics of a population. Generally, characteristics such as age, gender, ethnicity, education level, type of client, years of experience, location, etc.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter presents the background of the study, statement of the problem, objectives, research hypotheses, justification, significance, scope, limitations and assumptions of the study.

1.2 Background of the Study

Livestock rearing is successful as it contributes to over 40% of the world's agricultural gross domestic production (FAO, 2009). Livestock remains a major foundation of food, nutrition security and generation of income through milk and meat and also plays a crucial role as assets. They are regarded as a store of wealth by farmers, security to secure the loan and are also an important safeguard in times of crisis. Generally, embracing agricultural technologies is the only crucial route of getting poverty out of the majority of households in third world countries (Bandiera & Rasul, 2006 & Mendola, 2007).

The dairy sector in the United States of America has progressed through a rapid structural change in recent past across all levels of the value chain. Even though dairy tasks have conventionally been profoundly reliant on labour, technological improvements have stirred the dairy sector towards greater dependence on decision-making and innovations in terms of technology. Larger, more effective and well-organized operations contribute a lot to milk production share as smaller ones exit or expand (Khanal, Gillespie & MacDonald, 2010).

Productivity growth in agricultural sector and other economic sectors of United States of America (USA) could be attributed to acceleration of technological revolution (MacDonald, 2007). The factors that were presumed to contribute towards increase in productivity in dairy production included use of technologies that were collapsed into two broad categories: Capital-intense (for example advanced milking parlours, genetically superior milking cattle) and management-intense (for example use of record-keeping systems for total management, bovine somatotropin, improved nutrition and feeding practices). Capital-intensive technologies can only be accessed by farmers with larger and more specialized operations and require high start-up costs which limits open entry into dairy farming while management-intensive technologies are inexpensive, but their use requires higher levels of human capital (El-Osta, Mishra & Morehart, 2007).

It was found out that dairy cattle being milked in the U.S.A. declined on average by one percent per year since 1990, while the output of milk per cattle improved on average by two percent per year. The increase in output per cattle was attributed to the adoption of a number of technologies comprising but not exclusively to those that were computer-based. According to Shook (2006) considerable gains of 3,500 kg of milk, 130 kg of fat and 100 kg of protein per cattle per lactation was as a result of genetic improvements, nutrition and general management during the past 20 years, although the gains were not uniform across breeds (Gillespie, Davis & Rehelizatovo, 2004).

Smallholder dairy farming is a potential alternative non-crop enterprise to raise household incomes, reduce poverty and food security of smallholder farmers in Malawi who are deriving almost all their livelihood from agricultural related activities. Despite the huge potential of smallholder dairy enterprises, participation in and adoption of smallholder improved feeds and other dairy technologies such as breeding, housing and disease control is poor resulting in low dairy productivity. Although some farmers have received improved or crossbred cattle from government and Non- Governmental Organizations (NGOs), the high costs of improved feeds, poor dairy feeding and management practices, poor access to credit, and weak institutional linkages are major problems affecting dairy productivity. In addition, empirical studies have indicated that the low rates in technology adoption among smallholder farmers may be due to transaction costs arising from technology attributes, socio-economic factors including gender, household size, labour availability, and institutional arrangements influencing technology transfer (Makokha, 2008).

Artificial insemination (AI) is easily available and extensively adopted breeding technology in U.S.A. dairy farms. Artificial insemination was introduced in the 1940s and it witnessed a rapid initial diffusion (Khanal, 2013) and offered the farmers an opportunity to give up keeping potentially unreliable dairy bulls on their farms. The adoption rate of AI, in the year 2005 in the U.S.A. was 81.4%, (Khanal, Gillespie & MacDonald, 2010) and other modern breeding technologies, Embryo Transfer (ET) and Sexed Semen (SS), are newer, still-diffusing technologies in the U.S.A dairy farms. Embryo transplant technology was first used at the farm level after the development of non-surgical methods in the 1970s. According to Arendonk, Van and Bijma (2006) and Arendonk and Bijma (2003) recommended that ET use could result in significant genetic upgrading which will result in an improved reproductive rate of females. Its use reduces the number of dams needed to select for the next generation. However, according to Smeaton, Harris, Xu, and Vivanco (2003), there are lower uptake rates of embryo-based technologies in dairy, this was attributed to significant capital investment in facilities it requires (Funk, 2006). According to Baltenweck and Staal (2000), they observed that adoption of high-grade cattle by dairy farmers were encouraged by their quest to improve milk production, which was meant for sale and for domestic use. Smallholder dairy farmers are assumed to have a more advantage in keeping improved cattle, but they are constrained by a number of challenges including uptake of new technologies, the cost of buying an improved dairy cow was reasonably high; the dairy farming is risky in terms of livestock diseases and lack of consistent outlets to market the produce and products.

The Kenyan dairy sector is composed of over 625,000 smallholder dairy farmers who are distributed throughout the country. Smallholder dairy farmers produce over 56% of the total milk production produced in Kenya and 25% of the total marketed milk (Muiriki, 2001). Likewise, dairy cattle keeping helps in providing a year-round employment and in spreading the risks. Whichever aspect that might increase expenses in the enterprise could be the genesis of risks in the efficiency of the dairy business (Bailey, 2001).

Kenyan smallholder dairy farmers have always remained in the lead in embracing modern technologies in the region even though they have not reached the desired levels (Mekonnen, Dehninet & Kelay, 2009). These technologies include growing of leguminous crops to supplement dairy cattle dietary requirements, artificial insemination, disease and pest control and commercial feed rations (Ouma et al., 2007). Some of examples of dairy cattle production technologies according to Mekonnen, Dehninet and Kelay (2009) are deworming, rotational grazing, better animal feed techniques and improved management, use of acaricides, crossbred animals, improved methods of detecting heat, vaccination, baling of hay, silage making and fodder beet.

In Nandi County, dairy milk production is a key foundation of livelihood and impacts immensely to household income. Production of milk in the County is valued at Ksh. 7.44 Billion per year, (County Integrated Development Plan, 2018-2022, 2018). It is predicted that approximately 5% of milk produced within the County is consumed by calves, 10% on-farm, 5% spoiled / spillage and 80% is marketed (38.7% formal and 41.3% informal markets) (Ministry of Agriculture Livestock & Fisheries, 2013). The main dairy breeds that are kept are Friesians, Ayrshires and Crosses. There is a total of 33 milk chilling plants in the County that are owned and managed by New Kenya Cooperative Creameries (NKCC), farmer groups, Co-operatives and farmer companies (Department of Livestock Production Annual report, 2016).

Nestlé Kenya, East Africa Dairy Development (EADD) and Kenya Dairy Board (KDB) in conjunction with the County Government of Nandi through the Department of Livestock supported farmers in Mosop Sub County on various dairy cattle milk production technologies which included the type of breeds and breed selection, forage establishment, balanced feeding, silage making, methods of milking, hygiene and health of the dairy cattle (Nestle, 2013).

1.3 Statement of the Problem

The dairy cattle milk production technologies have been promoted by the Kenya government through the Department of Livestock and Fisheries and other partners and stakeholders since 1963. The technologies that have been promoted all along in Mosop Sub County are the feeding regimes which incorporate two major components of feed establishment and feed conservation. Breeding systems of dairy animals are moving away from the use of bulls towards more advanced technologies like Embryo transfer (ET), Artificial Insemination (AI) and Sexed Semen (SS). There are also technologies that are utilized for dairy management, such as record keeping, paddocking, modern milking parlour and feeding areas; mobile platform and computer applications. However, there has been a mismatch between the technologies that have been promoted and the rate of adoption by the recipients (MOAL & F, 2013). There are 21,534 dairy farmers in Mosop Sub County, out of which 30% have adopted the dairy cattle milk production technologies while 70% have not adopted the technologies despite using the conventional methods of milk production (Nandi County ASDSP baseline report, 2014).

Previous studies have focused on variables which are not specific to dairy cattle milk production technologies, and those studies have only focused on one technology adoption and its impact on production performance of dairy operations (Hisham and Mitchel, 2000). However, as per the secondary review so far carried out by the researcher, there is scanty information in the previous studies on the analysis of factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County. Thus, this current study endeavoured to breach gap by analysing the factors affecting the adoption of dairy cattle milk production technologies.

1.4 General Objective

The general objective of the study was to analyse the factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya.

1.5 Specific Objectives

The study addressed the following specific objectives:

(i) To analyse the socio-demographic characteristics affecting adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub-County, Nandi County

(ii) To determine technological factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County

(iii) To analyse economic factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County

(iv) To determine institutional factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County.

1.6 Hypotheses of the Study

The study tested the following hypotheses:

H_{01}: Socio-demographic characteristics have no significant effect on adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County.

H_{02}: Technological factors have no significant effect on the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County.

H_{03}: Economic factors have no significant effect on the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County.

H_{04}: Institutional factors have no significant effect on adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County.

1.7 Justification of the Study

Kenya Vision 2030 is the country's new ambitious development plan covering the period 2008 to 2030. Its purpose is to transform Kenya into a newly industrialized, "middle-income economy providing a high quality of life to all its citizens by the year 2030". The Vision is based on three "pillars": economic, social and political pillars. It identified agriculture as one of the key sectors to deliver the 10 percent annual economic growth rate envisaged under the economic pillar. To achieve this growth, transforming smallholder agriculture from subsistence to an innovative, commercially oriented and modern agricultural would be achieved through the promotion of agricultural enterprises through value chain development (Vision 2030, 2008). The Kenyan dairy sector is significant in sustaining the economy. It accounts for about 14 percent of the agricultural gross domestic product (GDP) and 3.5 percent of the total GDP. The sector depends on smallholder production, who are producing about 70 percent of milk produced in Kenya annually

(Kenya Dairy Board, 2012). The key challenges facing the dairy sector in Kenya and Nandi County is not exceptional is high cost of producing commercial feeds, the dairy industry performance has been going down over the years because of poorly implemented policies that has left the dairy sector vulnerable to effects of weather due to deforestation and poor farming practices, the incidence of disease is quite high due to changing weather patterns (Nation Media Group, 2013). In Nandi County, the dairy sector produces over 284 million litres annually. This constitutes over 5% of the National milk production and this about 20 percent of the county's income. It is also a source of livelihood for over 68% of the county household and employs over 60,000 workers both directly and indirectly (Nandi County Department of Agriculture, 2018). The main purpose of the research was to analyse the factors affecting dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya. The results of this study would give information that could be used to formulate policies and strategies to improve on the adoption of dairy cattle milk production technologies in Nandi County and Country as a whole. It would also assist extension officers and other service providers in designing appropriate interventions and approaches that would promote various technologies in the dairy sector.

1.8 Significance of the Study

The results of the study could stand utilized by policymakers when prioritizing, designing and coming up with the best approach on how the agricultural projects and programmes could be implemented in the Country at large and Counties. Extension service providers could benefit from the study by getting to know the current status of adoption of various technologies and factors hindering their adoption. The study would assist in the review of the technologies to be promoted and their mode of delivery based on the technical characteristics that would be identified. The change agents would also be able to use the results to come up with the most appropriate intervention strategies that link smallholder farmers to specialized training on dairy cattle milk production technologies. The investors who intend to venture in dairy husbandry would be able to tell from the identified socioeconomic, economic, technological and institutional factors whether it would be feasible in enhancing the adoption of the enterprise so that it may remain profitable. Projects and prospective investors who have expressed interests in dairy cattle milk production, marketing and processing may be able to use the findings of the study to make informed decisions on the extent and the area to invest in. This would depend on the socioeconomic, economic, technological and institutional issues that were identified in the study. The study findings may also be used by scholars as a basis to do further research.

1.9 Scope of the Study

This research concentrated on dairy cattle smallholder farmers in Mosop Sub County, Nandi County who had adopted at least three of the technologies which were of interest in this study. For the purpose of this study, the researcher targeted smallholder dairy farmers only, those who have between two and ten dairy cattle. The sampling was done from a population captured from seven wards within the Sub County.

The study dealt with socioeconomic, technological, institutional and economic factors that were affecting the adoption of dairy cattle milk production technologies. The adoption of these technologies was based on the variables that were being examined in the study.

1.10 Limitations of the Study

The research was limited to analysis of factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County. The study covered seven wards and with a sample of 199 farmers. On the other hand, the terrain of some parts of the study area was rough, this posed a major logistical challenge. The information which the researcher depended on was purely voluntary which could be subject to a lot of errors due to lack of farm records.

1.11 Assumptions of the Study

This research was carried out based on the following assumptions:

(i) That all the targeted respondents would provide honest, truthful, sincere and genuine responses to questions contained in the questionnaires.

(ii) That the weather would be favourable to allow data collection exercise to run smoothly.

(iii) That the respondents would be available during data collection.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the theoretical literature associated with adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya. It focuses on the empirical literature about dairy cattle milk production technologies and the socio-economic factors affecting dairy cattle technology adoption. Lastly, it considers the conceptual framework employed in the study.

2.2 Theoretical Framework

It is the avenue in which a phenomenon or research is understood and investigated.

2.2.1 Innovation diffusion theory

This study was guided by the Innovation Diffusion Theory (IDT). IDT is a method in which a technique or invention is transferred via a definite channel continuously for a long time among individuals in the same environment (Rogers, 2003). The central objective of Innovation Diffusion Theory (IDT) is to appreciate inventions in four elements of diffusion which includes communication channels, social systems, time and innovation. The innovation diffusion theory also postulates that a person’s technology adoption behaviour is entirely dependent on his or her insight regarding the relative advantage, trial ability, compatibility, innovation observability, social norms and complexity (Rogers, 2003). In general, adoption may be regarded as an act of accepting or choosing or assuming something belongs to you. According to Rogers (2003), the adoption of an innovation is the intellectual practice of making decisions that start with hearing about the innovation to its ultimate adoption. The five phases of the adoption process include knowledge, persuasion, decision, implementation and confirmation. The initial adoption is normally followed by diffusion, the spread of the technology within a region (Laxmi, 2007)

A lot of literature concerning technology adoption on-farm can be found on new agricultural technologies, for example, high yielding varieties that transformed Asia which can also be used to increase agricultural productivity and to transit agriculture in Africa from subsistence to the high agri-industrial economy (World Bank, 2008). According to Laxmi, (2007), changes in the constraints that touch on farmers decisions are as a result of rigorous processes such as accumulating resources information gathered or learned by doing. He also stated that the adoption choice of a farmer is grounded on the maximization of an anticipated utility subject to constraints such as inadequate resources including land, credit, experience of the farmer, the information collected from previous periods, information about indicators (such as yield, profit, income) gathered over period of time and information obtained from other farmers are used also in making the decision about the technology.

Mendola (2007) attempted to understand technology adoption across the universe. He made deliberate efforts to developed empirical models for studying technological adoption. According to Latruffle (2014), he deliberately looked at technology adoption and its association with technical efficiency, risk and attitude. Several factors have been enumerated as influencing technology adoption. Massey, Morris, Alpass and Flett,(2004) in their research relating to dairy sector in New Zealand established that factors affecting the farm business (financial stability, level of debt, etc.); efficiency and effectiveness of the innovation system (presence of extension and other service providers, the availability of information, the ease with which individuals can access information.); and individual characteristics (age, education, confidence, and innovation capacity) affect technological adoption. Rogers (2003), categorized adopters into early adopters, early majority, late majority laggards and innovators in relation to adoption decisions they make. Massey, Morris, Alpass and Flett, (2004) looked at literature regarding early adopters extensively and suggested that adoption will take place quickly if the individual is better educated, self-confident and younger, gifted with high absorption capacity, receptive to new ideas, the farm system is large, profitable, able to transfer information, linked with other farms and be able do networking.

According to Bandiara and Rasul (2006) did a study on farmers adoption alternatives regarding their social network and they found out that if there were few adopters in a network then the social effect would be positive, but it would be negative with many adopters. Abdulai and Huffman, (2005) looked at diffusion of cross-bred cattle in Tanzania and they found out that the technology adoption is largely depended on the close proximity of a farmer to other users. Credit availability and contact with extension agents are correlated with adoption (Abdulai and Huffman, 2005). However, according to Bandiara and Rasul (2006) study on social networks and technology adoption in Northern Mozambique, inducing farmers by giving incentives to adopt technologies early can actually influence technology adoption rate of other farmers around them.

According to the study by Abdulai, Monnin and Gerber (2008), on the decision of dairy farmers to get information and embrace technology in the presence of uncertainty in Tanzania, human resources and level of operation positively and significantly affected the adoption decision. Further, they stated that an increase in herd size, education, age and anticipation of higher profits from the technology established to have positive effects on adoption intensity.

2.3 Empirical Studies

Gillespie, Davis and Rehelizatovo (2004), carried out a study on the adoption of four breeding technologies in the hog industry. They used a multivariate probit technique to approximate the impact of issues affecting adoption. They found out that multinomial probit technique could also be used but its use was becoming a challenge and complex when more than two technologies are being considered.

According to research done by Mayen (2010) where binomial and multinomial logit techniques were used to study the adoption decision concerning organic techniques, apart from the two groups- “adopters” or “non-adopters,” he further categorized the adopters into “registered-adopters” and “unregistered adopters”. A likelihood ratio test was used to get significant differences between binomial and multinomial logit techniques. He found out that there was a significant difference between “registered” and “unregistered” groups and he proposed that the respondents should not be treated as homogenous.

According to the study by El-Osta, Mishra and Morehart (2007), they used the multinomial logit to determine the degree of the economic well-being of U.S. farm households among four different wealth categories. They predicted that there was a relative and absolute well-being of households. Using least squares estimates, they also incorporated the probabilities of off-farm work and government payments from the first stage multinomial logit models. The findings revealed that higher education level increased the economic status of the average farm household.

2.3.1 Socio-demographic characteristics and adoption of dairy technologies

Social factors are the variables that relate to the innovativeness of a farmer and include personal and socio-cultural characteristics. According to Rogers (2003), stated that socio-demographic characteristics included age, gender and education level of household head. He further stated institutional frameworks and socio-demographic characteristics play an important role in determining who does what, and who gets what especially in livestock development. Social and cultural norms determine the division of labour and control over assets.

Majority of empirical researches which have used econometric models regularly compare between a decision to adopt and characteristics of households. According to Diro (2016) many researches have enumerated the circumstances that hinder technology adoption in dairy farming. According to Benin and Ehui (2003), stated that social factors determine the level of awareness, costs, availability, risks associated and gains accrued with the various dairy cattle milk production technologies and management practices.

A research study by Mumba, Samui, Pandey and Tembo (2012) on the effects of socio-economic aspects determining the profitability of smallholder dairy farmers in Zambia suggested that the dairy cattle herd size, education level and market distance considerably affected the net earnings of smallholder dairy farmers. The researchers found out that as the education level of the household head increases, there was an increase in number of dairy cattle and reduction in the market distance which resulted to increase in profits to the farmers. The researchers further found out that household size, gender, age and marital status had no significance on productivity of smallholder dairy business. The results of the study showed that the average age of the respondents was 48.8years which implied that very few youths were involved in the dairy cattle milk farming.

According to the findings by Kimaro, Lyimo- Macha and Jeckoniah (2013) on their study on gender roles in smallholder dairy farming; they raised valid concerns relating to the use, control and decision making on resources generated and used in dairy farming in Arumeru district, Tanzania. They established that women endure a lot of burden in the dairy enterprise such as looking for feeds for dairy animals, milking, washing cowsheds and marketing of milk products. Further their results found out that children and men were least engaged in activities relating to milk production. The study revealed that being a member of a group relatively empower women to have access and control over income acquired from dairy farming and additional resources. The control and Access over income were not comparative to individual input. It was discovered that women who were not in any group were worse in a situation where their husbands had more control and access over the income obtained from sales of dairy products. The study suggested that women who were in groups were likely to be engaged in numerous activities for example production, management and decision-making over proceeds and expenditures acquired from sales of dairy products.

Dehinenet et al. (2014) carried out a study in Amhara and Oromia Regional States, Ethiopia. Their results revealed that accessibility to livestock training, household head age and engagement in activities outside the farm had a critical role in determining probability of dairy technology adoption and the extent of adoption.

2.3.2 Dairy cattle milk production technologies

Several authors describe the word technology in a variety of ways. Rogers (2003), uses technology and innovation interchangeably. The definition of technology according to him is a way of influencing actions which decrease the probability in the cause-effect relationship involved in accomplishing anticipated results. According to Bonabana (2002), the vigorous course of adoption consists of learning about technology over time. In this regard, many innovations call for an extensive period normally several years after becoming accessible and the time they have generally been adopted (Bonabana, 2002; Rogers 2003). The degree of adoption is ordinarily determined by the duration of time necessary for a number of people in an organization to take up an innovation. The level of adoption, on the other hand, is measured by the number of technologies that are being implemented and the number of farmers embracing the technologies (Mendola, 2007).

One of the most significant avenues of fast-tracking national development in agricultural-based economies is the development, adaptation and evaluation of modern agricultural innovations (Netherland's Ministry of Agriculture, 2000). Kenya’s economy and social development challenges are unemployment, poverty, food security and slow economic growth among others (MOA, 2004). FAO, (2009) specified that poverty affects 56% of the Kenyan population and that Kenya is amidst other countries in Africa whose percentage of undernourished persons is more than 35%. Different parameters may be used to measure adoption depending on the technology being investigated. The parameters could either be qualitative or quantitative for example, research that investigated the adoption of fertilizer and better-quality seed in Tanzania, projected the extent of uptake of technologies by investigating the area put under improved seed and the area receiving fertilizer (Lyimo, 2014). As compared to another study that investigated the adoption of the use of single ox technology, fertilizer use and pesticide; the dependent variable was the number of farmers using fertilizer and pesticide (Ibrahima, 2016).

According to Rogers (2003), there are numerous likely sources of information about new technology. For instance, a farmer may learn from his or her own experimentation with technology. Another option is a bit of advice or technical information may be accessible from the extension service or the media. If in case there are several farmers with a slightly similar situation, then the means of acquiring knowledge about the new technology may be social thing. Farmers may possibly acquire new technology from their neighbours’ own research.

In the study done by Suzuki, (2017) in Ghana, it was established that farmers learning to take place through social networks more than in the perspective of the communal experiment. Various models about the relationship between market orientation and innovation have been proposed (Verhees, 2007). Most experimental studies adopting econometric models frequently compare the decision on adoption to households and their technological characteristics. Many researchers have established that limitations caused by these factors often dampened technology adoption (Diro 2016; Odero, 2017). These factors encourage awareness, accessibility, related costs, benefits and risks associated to different livestock technologies and managerial practices (Benin and Ehui, 2003).

According to Khanal and Gillespie, (2011), the adoption of herd improvement technologies in the United States (U.S.) has been determined by features of the farm, service provider features, adoption of additional technologies and the location of the farm. Artificial insemination and ET and/or SS adopting farms are managed by more learned farmers and fairly younger and they also increase productivity of milk per cattle as compared to non-adopters.

Adoption of superior cattle by smallholders is an avenue to increase farm revenues and household food nutrition security through selling milk and for their own consumption. Baltenweck and Staal, (2000) research findings on factors affecting the adoption of dairy cattle technology in Kenya indicates that smallholders delay adoption of dairy cattle milk production technologies because of low access to credit and due to poor roads. On the other hand, they also found out that the speed of adoption has slowed down as a result of the consequence of the liberalization of the dairy sector.

Computerized milking systems introduced into the sector has ignited much debate on the merits and demerits of applying automated systems. The technology has a number of opportunities for advance systems, for example, wholly computerized robotic systems to modest systems, for example, high-tech data acquisition from the milker. According to Reinemann and Smith, (2001), suggested that Automatic Milking System (AMS), or robotic system, is a user-friendly technique for milking cattle as compared to milking the cattle manually.

2.3.3 Economic factors and adoption of dairy technologies

The efforts of transforming dairy sector begin with technological upgrading in the rural areas. Consequently, dairy cattle farmers must be inducted into using new technologies and adopt innovations so that they could expand their enterprises and hence the entire economy. The adoption rate of innovations rests squarely on the organization of the society, the living standard and economic impact of those innovations (Hasan, 2008).

Financial wisdom does not exclusively encourage investment in new innovations. Increase in farm size, technical progress, the challenge of skilled workers and endeavouring for improved quality of life have encouraged investments in technology in dairy farming (Mathijs, Meijering, Hogrvevn and Koning, 2004). Improved quality of life is not limited to facets such as less demanding work and flexible working hours, but it is focused on better economic performance. Investing in computerisation has remained an imperative approach for a huge number of milk producers to alleviate growing competition and speedy structural developments. This has become an attractive avenue for replacing rare farm labour with new technologies and capital. Since the ability to skilful farm labour has become a constantly limiting factor, the expansion of opportunities which was unlocked by robotics for expanding the scope of dairy processes are crucial (Feng et al., 2018).

Assessments of output change in the dairy sector indicate that productivity development of Finnish dairy farms stopped more or less completely in the early 1990s, but just before the end of the decade, the trend turned positive. The average increase in output per unit was 1.9% a year over the period 1987–2007 (Myyra, 2009). The progress in productivity increase was followed by the investments, which were subjugated by uncertainty over Finnish membership in the EU in 1995. It is believed that neither structural development nor investments encouraged by investment support have gotten the productivity of Finnish agriculture near to that of Central Europe.

Mekonnen, Kidoido and Guerne (2014) adopted Heckman two-stage models in their study to ascertain the reasons that determines the extent of uptake and the types of technologies adopted by 384 dairy farmers encompassing of 192 adopters and 192 non-adopters. The outcome shows that experience in farming, family size, availability of cross- breed cattle, access to dairy cattle milk production extension services, accessibility and availability of financial institutions, earnings from milk and milk products, access to livestock production trainings, household head age and involvement in off-farm activities have significant a part in the possibility of adopting dairy technologies and their levels of adoption. According to Nzomoi, et al. (2007), they stated that failure to make use of technologies was due to lack of finance, awareness of available technologies, businesses environment, availability of information and lack of access to technologies. According to Kaaya, Bashaasha and Mutetikka (2005), the ratio of farmers utilizing artificial insemination technology in Uganda was found to be an average of 36.1%. The age of the farmer, his experience on artificial insemination, superior artificial insemination services delivered to the farmers, milk production in the farm and the sales, extension farm visits per year were positively connected to embracing and utilization of AI technology.

2.4 Conceptual Framework

According to Wanjiku et al. (2003), farmers are adopters of the agricultural technologies. However, dairy farmers specifically smallholders, are confronted with many issues that forces them to decide on how to optimize income. Figure 2.1 illustrates the adoption of dairy cattle milk production technologies as inversely related socioeconomic, technological, economic and institutional factors. The smallholder dairy farmers have different personal characteristics which affect their decision making. The socio-economic factors play a bigger portion in affecting the adoption of dairy cattle milk production technologies. The conceptual framework for this study is as presented in figure 2.1

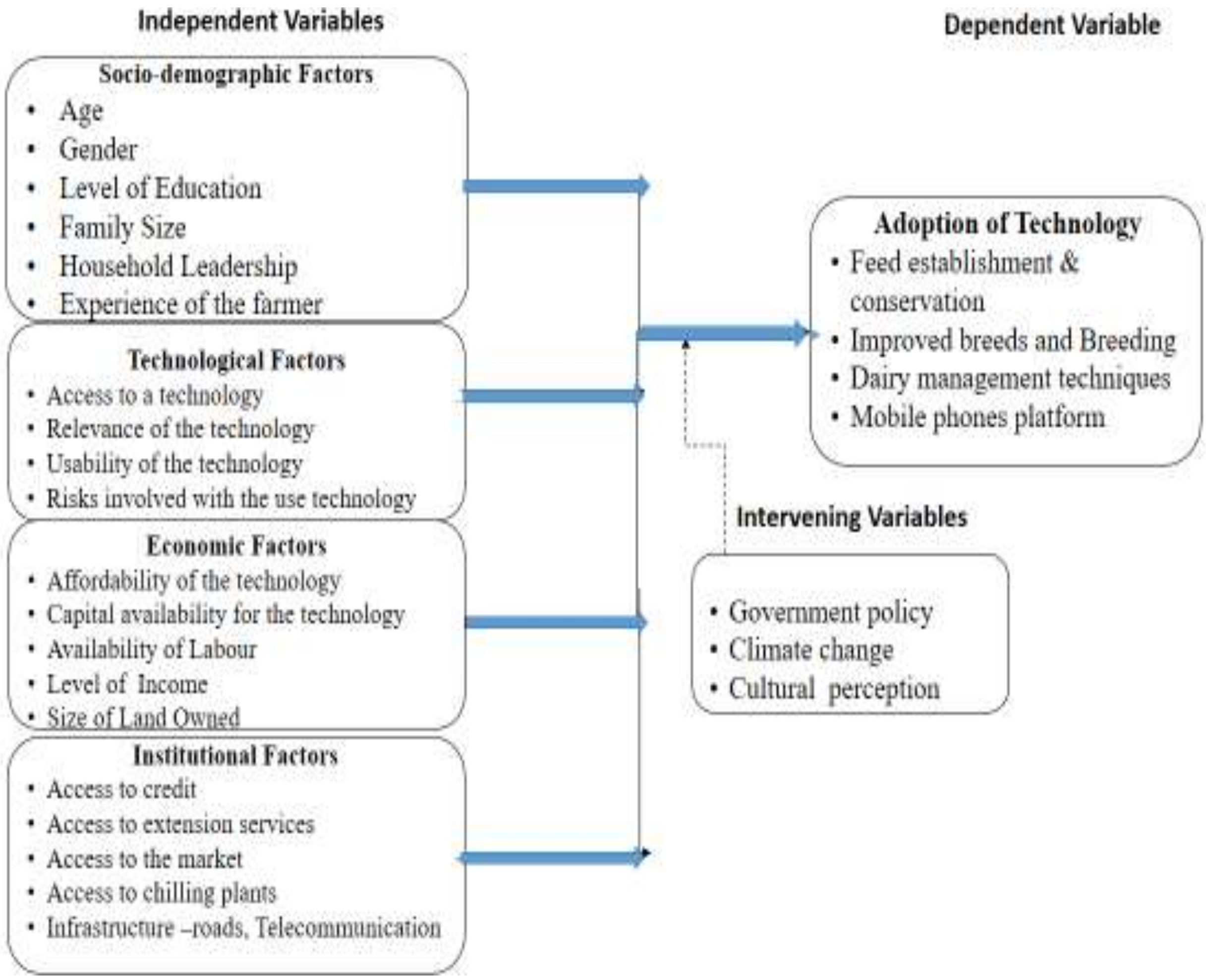

Figure 2.1: Conceptual framework of affecting adoption dairy cattle milk production technologies in Mosop Sub County.
Source: Author’s Conceptualization, 2018

Table 2.1

Operationalization of Variables

Objectives	Independent variables	Indicators	Measurement Scale	Tools of Analysis	Type of Statistics
To analyse socio-demographic characteristics affecting adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub-County, Nandi County.	Socio-demographic characteristics	▪ age ▪ gender ▪ level of education ▪ family size ▪ household leadership ▪ experience of the farmer	Ordinal	Mean, Percentage, Frequency, Standard déviation	Descriptive and inferential statistics
To determine technological factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County	Technological factors	▪ access to technology relevance of technology ▪ usability of technology ▪ risk involve with technology	Ordinal	Mean, Percentage, Frequency, Standard déviation	Descriptive and inferential statistics
To analyse economic factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County	Economic factors	▪ affordability of technology ▪ capital availability of technology ▪ labour availability ▪ level of income			Descriptive and inferential statistics

		▪ size of land owned			
To determine institutional factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County.	Institutional factors	▪ access of credit ▪ access of extension services ▪ access of market ▪ access of chilling plants ▪ infrastructure	Ordinal	Mean, Percentage, Frequency, Standard déviation	Descriptive and inferential statistics
	Dependent variable				
	Adoption dairy milk production technology	▪ feed establishment & conservation ▪ improved breeds and breeding ▪ dairy management techniques ▪ mobile phones platform Length of period in use	Ordinal	Mean, Percentage, Frequency, Standard déviation	Descriptive and inferential statistics

2.5 Identification of Knowledge Gap

There has been several studies carried out on specific technology adoption in the current area of study, for example, adoption of artificial insemination, use of pastures, feed formulation, Boma Rhodes, no one has carried out a research on a number or combination of technologies available to smallholder dairy cattle farmers. The main goal of this research was to analyse the factors that affected the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya. A study by Baltenweck, (2000) focused on geographical aspects as key determinants with a lot of emphasis on AI only and left a gap on factors which determines the uptake of other technologies. Burton,(2008) analysed the causes of adoption of organic horticultural methods in the United Kingdom (U.K.) while Mekonnen, Kidoido and Guerne, (2014) carried out their research on dairy technology adoption in smallholder farms in 'Dejen' District, Ethiopia. These two studies have actually added to literature specifically on the adoption of specific technologies in the areas of their respective research. However, factors influencing the adoption of dairy cattle milk production technologies by smallholder dairy farmers in the current study needed to be analysed and the findings be documented so that it could add into the existing knowledge and be able to address other existing knowledge gaps.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design, study area, target population, sample size, sampling procedure, instruments of data collection, data collection procedures, reliability and validity of the research data collection tools, data analysis and presentation and ethical considerations.

3.2 Research Design

Descriptive research design was adopted in this study. It was assumed that this would assist in providing solutions to inquiries of who, what, when, where, and how which are related to a particular study topic (Given, 2007). It was meant to get facts regarding the present position of the occurrence and also to define "what exists" in reference to circumstances in a given situation. According to McCombes (2019), descriptive research design was intended to investigate one or more variables, the researcher does not manipulate any of the variables. This could result in rich data for detailed analysis which would yield important recommendations.

3.3 Study Area

The study was conducted in Mosop Sub County in Nandi County. Mosop is divided into seven administrative Wards. It borders North Sub County in Kakamega County to the West, Turbo Sub County to the North West in Uasin Ngishu County and Chesumei Sub County to the South East. Mosop Sub County covers 730.9 Km^2 and of which 633.53 Km^2 is arable while 104.7 Km^2 is non-arable land. The population of Sub County was projected to be 187,253 with 31,106 households by 2019 (KNBS, 2009). The Sub County has a cool and moderately wet climate and receives 1200 mm – 2000 mm of rainfall per annum. The long rain season starts in early March and continues up to the end of August while short rains are from mid-September to the end of November. A dry spell is normally witnessed between December and March. There is a direct relationship between the rainfall pattern and agricultural activities within the Sub County. The southern and central parts, which receive a minimum of 1,600 mm rainfall per annum, form the tea production belt. The relatively drier areas to the East and Northeast, which receive an average of 1,200 mm of rainfall per annum, are ideal for maize cultivation (CIDP, 2018). The mean temperature is 18^0C – 22^0C during rainy seasons while higher temperatures averaging 23^0C are recorded during the drier months of December, January and February (Nandi County Development Profile, 2013).

Mosop Sub County has a dairy farmer population of 21,534 owning about 67,843 dairy cattle that produce on average 248,208 litres of milk per day (Nandi Strategic Plan 2018). Dairy cattle milk production is a major enterprise in Mosop Sub County. Currently, there are three milk cooling facilities installed in Mosop Sub County by Kabiyet Dairies in Kabiyet Ward, Tanykina dairy cooling plants Kipkaren Ward and Tulwo in Surungai/Kurgung Ward (MOAL& F, 2014).

3.4 Target Population

A target population, according to Burns, (2003) is an assembly of objects, events or individuals, with mutual features that the researcher intends to pursue, Kothari, (2004) it refers to all the characters in any domain of inquiry and constitute a ‘universe’ or ‘population’. As shown in Table 3.1, the target population was 21,534 smallholder dairy farmers with less than 10 dairy cattle.

Table 3.1

Target population of smallholder dairy per ward

	Category of Dairy Farmers
Name of ward	**Smallholder dairy farmers with <10 dairy cattle**
Kebulonik	4,114
Ndalat	2,225
Kabisaga	1,891
Chepterwai	3,336
Kabiyet	3,114
Kipkaren	3,559
Kurgung	3,225
Total	**21,534**

Source: Department of Livestock, Nandi County, (2016)

3.5 Sample Size and Sampling Procedures

3.5.1 Sample size

The study adopted Smithson (2015) proportionate size sampling methodology. Probability proportion to size sampling methodology was used. Probability proportion to size is a sampling procedure under which the probability of a unit being selected is proportional to the size of the ultimate unit, giving larger clusters a greater probability of selection and smaller clusters a lower probability. The following equations 3.1 and 3.2 were used to determine the'$\boldsymbol{n}$' value and '**s**'the sample size respectively.

$$\boldsymbol{n} = Z^2 \frac{P(1-P)}{D^2} \qquad (3.1)$$

$$\boldsymbol{s} = \frac{\boldsymbol{n}}{1+(\mathrm{n/population})} \qquad (3.2)$$

Where, **S**- sample size

$\boldsymbol{n}$ = Sample proportion,

P = True proportion of factor in the population, or expected frequency value,

D = Maximum difference between the sample mean and the population mean {or Expected Frequency Value - Worst Acceptable Value (D = Expected frequency - worst acceptable, that is: 11%-7%=4%, OR 7%-3%=4%)},

Z = Area under normal curve corresponding to the desired confidence level. Usually, 1.960 with a confidence level of 95%. This study used a population value of 21,534, expected frequency of the factor under study (P) of 7% and worst acceptable frequency of 11% or 3% using prevalence of 4 that represent high (7+4) and low values (7 – 4) which are endpoints of confidence level (Smithson, 2015),

P = Expected Frequency Value = 7%, and

Z = 1.960 with a confidence level of 95%

To compute the value of "**n**" (sample proportion), values for respective parameters were substituted into equation 3.1

$$\boldsymbol{n} = \mathrm{Z}^2 \ \frac{\mathrm{P}(1-\mathrm{P})}{D^2}$$

$$= 1.960^2 \ \frac{0.07(1-0.07)}{0.04 \text{ x } 0.04}$$

$$= 1.960^2 \ \frac{0.07(0.93)}{0.0016}$$

$$= 1.960^2 \ \frac{0.0837}{0.0016}$$

$$= 1.960 x \ 1.960 \ x \ 52.3125$$

= 1.960 x 102.5325

= 200.9637

Determination of the value of "**S**" was as shown below.

$$\boldsymbol{s} = \frac{n}{1+(n/population)}$$ was used:

$$= \frac{200.9637}{1+(200.9637/21{,}534)}$$

$$= \frac{200.9637}{1+0.0093906380607}$$

$$= \frac{200.9637}{1.0093906380607}$$

= 199.0940795588348

= 199

Therefore, the sample size used in the study was 199 dairy farmers which were proportionately distributed in the seven (7) wards as shown in Table 3.2.

Table 3.2

Sample size of dairy farmers per ward

Ward	**Target population(N)**	**Sample size (n)**
Kebulonik	4124	36
Ndalat	2245	21
Kabisaga	1901	18
Chepterwai	3346	31
Kabiyet	3124	29
Kipkaren	3569	33
Kurgung	3225	31
Total	**21,534**	**199**

Source: Department of Livestock, Nandi County, (2016)

3.5.2 Sampling procedures

Stratified random sampling method was used to obtain a sample of smallholder dairy farmers. Stratified random sampling is a method of sampling that involves the division of a population into smaller sub-groups known as strata. In stratified random sampling, or stratification, the strata are formed based on members' shared attributes or characteristics such as income or educational attainment. The area under study had seven (7) administrative wards which for this study formed the strata. In each ward, a simple random sampling procedure was used to identify the actual respondents. This gave more precise statistical results because the farmers were drawn from the seven wards. A list of farmers from Mosop Sub County Livestock Production Office and from the two major milk chilling plant companies namely Kabiyet Dairies Company Limited and Tany Kina Dairies Company Limited working in the Sub County was obtained. The names of the farmers in the lists were serially numbered and randomly ordered and then selected in such a way that it gave each farmer have an equal opportunity of being picked where every fifth farmer in the list was picked therefore increasing chances of obtaining an appropriate and representative sample size. This was advantageous in the sense that the sample frame was already available in the form of a list (Kothari, 2004). The study was designed to cover the whole of Sub County.

3.6 Data Collection Instrument

Structured questionnaire was utilized as instruments for data collection in this study. According to Brace, (2008), a questionnaire is a tool with questions to be completed by respondents. Therefore, a questionnaire which was structured was specifically designed to address all four objectives of the study. A structure questionnaire was administered to the respondents by the researcher and assisted by seven trained enumerators through face to face interview. The tool had four sections. Section A was on socioeconomic factors while sections B, C, D and E covered technological, economic, institutional factors and adoption of technologies respectively.

3.6.1 Validity of the instrument

The legitimacy of instruments was determined by availing them to experts at the University of Kabianga who determined face and content validity. The experts were experienced researchers who have been teaching and supervising postgraduate students at the university and their comments were included in the questionnaire.

3.6.2 Reliability of the instrument

Reliability of the questionnaire was determined through pilot testing using 30 farmers in neighbouring Kericho County. However, the key respondents did not take part in the pilot study. Cronbach Alpha was used to calculate the reliability coefficient. According to Tavakol (2011) stated that Cronbach Alpha measures reliability, or internal consistency of an instrument or a tool(questionnaire) and a reliability coefficient of 0.7 to 1 was given as acceptable range. The outcomes of the tests were as presented in Tables 3.3

Table 3.3

Questionnaire reliability statistics using Cronbach's Alpha.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
0.882	0.890	6

Source: Estimates from pre-test Survey Data, 2018

The Cronbach's Alpha value was computed from 6 items which included the relevance of technology, technical access, income, labour cost, market distance and land size was 0.882. The alpha coefficient was in the range of 0.7 to 1 which indicated that the instrument was reliable.

3.7 Data Collection Procedures

Having acquired an introductory letter from the University of Kabianga, application for the research permit at the National Council of Science Technology and Innovation (NACOSTI) was done using the introductory letter. Two weeks before conducting the interview, the researcher secured an appointment and permission to carry out the study from the Deputy County Commissioner, while the Sub County Livestock Production

Officer and Ward Livestock Production Officers of Mosop Sub County guided the researcher during data collection. Dairy household heads were interviewed because they were considered as household decision makers and are also crucial in influencing decisions with regard to adoption of dairy cattle milk production technologies. In some instances where the household head was not available, any household member who was responsible then in household decision making was interviewed.

To obtain data from key informants, they were visited in their respective places of work. In order to beef up data collected from primary sources, secondary information was reviewed from library materials, internet and from reports found in the offices of the key informants, for instance in Kabiyet Dairies, Tany Kina Dairies, Techno Serve and Sub County Livestock Production Offices.

3.8 Data Analysis and Presentation

Upon receipt of the filled questionnaires and interview schedule, initial screening of data began by sorting, coding and cleaning. The data was then entered into the STATA version 14 software. Descriptive and inferential statistics were used to analyse the data and the results presented in frequency tables.

The study adopted a Multivariate Probit Model (a bivariate model) as shown in equation 3.3 to 3.6 and as adopted from Greene, (2012) who started that the model is based on the hypothesis that the errors are typically distributed and provides for joint determination and a framework for modelling in two or more common applications. He further confirmed that Multivariate model is a generalization of the Probit Model used to estimate several correlated binary outcomes jointly. Each objective was fitted separately as follows: -

Objective 1 – Multivariate Probit Model for Socio-demographic Analysis

$$Yj = \beta 0 + \beta 1 X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6 X6 + u_t \text{ ....} 3.3$$

Where Yj = adoption of a technology

X_1 = age

X_2 = gender

X_3 = level of education

X_4 = family size

X_6 = Household leadership

X_6 = farming experience of the farmers

β_0 - β_6 are coefficients

u_t= error term

Objective 2 – Multivariate Probit Model for Technological Analysis

$Y_j = \beta_0 + \beta_1 X_1 + \beta 2X_2 + \beta_3 X_3 + \beta_4 X_4 + u_t$ ……………………………………….3.4

Where Y_j = adoption of a technology

X_1 = access to a technology

X_2 = relevance of the technology

X_3 = usability of the technology

X_4 = risk involved with the technology

β_0 - β_4 are coefficients

u_t = error term

Objective 3 – Multivariate Probit Model for Economic Analysis

$Y_j = \beta_0 + \beta_1 X_1 + \beta 2X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + u_t$ ………………………………..3.5

Where Y_j = adoption of a technology

X_1 = affordability of the technology

X_2 = capital availability for the technology

X_3 = availability of labour

X_4 = level of income

X_5 = size of land owned

β_0 - β_5 are coefficients

u_t = error term

Objective 4 – Multivariate Probit Model for Institutional Analysis

$Y_j = \beta_0 + \beta_1 X_1 + \beta 2X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + u_t$ ……………………………….3.6

Where Y_j = adoption of a technology

X_1 = access to credit

X_2 = access to extension services

X_3 = access to market

X_4 = access to chilling plant

X_5 = infrastructure – roads, telecommunication

β_0 - β_5 are coefficients

u_t = error term

3.9 Ethical Considerations

Yuko, (2005) argued that although there is a wealth of knowledge acquired through research, it cannot be pursued without putting human dignity into consideration. The major ethical issues of concern were informed agreement, secrecy and confidentiality, obscurity and researcher's obligation. Confidentiality has to do with the contract between persons that limits others' access to private information. Anonymity is where all the partakers in research have the right to remain anonymous and their individual characteristics. The researcher, therefore, got consent from the crucial authorities and the respondents before getting information from them. The researcher made sure that the interviewees were informed of the envisioned use of the data and also assured them that the data received from them would be handled with ‘utmost’ good faith and would not be divulged, shared or discussed with any unauthorized persons.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and discussion of the major findings of this study. It comprises of six subsections: subsection 4.1 is the introduction, 4.2 discusses the response rate while 4.3 is the discussion of the results on descriptive of socio-economic analysis of factors affecting adoption of dairy cattle milk production technologies. Subsection 4.4, 4.5 and 4.6 discusses the results on technological, economic and institutional factors affecting the adoption of dairy cattle milk production technologies respectively.

4.2 Response Rate

Sample size of one hundred and ninety-nine (199) smallholder dairy farmers were selected to take part in the study and 198 questionnaires were duly filled by the respondents, which represented a response rate of 99.5%.

4.3 Descriptive Analysis

4.3.1 Results and discussion of household socio-demographic characteristics.

The research considered socio-demographics characteristics of the respondents because they directly or indirectly affected their decisions in line with the adoption of dairy cattle milk production technologies. The data were analysed using frequency and percentages and the results as presented in Table 4.1, 4.2, 4.3, 4.4 and 4.5.

Table 4.1

Gender Distribution of the household head

	Frequency	Percent (%)
Male	178	89.9
Female	20	10.1
Total	**198**	**100.0**

Source: Author's Survey Data, 2018

The results as shown in table 4.1 revealed that about 90% of the smallholder dairy farmers households were headed by male while 10% were headed by female. According to the findings by Oni, Maliwichi and Obadire, (2010), male and female-headed households had almost equal participation in smallholder farming (male 56% and female was 46%) while the findings by Ward et al. (2008) on factors affecting adoption of livestock production practices revealed that 89% of the respondents were males which is in convergence with the current study findings. These findings imply that male-headed households have greater chances of participating in the up take of dairy cattle milk production technologies as compared to female-headed households.

Table 4.2

Age Distribution of dairy farmers' household head

	N	Minimum	Maximum	Mean	Std. Deviation
HH head's age in years	198	25	90	48.99	11.693
Valid N (list wise)	198				

Source: Author's Estimates, 2018

Table 4.2 shows the age of the household head. The youngest and the oldest small-holder dairy farmers were aged 25 and 90 years respectively. The average age of the majority of smallholder dairy farmers in the study area was 49 years. From these findings, it was found out that age was an important factor in technology adoption. The study found that when the gender of the farmer is male, the likelihood of using a milk production technology high. According to the findings by He et al. (2007); Sidibe' (2005), the probability of young household heads to adopt new technologies were high as compared to older household heads. Their finding on age was in convergence with the findings of this study on age and adoption of agricultural technologies.

Table 4.3

Highest education level

Education level	Frequency	Percent (%)
No formal education	10	5.1
Less than Primary	13	6.6
Pre-primary/Primary	85	42.9
Secondary	61	30.8
Vocational training	5	2.5
Post-sec/College	22	11.1
University	2	1.0
Total	**198**	**100.0**

Source: Estimates from Survey Data, 2018

Table 4.3 shows the analysed results for the education levels of the respondents. Results show that large number of smallholder dairy farmers in the area of study had attained the pre-primary and primary level of education which represented about 43% of the total respondents. About 31%, 3% and 11% of the respondents had attained secondary, vocational training and post-secondary /college levels of education respectively. Only two of the respondents had attained a university level of education. These results show that most of the smallholder dairy farmer household heads were fairly educated which could enable them to fairly adopt dairy cattle milk production technologies Mishra (2010) found out that higher education level leads to ease of access to knowledge and information on agricultural undertakings. This would lead to higher up take of technologies in agriculture. A study by Knowler (2007), education level has a positive influence on dairy cattle milk production technology adoption because there is a correlation between education and knowledge. The findings by Mishra, (2010) and Knowler, (2007) were in agreement with the current study findings. This means that dairy farmers with better education levels would easily adopt dairy cattle milk production technologies and hence be able to realise higher expected returns from dairy production.

Table 4.4

Dairy farmers' household heads

	Frequency	**Percent (%)**
Father	180	90.9
Mother	17	8.6
Child Headed	1	0.5
Total	**198**	**100.0**

Source: Estimates from Survey Data, 2018

Table 4.4 indicate that about 91% of dairy farmers household were father headed household while 8.6% and 0.5% were a mother and child-headed households respectively. From the results in the study area, it is clear that the most of the households were headed by male members, who are fathers. However, there was no prove to suggest that the household head had a significant influence on the adoption of milk production technologies.

Table 4.5

Years of farming experience of the household head

Farming experience(years)	Frequency	Percent	Cumulative
1-10	72	36.36	36.36
11-20	64	32.32	68.69
21-30	17	8.59	77.27
Over 30	45	22.73	100.00
Total	**198**	**100.00**	

Source: Estimates from Survey Data, 2018

Table 4.5 results show years of farming experience of dairy farmer household heads. From the results, 36% of the farmers have between 1-10 years of experience. Farmers between 11-20, 21-30 and over 30 years of experience account for 32%, 9% and 23% respectively. Farmers experience as put across by Ingabire et al. (2018) on the agricultural technology adoption found out that majority of none technology adopters had farm experience of between 1-4 years while adopters had experience of above 10 years. This finding was in convergence with current results since farmers with 10 and above years of farming experience account for about 64%. This implies that farmers with experience have a high results on the adoption of dairy cattle milk production technologies.

4.4 Econometric Analysis

The section presents a detailed econometric analysis of the objectives using multivariate regression model and diagnostic tests that were estimated in this study.

4.4.1 Diagnostic test.

Multicollinearity was measured by the variance inflation factor (VIF) and contingency coefficient factor (CCF) among continuous and discrete variables for each of the specified objectives. Multicollinearity arises once two or more predictors in the model are correlated and provide redunt information about the response. According to Ringle et al. (2015) and Mile (2014), the maximum VIF values should be less than 5 and 10, respectively. The results of multicollinearity test are presented in Table 4.6

Table 4.6

Multicollinearity test using Variance Inflation Factor (VIF)

Variable	VIF	1/VIF
Gender	3.91	0.255637
Household head	3.57	0.280337
Age	2.55	0.391419
Farming years	2.24	0.447239
Education level	1.20	0.830199
Family size	1.02	0.980780
Mean VIF	**2.42**	

Source: Estimates from Survey Data, 2018

Test results as shown in Table 4.6, revealed that the output coefficient or collinearity statistics as shown by the VIF values ranged from 1.02 to 3.91. This shows that there were no multicollinearity symptoms between the predictors. Therefore, the small VIF values as shown in the table indicates that there was a low correlation among the variables under consideration.

4.4.2 Socio-demographics characteristics of adoption of dairy cattle milk production technologies.

This section presents a detailed econometric result of the multivariate probit regression model for all the objectives of this study. The parametric estimates of the probit model were used to give direction of the effects of independent variables on the dependent variable. These estimates represent neither the actual magnitude of change nor the probabilities. The coefficients had no direct interpretation. They were simply the values that maximized the likelihood function. The real expected change in probability was measured by use of marginal effects of each objective's dependent variable with regard to a unit change in the independent variable from the mean (Green, 2002).

Data for the objective was obtained by requesting the respondents to declare the level at which different socio-demographic characteristics were by affected the adoption of dairy cattle milk production technologies. The data was then subjected to a multivariate probit regression analysis to determine the effect of socio-demographic characteristics on the adoption of dairy cattle milk production equipment technologies. The analysis used 197 observations. However, two of the observations were missing. The results of the analysis are shown in Table 4.7. Results reveal that the likelihood chi-square ratio test of 43.63 with a p-value of 0.0000, means that the model as a whole was statistically significant, that is, it fits significantly better than a model with no predictors. Three predictor variables namely age, gender and education level were statistically significant. The probit regression coefficients gave a change in the z-score or probit index for a one-unit change in the predictor. For a one-unit increase in age, the z-score increased by 0.039, and as z-score increases by 0.27, level of education increases by one-unit. Gender was a dummy variable with 1 and 0 values, where 1 represented male respondents and 0 represented female respondents.

Table 4.7

Probit regression estimates of adoption of milk equipment and socio-demographics characteristics

Milk Equipment	dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
Age	0.0388243	0.0136529	2.84	0.004*	0.0120651	0.065583
Gender	2.046087	0.4823852	4.24	0.000*	1.100629	2.991544
Education level	0.2729715	0.1106942	2.47	0.014**	0.0560149	0.489928
Family size	-0.0165469	0.0198834	-0.83	0.405	-0.0555175	0.022424
Farming years	-0.2550132	0.1312307	-1.94	0.052	-0.5122207	0.002194
_cons	-3.426247	0.976716	-3.51	0	-5.340575	-1.511919
Legend						
Probit regression			Number of Obs =		197	
			LR ch² (5) =		43.63	
			Prob > ch² =		0.0000	
Log likelihood =	96.693637		Pseudo R² =		0.1841	
*=1 percent, **= 5 percent and ***= 10 percent levels of significance.						

Source: Author's Estimates from Survey Data, 2018

Table 4.8 show results of average marginal effects for the multivariate probit model estimates. Results indicated that the signs of marginal effects variable were in line with the signs obtained from parameter estimates in Table 4.7. Output results revealed that the predicted probability for socio- socio-demographic characteristics on adoption of milk equipment technologies by dairy farmer household was significant with the following factors; level of education, age, years of farming experience and gender.

Results revealed that the age of the household head had a positive and significant marginal effect at 1% level of significance on the adoption of milk equipment technologies. For a unit increase in the age of the dairy farmer, the marginal probability of adopting milk equipment technology (z-score) increased by 1.1 percentage points, which means that as farmer's age increases, the adoption of the milk equipment increases or their chances to adopt new technologies would be high. This would be attributed to the generalized increase in experience. The research findings were similar with the findings by Kafle and Shah

(2012) who found out that the up take of potato superior varieties was popular amongst the adult farmers. The findings by Tesfaw (2013), who found out that the age of the household head negatively influenced market participation in decision making since as the head gets older and older, they shift to production of lesser labour-intensive farming alternative was in contrast with the current results.

Table 4.8

Average marginal effects for socio-economic factors on the adoption of milk equipment

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Age	0.010631	0.0035388	3.00	0.003*	0.0036951	0.0175668
Gender	0.5602664	0.1135051	4.94	0.000*	0.3378004	0.7827323
Family size	-0.0045309	0.0054283	-0.83	0.404***	-0.0151702	0.0061084
Highest education	0.074746	0.0291629	2.56	0.010**	0.0175877	0.1319042
Farming experience	-0.0698286	0.03509	-1.99	0.047**	-0.1386038	-0.0010533

Legend

Average marginal effects Number of obs = 197

Model VCE : OIM

Expression : Pr (Milk equipment), predict ()

dy/dx with respect to : Age, Gender, family size, education level, Farming experience

*= 1 percent, **= 5 percent, ***=10 percent level of significance respectively

Source: Author's Estimates from Survey Data, 2018

Gender of the head of household was positive and significantly related to the adoption of milk equipment at 1% significance level. When the probability of adopting milk equipment is increased by 56 percentage points, the gender roles will increase by one unit as confirmed by marginal effect. The outcomes on the gender of head of the household as per the current study was in convergence with findings by Doss and Morris (2001) who found out that if the gender of head of the household was a male, then they would adopt new agricultural technologies easily compared to households headed by female. This is attributed to the easy access to resources by the male gender as compared to the female gender. However, the current study finding was in divergence to the ones by Nungo et al. (2007) who stated that female-headed household engages themselves more in adding value to sweet potatoes than male-headed households.

The household head education level was positive with a significant marginal effect at 5% level of significance on the adoption of milk equipment technologies. Increase in a unit level of education of the household head, increases the marginal effect of using the milk equipment by 7.5 percentage points. The findings of the household head on education were consistence with the study findings by Caswell et al. (2001) who found out that education facilitated a positive attitude to appreciating new technologies.

Farming experience of household head was significant though had a negative significant marginal effect on the adoption of the milk equipment at 5% significant level. With a one-year increase in farming experience, the adoption of the milk equipment decreased by 6.5 percentage points. The results of the study were similar with the findings by Komolafe et al. (2014) who found out that as the dairy farmers grow old, their level of output decline while findings by (Osanyinlusi & Adenegan 2016) found out that experience in farming was negatively related to production per unit area. The findings of the study were inconsistence with the finding by Makokha et al. (2007), found out that farmers with experience utilized their long term acquired knowledge and skills to reduce risks related with dairying and management of diseases. In addition, a study by Kinambuga (2010) revealed that experience assists in making decisions and allocation of resources which meant that the more experience one has, the wiser decisions are being made in terms of allocating resources to new technologies.

Furthermore, the data were subjected to multivariate probit regression analysis to determine the effect of socio-economic factors on the adoption of AI technology. The results from the analysis are as shown in Table 4.9.

Table 4.9

Average marginal effect estimates for the adoption of AI technology.

AI	dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
Age	-0.0316774	0.0113199	-2.80	0.005*	-0.053864	- 0.009491
Gender	-0.2288996	0.348659	-0.66	0.511	-0.9122588	0.45446
Education level	-0.0261317	0.0789844	-0.33	0.741	-0.1809384	0.128675
Family size	0.0083315	0.018395	0.45	0.651	-0.0277219	0.044385
Farming experience	-0.006034	0.1089846	-0.06	0.956	-0.2196399	0.207572
_cons	2.077987	0.7061331	2.94	0.003	0.6939913	3.461982
legend						
Probit regression			Number of obs=		198	
			LR chi² (5) =		13.91	
			Prob> chi² =		0.0162	
Log likelihood =	125.80161		Pseudo R² =		0.0524	

*=1 percent, **= 5 percent and ***= 10 percent levels of significance.

Source: Author's Estimates from Survey Data, 2018

Table 4.9 results from the probit analysis to determine whether socio-demographics characteristics have an influence on the adoption of Artificial Insemination (AI) show that the likelihood ratio chi-square of 13.91 with a p-value of 0.0162 indicates that the model as a whole is statistically significant, and it fits significantly better than a model with no predictors. Only age is statistically at 1% level significance although with a negative marginal effect. The rest of the variables in the model namely gender, education level, farming experience and family size were not statistically significant when all the variables were in the model.

The age marginal effect coefficient is -0.032 and the p-value is 0.005 which implies that as the age increases by a year, the marginal probability of adopting AI technology decreases by 3.2 percentage points. This finding means that young dairy farmers can easily adopt new technologies. They can also easily change to other technologies as compared to older dairy farmers who are reluctant to abandon old technologies for ones that are new. The findings of the study were consistence to findings by Quddus, (2013) who found out that young farmers within the productive age, are able to take up new technologies easily as compared to farmers who are old. This finding is in convergence with the current study findings. As dairy farmers get older, their experience notwithstanding, they tend to relax, lack of long term planning and became a risk-averse and therefore adopting new technologies would be a challenge.The results of the study were inconsistence with the study finding by Kaaya, Bashaasha and Mutetikka (2005) who found out that age is positively connected to embracing and utilization of AI technology. The result of the study was also inconsistence with the study findings by Nzomoi et al. 2007) who found out that household head age played an important role in adoption of dairy technology.

Similarly, the study investigated socio-demographics characteristics that influenced farmers to use vaccination regime technologies. Probit analysis was performed because the outcome of the predicted variables was binary. The results analysed were presented in Table 4.10.

Table 4.10

Marginal effects estimate for use of vaccination regime technology

Vaccination regime	dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
Age	-0.0100701	0.0121704	-0.83	0.408	-0.0339236	0.013783
Gender	1.029128	0.4144704	2.48	0.013**	0.2167806	1.841475
Highest education	0.0356271	0.082599	0.43	0.666	-0.1262639	0.197518
Family size	0.0113402	0.0191948	0.59	0.555	-0.026281	0.048961
Farming experience	-0.2429342	0.1165877	-2.08	0.037**	-0.4714418	-0.014427
_cons	0.2435127	0.8036385	0.30	0.762	-1.33159	1.818615
legend						
Probit regression			Number of obs =		196	
			LR chi² (5) =		35.17	
			Prob> chi² =		0.0000	
Log likelihood =	110.73812		Pseudo R² =		0.1370	
*=1 percent, **= 5 percent and ***= 10 percent levels of significance.						

Source: Author's Estimates from Survey Data, 2018

Table 4.10 results revealed that the likelihood ratio chi-square is 35.17 with a p-value of 0.0000. This shows that the model as a whole is statistically significant and it fits significantly better than a model with no predictors. The p-values for years of farming experience and gender were statistically at 5% significance level. Since gender is a dummy variable with values 1 for male respondents and 0 for non-male respondents, the coefficient of gender indicates that when the respondent is male the z-score increases or the marginal probability of adopting vaccination regime by dairy farmers increases by 103 percentage points. Similarly, a unit increase in the years of experience in farming results in a decrease in adoption of the vaccination regime by 24 percentage points by the dairy farmers household head. Experience in any venture cannot be overemphasized; in the dairy sector, the experience is very important especially in improving the breeds and breeding. Farmers with fast experience are better placed to address the challenges related to dairy cow milk production. The results of the study were similar to the findings of Idrisa et al. (2012) who found out that farmers with more experience have enhanced skills, accessed to information and exposed to better technologies.

Marginal effect results for gender is positive which means it has a positive and significant effect on adoption of vaccination regime at 5% level significance. It means that as the gender roles changes, the marginal probability in adopting a vaccination regime increases by 102 percentage points. Gender roles were found to be closely related to access and utilization of the dairy cow milk production technologies. The findings of the study were in agreement with Adebiyi and Okulola (2013) who found out that households headed by female were less experienced in terms of dairy cow milk technologies as compared to male-headed households because the female was too engaged with home chores and family management as compared to male counterparts. Adesina and Chianu (2002) confirmed that female is less likely to adopt new technologies while according to Baiyegunhi, (2015) found out that male farmers tend to accept new technologies as equated to female counterparts.

4.4.3 Estimates of technological factors on adoption of dairy cattle milk production technologies

The data then was further subjected to multicollinearity test in order to find out if there were multicollinearity symptoms between the predictors. The results from the test are shown in table 4.11. Based on the coefficients output - collinearity statistics obtained VIF values ranged from 1.25 to 10.51. The VIF values for the relevance of technology (2.75), technology risk level (1.43), cost of acquiring technology (1.96), and technology accessibility level (1.96) obtained is between 1 to 10. It can be concluded that there are no multicollinearity symptoms between these predictors. However, the VIF values for new technology emergence and technology safety are 10.51 and 10.18 respectively, meaning the values obtained are more than 10 which reveals the presence of multicollinearity between the predictors. This implies that new technology emergence predicts technology safety and vice versa.

Table 4.11

Multicollinearity test using variance inflation factor (VIF)

Variable	VIF	1/VIF
New Technology emergence	10.51	0.095160
Technology safety	10.18	0.098196
Relevance of technology	2.75	0.364110
Technology risks	2.48	0.402701
Cost of acquiring	1.96	0.510384
Technology risk level	1.43	0.699288
Technology access level	1.25	0.797684
Mean VIF	**4.37**	

Source: Author's Estimates from Survey Data, 2018

The data relating to this objective were collected by asking the respondents to state how different technological factors influenced their adoption of dairy cattle milk production technologies. The model used 48 observations since the observations with missing values were omitted to avoid errors. Table 4.12 show results of the marginal effects of technological factors affecting AI technology adoption.

The likelihood ratio chi-square is 30.23 with a p-value of 0.0001. These values indicate that the model as a whole is statistically significant and it fits significantly better than a model with no predictors. The table of results show only statistically significant variance which are; relevance of technology, the emergence of new technology and technology risk.

Table 4.12

Marginal effects estimate of technological factors on AI adoption

AI	**dy/dx**	**Std. Err.**	**Z**	**P>z**	**95% Conf.**	**Interval**
Relevance of technology	2.446411	0.684273	3.58	0.000*	1.105261	3.787562
Cost of acquiring	0.8969884	0.5925672	1.51	0.13	-0.264422	2.058399
Technology access level	-1.722038	2.271335	-0.76	0.448	-6.173774	2.729698
New technology emergence	2.543512	1.100597	2.31	0.021**	0.3863818	4.700641
Technology risks	-1.899647	0.6292044	3.02	0.003*	0.6664287	3.132864
Technology risk level	0.1126918	0.3297295	0.34	0.733	-0.5335661	0.75895
Technology safety	-0.6909931	0.8942399	-0.77	0.44	-2.443671	1.061685
_cons	-13.61597	10.63746	-1.28	0.201	-34.46501	7.233077
legend						
Probit regression			Number of obs=		48	
			LR chi² (7) =		30.23	
			Prob> chi² =		0.0001	
Log likelihood =	17.989066		Pseudo R² =		0.4557	

*=1 percent, **= 5 percent and ***= 10 percent levels of significance.

Source: Author’s Estimates from Survey Data, 2018

The marginal effect results for the relevance of the technology is positive which has a positive marginal effect on adoption of AI at 1 % significance level. This means that a one-unit increase in relevance of technology would result in an increase in the marginal probability of adopting AI by 244 percentage points. In the study area, results revealed that the dairy farmers adopted technologies which were relevant and which they could derive a lot of benefits out of them. The dairy farmers adopted the use of AI purposely because they were going to get better returns from it as result of improved breeds. The current study finding is in convergence with a study by Quddus (2012) who found out that the relevant technology exploited by the farmers had a bigger contribution to milk production and productivity.

On the new technology emergence, it was positive which means it had a positive and significant effect on the adoption of AI at 5% level significance. This indicated that a unit increase in new technology emergence the marginal probability of adopting AI increases by 254 percentage points. Emergence of new dairy technologies would increase the production and productivity of milk which would result in increased use of new AI services. The results of the study were in line with the findings by Aker (2011) who found out that farmers owning a mobile phone offered them the chance to acquire information about dairy cow milk production technologies and market information, improve the linkage between input suppliers and farmers and the market as well.

Technological risk had a negative marginal effect on the adoption of AI in other words it has a negative and significant effect at 1% level significance. A unit increase in technological risks reduces the marginal effect of adopting AI by 189 percentage points. The dairy farmers in the study area were opting to use contemporary technologies for example use of bulls because of the risk associated with the new IA technologies like repeat inseminations which would affect the dairy farmers' time and money. The findings of the study were consistence with findings by Kaaya et al. (2005) who found out that repeats on the AI use leads to delayed conception, longer calving period intervals, calving numbers and reduced earnings.

Table 4.13 presents results of the marginal effects estimates of technological factors on the use of milking parlour. The model used only 45 observations since the observations with missing values were omitted to avoid errors. Results revealed that the likelihood ratio chi-square is 25.15 with a p-value of 0.0003 indicates that the model as a whole is statistically significant and it fit significantly better than a model with no predictors. From the results, the only relevance of technology and technology risk was statistically significant at 5% level.

Table 4.13

Marginal effects estimate of technological factors on the use of milking parlour

Milking Parlour	**dy/dx**	**Std. Err.**	**Z**	**P>z**	**[95% Conf.**	**Interval]**
Relevance of technology	0.9508524	0.3816606	-2.49	0.013**	-1.698893	-0.202811
Cost of acquiring technology	0.1364326	0.4027261	0.34	0.735	-0.652896	0.925761
New technology emergence	-0.04053	1.284102	-0.03	0.975	-2.557325	2.476265
Technology risks	-1.253342	0.5674927	-2.21	0.027**	-2.365608	-0.141077
Technology risk level	0.2429826	0.2806635	0.87	0.387	-0.3071077	0.793073
Technology safety	0.7411712	1.302132	0.57	0.569	-1.81096	3.293302
_cons	0.6904902	4.359248	0.16	0.874	-7.853479	9.234459
legend						
Probit regression			Number of obs =		45	
			LR chi² (6) =		25.15	
			Prob> chi² =		0.0003	
Log likelihood =	17.260576		Pseudo R² =		0.4214	
*=1 percent, **= 5 percent and ***= 10 percent levels of significance.						

Source: Author's Estimates from Survey Data, 2018

The relevance of technology was related positively with a significant marginal effect on the use of the milking parlour at 5% significance level. This means that an increase in relevance of technology by a unit, the marginal probability of using milking parlour increases by 95 percentage points. It means that when a technology is relevant to the farmers in the study area, they would embrace the technology easily. The findings of the study were in agreement with the findings of Tefera et al. (2014) who found out that adopting AI purposely to up-grade dairy breeds and the properly feeding them on concentrates provides synergistic benefits to crossbred cows as they have larger responses to supplementary feeding.

Results show that technological risk is negative hence it means that technological risk was negatively related with the use of milking parlour though statistically at 5% significant level. As technology risk is increased by a unit, it leads to a decreases in marginal probability of using milking parlour by 125 percentage points. The results indicated that dairy farmers only adopted technologies that were less risky. The finding current study was similar to the findings by Mugisha et al. (2014) findings, who stated that the perceived high cost of AI compared to natural service, and too high expectations from the farmers on AI technology, are some of the reasons for low utilization of AI services.

4.4.4 Marginal effect estimates of economic factors on adoption of dairy cattle milk production technologies.

The data were subjected to multicollinearity test to find out if there were multicollinearity symptoms between the economic factors. The results of analysis were as shown in Table 4.14 reveals the VIF values obtained ranged from 1.16 to 1.78. This means that there is no multicollinearity, and hence the predictors were independent of each other and could not be predicted by other predictors.

Table 4.14

Multicollinearity test using variance inflation factor (VIF)

Variable	VIF	1/VIF
Labour cost	1.78	0.562287
Income	1.70	0.587114
Technology spending	1.23	0.811325
Land acreage	1.22	0.819658
Technology affordability	1.16	0.858828
Mean VIF	1.37	

Source: Author's Estimates from Survey Data, 2018

The data for this objective was obtained by asking the respondents to state how economic factors influenced their adoption of dairy cattle milk production technologies. In order to determine how adoption of AI technology were influenced economic factors, the data were subjected to multivariate probit regression analysis. The results of the analysis were as presented in Table 4.15. The analysis used 129 observations. The likelihood ratio chi-square of 14.92 with a p-value of 0.0107, indicates that the model as a whole is statistically significant and it fits significantly better than a model with no predictors. Results reveal that only labour cost and land acreage were statistically significant 5% and 1% levels respectively when all the predictors were encompassed in the model.

Table 4.15

Marginal effect estimates of economic factors on the adoption of AI

AI	dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
Technology affordability	-0.1047167	0.1251804	-0.84	0.403	-0.3500657	0.140632
Technology spending	0.0028978	0.2750434	0.01	0.992	-0.5361774	0.541973
Income effects	-0.170401	0.198176	-0.86	0.39	-0.5588188	0.218017
Labour cost effects	-0.5271431	0.2659444	1.98	0.047**	0.0059016	1.048384
Land size	0.4012606	0.1268154	3.16	0.002*	0.152707	0.649814
_cons	-1.441441	1.323989	-1.09	0.276	-4.036412	1.153531
legend						
Probit regression			Number of obs=		129	
			LR chi² (5) =		14.92	
			Prob> chi² =		0.0107	
Log likelihood =	-18.666373		Pseudo R² =		0.0866	
*=1 percent, **= 5 percent and ***= 10 percent levels of significance.						

Source: Author's Estimates from Survey Data, 2018

Labour cost effects were negatively and significant related to the AI adoption at 5% significance level. The marginal effect results reveal that the probability of adopting AI decreases by 53 percentage points as the labour costs increase by one unit. Access to labour to facilitated dairy farmers in the study area to utilize all dairy cow milk production technologies was high. The wage rates were way beyound reach by dairy farmers hence negatively affecting the adoption of dairy cow milk production technologies especially artificial insemination. The results of the study were similar to the findings of Shortall et al. (2016) found out that Labour availability is believed to be one of the hurdles facing dairy cow milk farmers in expanding dairy enterprises. The finding of the study area were in divergence with the findings by Ogundele and Okoruwa (2006) who found out that labour which is hired contributed positively to productivity in farm.

The results reveal that land size had a positive and significant marginal effect at 1% significant level on the adoption of AI. An increase by an acre of land size results to increase in the marginal effect of adopting AI by 40 percentage points. As the dairy farmer increases the land under dairy, the use of AI in the farm increases. The findings of the study were consistence with the findings by (Melesse, 2018), who found out that joint adoption of inorganic and improved varieties of maize had a positive relationship with farm size.

The study also considered the outcome of economic factors on milking parlour use by the dairy farmers as shown in table 4.16. Results reveal that the likelihood ratio chi-square test and p-value of 19.40 and 0.0016 respectively, show that the model as a whole was statistically significant and fitted better than a model with no predictors. Only three variables namely technological spending, income effects and labour cost were statistically significant. However, labour cost had a negative marginal effect on of milking parlour use.

Table 4.16

Marginal effect estimates of economic factors on the use of milking parlour.

Milking Parlour	**dy/dx**	**Std. Err.**	**z**	**P>z**	**[95% Conf**	**Interval]**
Technology affordability	0.1716008	0.1206595	1.42	0.155	-0.0648874	0.40809
Technology spending	0.6174556	0.2458191	2.51	0.012**	0.135659	1.09925
Income effects	0.388769	0.194184	2	0.045**	0.0081754	0.76936
Labour cost	-0.7128687	0.2340756	-3.05	0.002*	-1.171648	-0.25409
Land size	0.0024362	0.1002644	0.02	0.981	-0.1940783	0.19895
_cons	-0.3611364	1.129501	-0.32	0.749	-2.574917	1.85264
legend						
Probit regression			Number of obs =		144	
			LR chi² (5) =		19.40	
			Prob> chi² =		0.0016	
Log likelihood =	-87.374029		Pseudo R² =		0.0999	

*=1 percent, **= 5 percent and ***= 10 percent levels of significance.

Source: Author's Estimates from Survey Data, 2018

Technology spending was positive with significant marginal effect on the use of milking parlour at 5% significance level. As the technology spending increases by a unit, the marginal probability of using milking parlour increases by 62 percentage points. The results of the study were similar to the findings of Martey et al. (2016), found out that financial institutions access increased the likelihood of farmers accessing funds for investment in legume inoculants.

Results for income had a positive effect with a significant at 5% level on the use of milking parlour. If an income effect is increased by a unit, it leads to an increase in the marginal probability of using milking parlour by 39 percentage points. This means as income of households increases, the adoption rate of the dairy cow milk technologies increases because the household has the ability to meet the cost of dairy cow milk technologies. Addition sources of income earned by dairy farmers in the study area helped them acquire or reinvest the same in new dairy technologies in their farms. The results of the study were consistence to the findings of Ward et al. (2008), found out that income from off-farm was an important factor affecting the uptake of number of cow-calf production and management practices.

Labour cost indicated negative effect with a significant relationship on the use of milking parlour at 1% significance level. The marginal effect reveals that as the labour costs increases by one unit, the marginal probability of using milking parlour decreases by 71 percentage points. The findings of the study were in line to the findings of Shortall et al. (2016), found out that labour availability was regarded as amongst the highest hurdles affecting dairy farmers in expanding their enterprises.

The study further examined how different economic aspects influence farmers use of vaccination regime as shown in Table 4.17. The model used 128 observations to compute statistical values. Results show that the likelihood ratio chi-square test and p-values were 62.05 and 0.000 respectively. This indicated that the model as a whole was statistically significant and it fitted significantly better than a model with no predictors. Three variables namely Technology spending, Technology affordability and Labour cost were statistically significant. However, Land size had a negative and significant marginal effect on the use of vaccination regime.

Table 4.17

Marginal effect estimates of economic factors on the use of vaccination regime

Vaccination Regime	dy/dx	Std. Err.	z	P>z	95% Conf.	Interval
Technology affordability	0.9383315	0.1636809	5.73	0.000*	0.6175228	1.25914
Technology spending	0.8375669	0.3459688	2.42	0.015**	0.1594805	1.51565
Income effect	-0.1287114	0.2498345	-0.52	0.606	-0.618378	0.36096
Labour cost	0.9404424	0.3610759	2.6	0.009*	0.2327466	1.64814
Land size	-0.4758789	0.1204363	-3.95	0.000*	-0.7119298	-0.23983
_cons	-5.741892	1.581131	-3.63	0.0000	-8.840851	-2.64293

legend

Probit regression		Number of obs=	128
		LR chi² (5) =	62.05
		Prob> chi² =	0.0000
Log likelihood =	-45.941551	Pseudo R² =	0.4031

*=1 percent, **= 5 percent and ***= 10 percent levels of significance.

Source: Author's Estimates from Survey Data, 2018

Technology affordability had a positive and a significant relationship with the use of vaccination regime at 1% significance level. As technology affordability is increased by a unit, the marginal probability of using vaccination regime increases by 94 percentage points. The findings of the study were in agreement with the findings of Temba (2011) found out that dairy farmers with better income have the capacity to acquire and embrace AI technology than those with lower income. Similarly, the results of the study were consistence with the findings of Tefera et al. (2014) who found out that farmers with a strong financial base enabled them adopt new technologies.

Technology spending was positive with significant marginal effect on the adoption of vaccination regime at 5% significance level. As technology spending is increased a unit, the marginal probability of using vaccination regime would increase by 84 percentage points. This indicated that as the dairy farmers increase their expenditure in the acquisition of new technologies, there would be high chances of using vaccination regime as a technology. The findings of the study were similar to the findings by Caswell et al. (2001) who found out that the spending on a particular technology was depended on the available resources and cost of the technology. The study finding was in divergence with finding by Khanna (2001) found out that the uptake of dairy technologies were only limited to large scale farmers who were well endowed with resources

Labour cost had a positive and significant relationship with the use of vaccination regime at 1% significance level. The results as labour cost increased by one unit, the marginal probability of using vaccination regime increases by 94 percentage points. Efficient utilization of hired labour would result in increased production of milk due to adoption of dairy cattle milk production technologies. The results of the study were in agreement with the findings of Mburu et al. (2007) who found out that labour hired on permanent basis influenced positively milk marketing through dairy cooperatives.

The land size indicated a negative and statistically significant relationship to the use of the vaccination regime at 1% level. As one acre of land is put into new cattle milk production technologies, the marginal probability of using vaccination regime by dairy farmers decreases by 48 percentage points. This means that the dairy farmers would venture into a more intensive system of keeping dairy cattle as they continue using vaccinations regime. As the study area witnesses increase in human population, the pressure on land also increases and hence its extra unit available for use on dairy cow milk production is reducing which in turn reduced the adoption of the vaccination regimes. The results of the study were consistence to the findings of Wambugu et al. (2003) which revealed that farm sizes are becoming smaller and smaller and thereby affects its utilization. This, therefore, determines and encourage intensification of land use, adoption of production enhancing, labour intensive and cost-saving technologies.

4.4.5 Marginal effects estimates of institutional factors on adoption of dairy cattle milk production technologies.

The data for this objective was obtained by asking the respondents to state how institutional factors influenced their adoption of different dairy cattle milk production technologies. The data were further subjected to multicollinearity test to find out whether there were multicollinearity symptoms between the institutional factors that influenced the adoption of dairy cattle milk production technologies. The results of the test are as shown in Table 4.18. Results show that the VIF values obtained ranged from 1.07 to 2.44, which means that there was no multicollinearity and hence this implies that the predictors were independent of each other and could not be predicted by other predictors.

Table 4.18

Multicollinearity test

Variable	**VIF**	**1/VIF**
Distance to all-weather	2.44	0.409247
Market distance	2.36	0.423955
Extension services	1.14	0.878517
Availability of Microfinance	1.11	0.904150
Low credit access	1.09	0.915123
Milk chilling plants	1.07	0.934178
Mean VIF	**1.53**	

Source: Author’s estimates from survey Data, 2018

Probit analysis was performed to determine the effect of different institutional factors on the adoption of AI technology. The results of the probit analysis were shown in Table 4.19. The analysis used 184 observations because 13 observations were missing. The likelihood ratio chi-square of 19.89 with a p-value of 0.0029 shows that the model as a whole is statistically significant, that is, it fits significantly better than a model with no predictors.

Results show market distance and distance to all-weather roads were the only two statistically significant variables at 1% level. However, market distance had a negative and significant relationship with the adoption of AI.

Table 4.19

Marginal effect of institutional factors on adoption of AI

AI	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Low credit access	-0.2429011	0.1750414	-1.39	0.165	-0.5859759	0.10017
Microfinance institutions	0.1136357	0.2042799	0.56	0.578	-0.2867456	0.51402
Extension services	0.1966025	0.1163059	1.69	0.091	-0.0313529	0.42456
Market distance	-0.4342837	0.1578328	-2.75	0.006*	-0.7436303	-0.12494
Distance to all Weather	0.3777629	0.1282229	2.95	0.003*	0.1264506	0.62908
Milk chilling plants	-0.2441556	0.1522754	-1.6	0.109	-0.5426099	0.0543
_cons	1.532649	1.391045	1.1	0.271	-1.193749	4.25905
legend						
Probit regression			Number of obs =		184	
			LR chi² (6) =		19.89	
			Prob> chi² =		0.0029	
Log likelihood =	-113.21081		Pseudo R² =		0.0808	

*=1 percent, **= 5 percent and ***= 10 percent levels of significance.

Source: Author's Estimates from Survey Data, 2018

The market distance showed a negative with a significant relationship on the adoption of AI at 1% significance level. This shows that as the market distance increases by a kilometre, the marginal probability of adopting AI by dairy farmers reduces by 43 percentage points. Market distance determines the market availability of dairy products and produce. As the market distance increases away from the farmer, it means that the market is not readily accessible hence determining the adoption of AI technology by dairy cow milk producers. Market distance affects purchase and flow or supply of dairy cow inputs to the farmers. Transport cost of the inputs supplied into the farms that are far away from the market is high as compared to those closer to the market. Poor road networks greatly affects the adoption of the technologies in the study area as its humper's communication and accessibility of AI technologies to dairy farmers in the remote areas. The results of the study were in agreement with the findings by Menale et.al. (2012) who found out that input adoption and farm income decrease as farm distance from market increases, this is in convergence with the current finding.

The current study is in convergence with the study done by Thorpe et al. (2000) who found out that in the Eastern Africa region, just as in many parts of the tropics, market availability played a key role in the promotion of smallholder dairy farming. It makes many smallholder dairy farmers concentrate near or within urban areas to easily access market. The study by Lwelamira et al. (2010) had also observed that unreliable market is a major challenge to small scale dairy farming in Karagwe district of Tanzania, which was also in convergence with the current study.

Results show that distance to all-weather roads was a positive and significantly related to the adoption of AI at 1% level significance. As the distance to all-weather road increases by a kilometre, the marginal probability of adopting AI increases by 38% percentage points. The farmers that are closer to the source of technology tend to adopt innovations easily as compared to dairy farmers in the study area that are far away. The results of the study were similar to the findings by Ali (2005) who found out that rural roads improvement and being closer to the market increase land under crop production and improve intensification of production through technology adoption. The findings of the study were inconsistence to the findings of Idrisa et al. (2012) who found out that proximity to the source of technology such as AI station was an important factor in determining the probability of adopting AI technology.

The study also investigated the outcome of institutional factors affecting the use of dairy cattle milk production technologies. The analysis used 184 observations to compute statistical values. The results of the analysis are as shown in Table 4.20. Results show that the likelihood ratio chi-square of 92.44 with a p-value of 0.0000, shows that the model as a whole was statistically significant and it fitted significantly better than a model with no predictors. The results show that extension services, distance from the all-weather road and the availability of milk chilling plant were the only significant predictors at 1% significance level respectively.

Table 4.20

Marginal effect estimates of institutional factors on the adoption of cattle milk production technologies.

Production Technologies	dy/dx	Std. Err.	z	P>z	95% Conf.	Interval
Low credit access	-0.4376692	0.2347418	-1.86	0.062	-0.8977548	0.0224163
Microfinance institutions	-0.0591652	0.2826482	-0.21	0.834	-0.6131455	0.4948151
Extension services	1.072564	0.2808115	3.82	0.000*	0.5221835	1.622944
Market distance	0.0269737	0.2119426	0.13	0.899	-0.3884262	0.4423736
Distance to all Weather	-1.001004	0.2277555	4.40	0.000*	0.5546115	1.447397
Milk chilling plants	0.647572	0.2166353	-2.99	0.003*	-1.072169	-0.2229747
_cons	2.047773	2.044782	1.00	0.317	-1.959925	6.055472

legend

Probit regression		Number of obs=	184
		LR chi^2 (6) =	92.44
		Prob> chi^2 =	0.0000
Log likelihood =	-67.662955	Pseudo R^2 =	0.4059

*=1 percent, **= 5 percent and ***= 10 percent levels of significance.

Source: Author's Estimates from Survey Data, 2018

Output results for extension services revealed a positive with a significant relationship between extension service and the adoption of dairy technologies at 1% significance level. An increase in extension service provision leads to a corresponding marginal probability increase in the adopting of dairy cattle milk production technologies by 107 percentage points. This implies that the extension service plays a critical part in the uptake of dairy cattle milk production technologies in the study area. It enhances uptake and continued use of dairy cattle milk technologies by the farmers. The results of the study were consistence with the findings by Tura et al. (2010) who stated that extension service positively influenced the adoption of ideas and give the farmers the opportunity to share knowledge and skills about new agricultural technologies amongst themselves. Similarly, the findings of the study were in agreement with findings by Homes and Jones, (2010), who found out that adoptions of technologies which were new was often determined by the farmers access to extension services.

The marginal effects results for distance to all-weather roads showed a negative with a significant relationship on the adoption of cattle milk production technologies at 1% significant level. It confirms that as the distance to all-weather road increases, the adoption of dairy cattle milk production technologies reduces by 100 percentage points. The further dairy farmers are from the weather roads the lesser their chances of adopting dairy cattle milk production technologies as opposed those closer to the weather roads. The results of the study were similar with the findings of Murage and Ilatsia, (2011) who found out that distance from the technology service provider affects significantly the uptake of breeding technologies. Likewise, the findings of the study were in line with findings by Makokha et al, (2007) found out that nearest to the tarmac road did not have any significant impact on the adoption of dairy cattle milk production technologies.

Marginal effects results revealed that milk chilling plants was positive and significantly related with the adoption of cattle milk production technologies at 1% significance level. This means that a unit increase in the number of milk chilling plants leads to an increase in the adoption of the cattle milk production technologies by 65 percentage points. Proximity to milk chilling plants by the dairy farmers meant that there was a consistent market for their milk, hence increasing the adoption of dairy cattle milk production technologies. The current study findings were in convergence with study findings by Ali, (2005), who revealed that those farmers who are far away from the market take a lot of their time to get to the market. This would result in low adoption of technologies as opposed to those farmers who are nearer to the market.

Finally, the institutional factors effect on the adoption of vaccination regime was investigated using multivariate probit regression analysis. The analysed results were as shown in Table 4.21. The analysis used 183 observations to compute for the statistical values. Likelihood chi-square ratio test of 68.37with a p-value of 0.0000, shows that the model as a whole fit significantly better than a model with no predictors. Only two microfinance institutions and distance to all-weather were significant at 5% level respectively and positively associated to the adoption of vaccination regime.

Table 4.21

Marginal effect estimates of institutional factors on the adoption of vaccination regime

Milk equipment	dy/dx	Std. Err.	z	P>z	95% Conf.	Interval
Low credit access	0.2285188	0.1915065	1.19	0.233	-0.1468271	0.603865
Microfinance institutions	0.6417477	0.2503417	2.56	0.010**	0.151087	1.132408
Extension services	0.1166751	0.121006	0.96	0.335	-0.1204923	0.353843
Market distance	0.3845645	0.2032481	1.89	0.058	-0.0137944	0.782923
Distance to all Weather	0.9934247	0.2224297	4.47	0.000*	0.5574706	1.429379
Milk chilling plants	-0.2551536	0.166521	-1.53	0.125	-0.5815288	0.071222
_cons	-4.215316	1.708324	-2.47	0.014	-7.563569	-0.867063
legend						
Probit regression			Number of obs =		183	
			LR chi^2 (6) =		68.37	
			Prob> chi^2 =		0.0000	
Log likelihood =	-82.29941		Pseudo R^2 =		0.2935	

*=1 percent, **= 5 percent and ***= 10 percent levels of significance.

Source: Author's Estimates from Survey Data, 2018

Microfinance institutions was positively related with the adoption of vaccination regime at 5% significance level. The marginal effects results reveal that a unit increase in the number of microfinance institutions leads to an increase in the adoption of vaccination regime by 64 percentage points. This means that dairy farmers who are closer to microfinance institution can easily access agricultural credits which they could then use to purchase vaccines as opposed to those who are far from microfinance institutions. The results of the study were in agreement with the findings of Teklewold et al, (2006) who found out that dairy farmers who were easily accessed to financial loans adopted new cattle milk technologies.

Distance to all-weather roads had a positive and significant relationship with the adoption of vaccination regime at 1% level significance. A kilometre increase in distance to all-weather road, the probability of adopting a vaccination regime increases by 99 percentage points. This current finding is in divergence from the findings by Murage and Ilatsia, (2011) who found out that distance away from all-weather road affected significantly the adoption of vaccination regime. It was expected that those dairy farmers who were closer to all-weather road were able to adopt vaccinations regimes as they were easily accessible to veterinary service providers as opposed to those dairy farmers who were far away from the all-weather roads.

The Table 4.22 shows the summary of hypotheses tests and results

Table 4.22

Summary of tests of hypotheses and Results

Research Objective	Hypothesis	Results	Table	Remarks
To analyse influence of socio-demographic characteristics on adoption of dairy cattle milk production technologies	H0: Socio-demographic characteristics have no significant influence on adoption of dairy cattle milk production technologies	LR ch^2 (5) = 43.63, Prob > ch^2 =0.0000, Pseudo R^2 =0.1841	4.7	H0 rejected
To determine influence of technological factors on the adoption of dairy cattle milk production technologies	H0: Technological factors have no significant influence on the adoption of dairy cattle milk production technologies	LR ch^2 (5) = 25.15, Prob > ch^2 =0.0003, Pseudo R^2 =0.4214	4.13	H0 rejected
To analyse influence of economic factors on the adoption of dairy cattle milk production technologies	H0: Economic factors have no significant influence on the adoption of dairy cattle milk production technologies	LR ch^2 (5) = 14.92, Prob > ch^2 =0.107, Pseudo R^2 =0.0866	4.15	H0 rejected
To determine influence of institutional factors on the adoption of dairy cattle milk production technologies.	H0: Institutional factors have no significant influence on adoption of dairy cattle milk production technologies.	LR ch^2 (5) = 19.89, Prob > ch^2 =0.0029, Pseudo R^2 =0.0808	4.19	H0 rejected

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, conclusion drawn from the findings and their corresponding recommendations.

5.2 Summary

The study sought to determine the factors that influence adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County. The objectives of the study were:- to analyse the influence of socio-demographic characteristics on adoption of dairy cattle milk production technologies; To determine influence of technological factors on adoption of dairy cattle milk production technologies; To analyse influence of economic factors on adoption of dairy cattle milk production technologies and to determine influence of institutional factors on adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County. The major findings have been presented according to the objectives.

The first objective was to analyse socio-demographic characteristics influencing the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County. The sub- indicators used to measure socio-demographic were Age, Gender, level of education, household leadership and experience of the farmer. The findings of this objective showed that gender of the head of household, age of the household head, household head education and one-year farming experience statistically significantly influenced adoption of milk equipment. Further a 1% increase in unit level of gender of the head of household, age of the household head, household head education and one-year farming experience increases the adoption of dairy cattle milk production technologies 56%, 1.1%, 7.5% and 6.5% respectively. Likewise findings of the head of household did not statistically significantly influence adoption of the milk equipment. Lastly the gender coefficient indicated that when the respondent is male 1% unit increases in male participation in dairy keeping increased adoption of vaccination regime by 103 %.

The second objective was to determine the influence of technological factors on adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub-County, Nandi County. The sub- indicators used to measure technological factors were access, relevance, usability and risk involved in technology. The findings of the objective revealed that relevance of the technology, technology emergence and technology risk positively statistically significantly influenced adoption of dairy cattle milk production technologies. Similarly a unit increase in relevance of the technology and technology emergence caused an increase in adoption of dairy cattle milk production technologies by 244% and 254%. However the results showed that a 1% unit increase in technological risk caused a decrease in adoption of dairy cattle milk production technologies like milk parlour and AI by 125% and 189% respectively.

The third objective was to analyse economic factors influencing adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub- County, Nandi County. The sub- indicators used to measure economic factor were affordability, capital availability, labour availability, level of incomes and size of land owned. The results of the objectives showed that technological spending, income effects, land size and labour cost were positively statistically significant. Further a 1% unit increase in land size caused an increase of adoption of dairy cattle milk production technologies by 40%. However the 1% increase unit labour cost caused a decrease 53% in adoption of technologies.

The fourth objective was to determine institutional factors influencing the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub-

County, Nandi County. The sub- indicators used to measure institutional factors were access to credit, extension services, market, chilling plants and infrastructure. The findings of objective showed that chilling plant, credit, extension services, distance from the all-weather road statistically significantly influenced adoption of dairy cattle milk production technologies. Further results showed that a unit increase of chilling plant, credit, extension services and distance from the all-weather road caused an increase of adoption of dairy cattle milk production technologies by 65%, 64%, 107% and 99% respectively. However 1% unit increase in market distance reduced the adoption of dairy cattle milk production technologies by 43%.

5.3 Conclusions

The first objective on to analyse influence of socio-demographic characteristics on adoption of dairy cattle milk production technologies, the model gave Prob > ch^2 =0.0000 and Pseudo R^2 =0.1841. The results showed that socio-demographics statistically significantly influenced adoption of dairy cattle milk production technologies with Prob > ch^2 =0.0000 at both 1% and 5% level of significance. Similarly socio-demographics contributed to 18% increase in adoption of dairy cattle milk production technologies

The second objective to determine influence of technological factors on the adoption of dairy cattle milk production technologies the model gave Prob > ch^2 =0.0003 and Pseudo R^2 =0.4214. The results showed that technological factors statistically significantly influenced adoption of dairy cattle milk production technologies with Prob > ch^2 =0.0000 at both 1% and 5% level of significance. Likewise technological factors contributed to 42% increase in adoption of dairy cattle milk production technologies

The third objective on to analyse influence of economic factors on the adoption of dairy cattle milk production technologies the model gave Prob > ch^2 =0.107 and Pseudo R^2

=0.0866. The results showed that economic factors statistically significantly influenced adoption of dairy cattle milk production technologies with Prob > ch^2 =0.0000 at both 1% and 5% level of significance. Further economic factors contributed to 8.7% increase in adoption of dairy cattle milk production technologies

The fourth objective on "to determine influence of institutional factors on the adoption of dairy cattle milk production technologies" the model gave Prob > ch^2 =0.0029 and Pseudo R^2 =0.0808. The results showed that institutional factors statistically significantly influenced adoption of dairy cattle milk production technologies with Prob > ch^2 =0.0000 at both 1% and 5% level of significance. Likewise institutional factors contributed to 8% increase in adoption of dairy cattle milk production technologies.

5.4 Recommendations

According to discussions and findings of this study, recommendations were made to guide other persons who read this study, researchers, farmers and policy makers in dairy industry. This research is meant to improve the way dairy industry is done.

Socio-demographic characteristics and adoption of milk production technologies

The study showed that most dairy cattle keeping were done by men. This was revealed by the findings on gender parameter. To enable the participation of youth, women in the dairy industry the study recommends that the government should come up with a policy that will support both women and youths financially to venture into dairy cattle milk production.

Technological factors and adoption of milk production technologies

The study showed that the dairy farmers did not want to take up the technological risk and that is why it caused a decrease in adoption of milk production technologies. Therefore the study recommends that the farmers are trained on decision making and change of attitudes towards technology uptake. By this the policy makers should come up with legislations that would increase budget on extension services to enable farmers get all the information they require. The extension service be revamp in order to aid dissemination of dairy cattle milk production technologies and continued use of the same by the farmers

Economic factors and adoption of dairy cattle milk production technologies

The study showed that an increase in labour caused a reduction of adoption of dairy cattle milk production technologies. Therefore the study recommends the adoption of equipments like feed mixers, composite chaff cutters and milking machines. This would reduce use of a high number of human labour. To enable adoption of these technologies the government needs to zero rate all agricultural machinery used in cattle milk production in order to promote access, adoption and use of the technologies.

Institutional factors and adoption of dairy cattle milk production technologies

The findings of this objective showed that market distance influenced adoption of AI negatively. To enable most of the dairy farmers adopt AI, the study recommends that the dairy small holders should form groups and acquire AI kits. Further the government should subsidise or give grants to enable farmers by the AI kit.

5.5 Suggestions for Further Research

The current study focused only in Mosop Sub County; therefore, similar research should be conducted in other regions of the country to examine the effect of studied variables on the adoption of dairy production technologies. Also because of gaps identified, it is necessary to study the extent of adoption of dairy cattle milk production technologies in Mosop Sub County, Nandi County or in the region to establish whether the smallholder dairy farmers are deriving any benefits from the technologies.

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APPENDICES

Appendix 1: Questionnaire for Small Scale/ Large Scale Farmers

Introduction

I am Job Kipruto Kosgei undertaking a Master of Science in Agricultural Economics and Resource Management. I am carrying out a study entitled "**factors affecting adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya".**

The purpose of this study is purely academic and more so to contribute to the understanding of the social, technological, economic, and institutional factors determining technology adoption in dairy cattle milk production in Mosop Sub County, Nandi County, Kenya. Respondents are requested to **VOLUNTARILY** participate in answering this questionnaire and are assured that any information shared will be strictly **CONFIDENTIAL** and will be used for purposes of this study only.

	SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS			
A01	Are you the head of the household (HH)	1 = Yes [ ] 2 = No [ ]		
A02	[If No], what is the relationship of the respondent to the household head if different from the head	1 = Spouse [ ] 2 = Son [ ] 3 = Daughter [ ] 4 = Employee/Farm Manger [ ] 5 = Other relative 6 = Other (Specify) [ ] ………		
A03	Who is the household Head?	1 = Father [ ] 2 = Mother [ ] 3 = Child headed [ ] 4 = single Parent [ ]		
A04	Gender of the Household (HH) head's?	1 = Male [ ] 2 =Female [ ]		
A05	Household (HH) head's marital status?	1=Single [ ] 2=Married [ ] 3=Separated [ ] 4=Widowed [ ] 5=others (specify) ……… [ ]		
A06	Household (HH) head's age in years?	…………………..		
A07	Who is the decision maker in the household?	1= HH head [ ] 2 = others [ ]		
		Males	**Females**	**Total**
		A	**b**	**c**
A08	How many of members are living in the household in number?			
	Adults (>18 years)			
	Children (<18 above 5 years)			
	Children (under 5 years)			
A9	What is the highest education level completed by the Head of Household?	1 = No formal education [ ] 2 = Less than primary [ ] 3=Completed Pre-primary/primary [ ] 4=Completed Secondary school [ ] 5=vocational training [ ] 6 = Completed Post-Sec./College [ ] 7 = Completed University [ ]		

A10	Low level of education of dairy farmer affects adoption of dairy cattle milk production technologies	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
A11	Do you have any knowledge on dairy cattle milk production technologies?	Yes [ ] No [ ]
A12	How long have you been in farming (Years)?	1.Over 30 years [ ] 2.20-30 years [ ] 3.10-20 years [ ] 4.1-10years [ ]
A13	In your opinion, lack of experience in dairy farming affect t he adoption of dairy cattle milk production technologies	1.Strongly agree [ ] 2. Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
	SECTION B: TECHNOLOGICAL FACTORS	
B1	Are the dairy cattle milk production technologies available i n the area?	Yes [ ] No [ ]
B2	If yes, are they readily available?	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
B3	Is it easy to learn the new agricultural technologies	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
B4	Have you embraced all the dairy cattle milk production tech nologies	Yes [ ] No [ ]
B5	If yes, can you rate the level of satisfaction after embracing the technologies?	1.Highly satisfied [ ] 2. Moderately satisfied [ ] 3. Satisfied [ ] 4. Fairly satisfied [ ] 5. Dissatisfied [ ]
B6	Have you acquired new dairy cattle milk production technol ogy, computer, Semen for use in the farm for the last one ye ar?	Yes [ ] No [ ]
B7	If yes, can you rate the ease of acquiring the technology?	1.Very easy [ ] 2.Easy [ ] 3. Not sure [ ] 4. Difficult [ ] 5. Very difficult [ ]
B8	In your opinion how is the cost of acquiring each technolog y?	1. Very Expensive [ ] 2. Expensive [ ] 3. Fair [ ] 4. Cheap [ ] 5. Not aware [ ]
B9	Do you have access to any of the cattle milk production tec hnologies in your area?	Yes [ ] No [ ]
B10	If yes, then can you rate the level of access of the technolog y	1.Very accessible [ ] 2.Accessible [ ] 3. Uncertain [ ]

		4. Inaccessible [ ] 5. Very difficult to access [ ]
B11	Have you ever found the cattle milk production technologies useful in your farm?	Yes [ ] No [ ]
B12	Have you ever experience any challenged in using the technologies?	Yes [ ] No [ ]
B13	The emergence of new technology affects the adoption of existing one?	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
B14	The technological threats such as resistance are factors affecting technology adoption?	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
B15	Have you had any risk as result of using any cattle milk pro duction technologies?	Yes [ ] No [ ]
B16	If yes, rate the levels of risk of the technologies?	1.Very risky [ ] 2. Risky [ ] 3. Uncertain [ ] 4. Less risky [ ] 5. Not risky [ ]
B17	The safety of technologies and its side effects affects t he implementation	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
	SECTION C: ECONOMIC FACTORS	
C1	How much money have you used for the last one year on da iry cattle milk production technologies?	1.Over 1 million [ ] 2.Ksh 500,000-1,000,000 [ ] 3.Ksh 100,000-500,000 [ ] 4.Ksh 50,000-100,000 [ ] 5.Ksh below 50,000 [ ]
C2	What type of tenancy arrangements do you have over the land you are farming on?	1 = Registered Owner [ ] 2 = Owner without title [ ] 3 = Leaser [ ] 4 = Son/Daughter of the owner [ ]
C3	Are you in any other employment outside of farming (off-farm work)?	1 = YES [ ] 2 = NO [ ]
C4	If yes, what kind of employment?	1 = Formal employment [ ] 2 = Casual [ ] 3= Self-employment [ ] (Specify)………
C5	Which is your major source of income?	1 = Farm [ ] 2 = Off-farm business [ ] 3 = Off-farm employment [ ]
C6	Family income affects adoption of dairy cattle milk production technologies?	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
C7	Cost of adopting dairy cattle milk production technologies is affordable?	1.Strongly agree [ ] 2.Agree [ ]

		3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
C8	What is the distance to the nearest milk market from your farm?	1.Over 20 Km [ ] 2.15-20Km [ ] 3.10-15Km [ ] 4.5-10Km [ ] 5. below 5Km [ ]
C9	What is the distance to the nearest all weather road from yo ur farm?	1.Over 20 Km [ ] 2.15-20Km [ ] 3.10-15Km [ ] 4.5-10Km [ ] 5. below 5Km [ ]
C10	Do you engage anybody apart from your family members in the your farm	Yes [ ] No [ ]
C11	If yes, how often do you engage	1.Daily [ ] 2.Once a week [ ] 3.On monthly [ ] 4.After every month [ ] 5.Permanent basis [ ]
C12	Is the labour available?	Yes [ ] No [ ]
C13	How much are you paying per man day?	1.over Ksh 1,500 [ ] 2.Ksh 1000-1500 [ ] 3.Ksh 500-1000 [ ] 4.Ksh 100-500 [ ]
C15	The cost of labour affects the dairy cattle milk production technologies	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
C16	How many acres of land do you own?	1.Over 20 acres [ ] 2.15-20 acres [ ] 3.10-15 acres [ ] 4.5-10 acres [ ] 5. below 5 acres [ ]
C17	How many acres have you set aside for livestock production?	1.Over 20 acres [ ] 2.15-20 acres [ ] 3.10-15 acres [ ] 4.5-10 acres [ ] 5. below 5 acres [ ]
C18	Do you have rented land? How many acres?	Yes [ ] No [ ] 1.Over 20 acres [ ] 2.15-20 acres [ ] 3.10-15 acres [ ] 4.5-10 acres [ ] 5. below 5 acres [ ]
C19	What is the size of land have you allocated to the following in acres?	1. Fodder…………… 2. Boma Rhodes……… 3. Maize for silage………………… 4. Nappier ……………….. 5. Milking parlour………….
C20	Land available affects the adoption of dairy cattle milk production technologies	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ]

		4. Disagree [ ] 5. Strongly disagree [ ]
	SECTION D: INSTITUTIONAL FACTORS	
D1	Have you gotten any credit for farm development for last one year?	Yes [ ] No [ ]
D2	If yes, what was the source of credit?	1.Shylock [ ] 2.Micro finance institution [ ] 3.Cooperative society [ ] 4.Commercial bank [ ]
D3	What did you use the loan for?	1.Purchase of a cattle [ ] 2.Purchase Boma Rhode seeds [ ] 3.Purchase of fodder seeds [ ] 4.Purchase of farm machinery [ ] 5.Hay baling [ ] 6.Construction of milking parlour [ ] 7.Purchase of a computer [ ] 8.All the above [ ]
D4	How did you acquire the loans?	1.Individual basis [ ] 2. Group basis [ ]
D5	Did you give as a collateral in order to acquire the loan?	1.title deed 2.logbook 3.cattle/cattles 4. household furniture 5.proceeds from tea 6. proceeds from maize 7. proceeds from milk
D6	Was the rate of acquiring the loan prohibitive?	Yes [ ] No [ ]
D7	Low access to credit facilities to dairy farmers influence adoption of the dairy cattle milk production technologies	1.Strong agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
D8	There are micro finance institutions within my area offering banking facilities.	1.Strong agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
D9	Is there any extension service provider in your area?	Yes [ ] No [ ]
D10	If yes, have you ever gotten his or her services?	Yes [ ] No [ ]
D11	If yes, in what areas?	1.Crop production [ ] 2. Livestock production [ ] 3. Pasture establishment [ ] 4. Animal feed conservation [ ]
D12	Have you received any advice from the extension service providers on dairy cattle milk production technologies for last one year?	Yes [ ] No [ ]
D13	How many times have you been visited by the extension service provider in the last one year?	1.over 20 times [ ] 2.15-20 times [ ] 3. 10-15 times [ ] 4.5-10times [ ] 5.1-5 times [ ]
D14	Did you find the advices from extension service provider useful in adopting dairy cattle milk production technologies?	Yes [ ] No [ ]

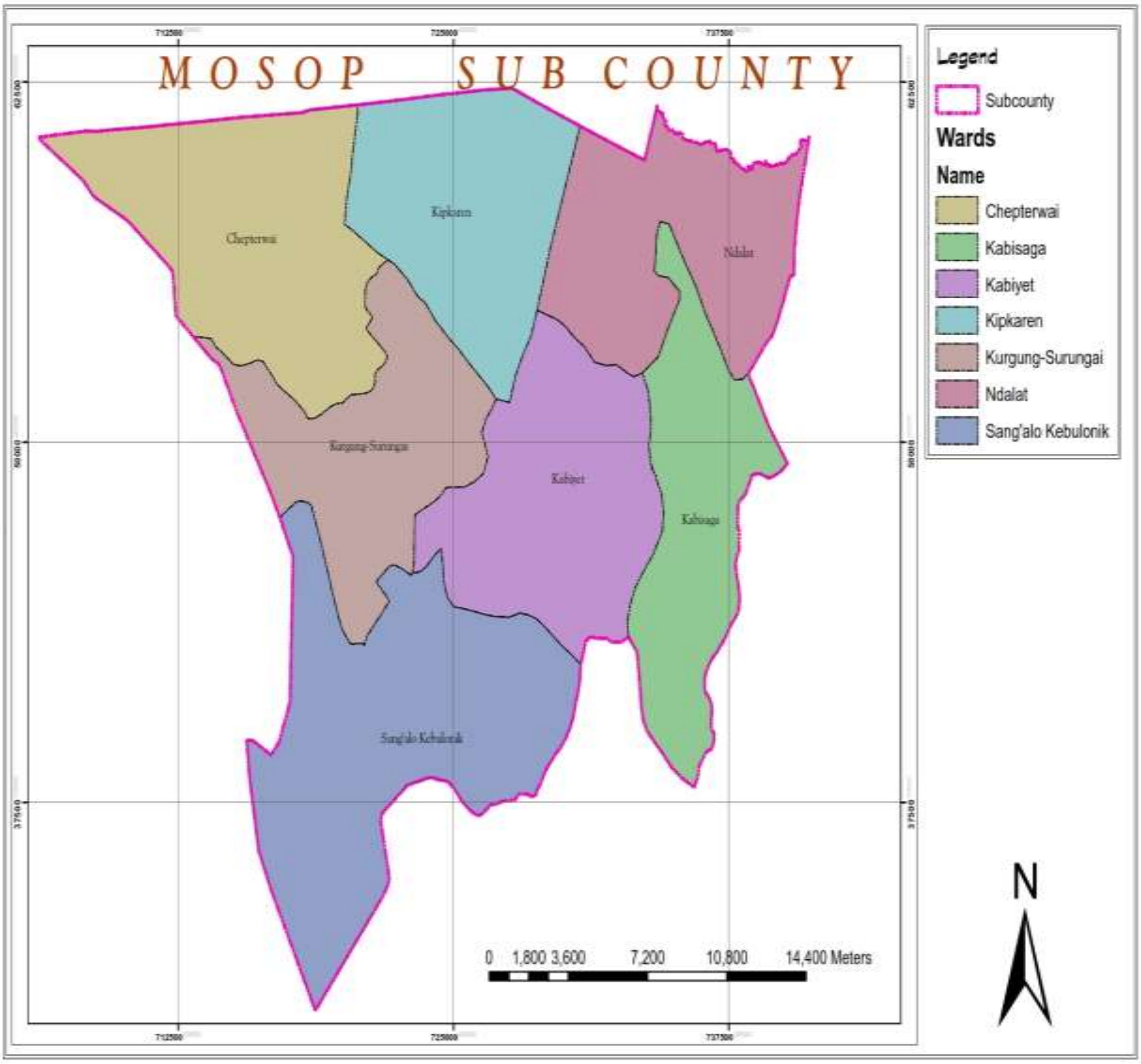
D15	If yes, rate advices provided by the extension service providers on adoption of dairy cattle milk production technologies?	1.Very adequate [ ] 2.Adequate [ ] 3. Not sure [ ] 4. Inadequate [ ] 5. Strongly inadequate [ ]
D16	Are you a member of a cooperative society?	Yes [ ] No [ ]
D17	Do you sell your milk through a cooperative?	Yes [ ] No [ ]
D18	What is the farm gate price of your milk?	1.over Ksh 50 [ ] 2. Ksh 40-50 [ ] 3. Ksh 30-40 [ ] 4.Ksh20-30 [ ] 5.below Ksh.20 [ ]
D19	Where do you sell your milk?	1.At farm gate [ ] 2.To milk hawker [ ] 3.Nearest market place [ ] 4.Through cooperative [ ] 5. To processor [ ]
D20	Have you faced any challenge selling your milk for last one year?	Yes [ ] No [ ]
D21	If Yes, what did you do with the milk?	1.Produced mala [ ] 2.Consumed at home [ ] 3.Feed the calves [ ] 4.Distributed to neighbours [ ]
D22	Availability of the milk chilling plants in your area has positively influence adoption of dairy cattle milk production technologies?	1.Strong agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. strongly disagree [ ]
D23	Are you a member of any farmers group?	Yes [ ] No [ ]
D24	Is the group engage in a dairy cattle milk production activities?	Yes [ ] No [ ]
D25	Are you intending to transform the group into a cooperative?	Yes [ ] No [ ]
D26	Are you satisfied of being a member of the group?	Yes [ ] No [ ]
D27	What benefits have you derived from being a member of the group?	1.Timely sales of milk 2. Access to loans 3. Joint performance of tasks in the fa rm 4. Others. Specify…………..
D28	Do you have an access to electricity in your farm?	Yes [ ] No [ ]
D29	What is the distance to the nearest water source from your farm?	1.Over 20 Km [ ] 2.15-20Km [ ] 3.10-15Km [ ] 4.5-10Km [ ] 5. below 5Km [ ] 6. roof harvesting 7. borehole/well
D30	Is availability of water affects adoption of dairy cattle milk production technologies?	1.Strong agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
	SECTION E: ADOPTION OF TECHNOLOGIES	
E1	What kind of pasture have you established in your farm?	Tick as appropriate 1.Nappier grass [ ]

		2.lucerne [ ] 3. calliandra [ ] 4.Boma Rhodes [ ] 5.Sweet potatoes [ ] 6.others specify ………….
E2	How do you harvest the pasture?	1.by hand [ ] 2. hay bailer [ ] 3. forage harvester [ ] 4.others specify …………..
E3	At what interval do you harvest your pasture in a year?	1.once a year [ ] 2.twice a year [ ] 3.three times [ ] 4.four times [ ]
E4	How do you conserve the pasture in your farm?	1.standing hay [ ] 2.bale hay [ ] 3. silage [ ]
E5	When did you start making silage in your farm?	1.10 years [ ] 2.5 years [ ] 3.3 years [ ] 4. 1 year [ ]
E6	Which method do you use to conserve silage?	1.silo [ ] 2.trench [ ] 3.polythene [ ] 4. others specify……………..
E7	is the cost involved in conservation of feeds affordable?	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
E8	Do you use Artificial insemination in your farm	Yes [ ] No [ ]
E9	If yes, since when?	1.over 10 years 2.10 years [ ] 3.5 years [ ] 4.3 years [ ] 5. 1 year [ ]
E10	Do you have breeding records	Yes [ ] No [ ]
E11	At what stage are you in breeding your dairy cattle?	1.Foundation [ ] 2.intermediate [ ] 3.Appendix [ ] 4.Pedigree [ ]
E12	What type of breed or breeds to you have in your farm	1.crosses [ ] 2.Frieshan [ ] 3.Ayrshire [ ] 4.Gunsey [ ] 5. Jersey [ ]
E13	What are the major constraints in using AI? (Tick as appropriate)	1.High charges [ ] 2.not available [ ] 3.AI challenges [ ] 4.negative attitude [ ] 5.unskilled personnel [ ] 6.others specify……..
E14	Do you have a milk parlour in place	Yes.[ ] No..[ ]
E15	How often do you clean?	1.Once a day .[ ] 2.Twice a day .[ ]

		3.Three times in a week .[ ] 4.Once a week .[ ]
E16	Do you use milking equipments?	Yes .[ ] No. .[ ]
E17	How often do you clean?	1.Once a day .[ ] 2.Twice a day .[ ] 3.Three times in a week .[ ] 4.Once a week .[ ]
E18	Do you have a vaccination regime for your dairy cattle	Yes .[ ] No. .[ ]
E19	If yes, how many times do you treat or vaccinate	1.Once a month .[ ] 2.Once in three months.[ ] 3.Once in six months .[ ] 4.Once a year .[ ]
E20	Do you use feed supplement to feed your dairy cattle?	Yes .[ ] No. .[ ]
E21	Do you agree with the cost of supplement that is incurred in the farm	1.Strongly agree [ ] 2.Agree [ ] 3. Not sure [ ] 4. Disagree [ ] 5. Strongly disagree [ ]
E22	Do you own a mobile phone?	Yes [ ] No.[ ]
E23	If yes which type?	1.ordinary [ ] 2.smart phone [ ]
E24	Do you have accessed to a platform where you get information relating to cattle milk production technologies?	Yes [ ] No. [ ]
E25	Rate the level of satisfaction on the information you get from the platform	1.Highly satisfied [ ] 2. Moderately satisfied [ ] 3. Satisfied [ ] 4. Fairly satisfied [ ] 5. Dissatisfied [ ]
E26	How do you get information from a platform?	1.text message [ ] 2. from Email [ ] 3.voice mail [ ] 4. WhatsApp [ ]
E27	Can you rate the quality of service you get from the platform	1.Highly satisfied [ ] 2. Moderately satisfied [ ] 3. Satisfied [ ] 4. Fairly satisfied [ ] 5. Dissatisfied [ ]
E28	In your own opinion, what percentage of cattle milk production technologies have you adopted in your farm?	No technologies percentage 1. 1-3 1-24% [ ] 2. 4-6 25-49% [ ] 3. 7-9 50-74% [ ] 4. over 10 75-100% [ ]

Thank you.

Appendix 2: Map of Mosop Sub County



Annex 1: National Commission for science, technology and innovation licence

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone +254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref No. **NACOSTI/P/18/33419/25837**

Date: **18th October, 2018**

Job Kipruto Kosgei
University of Kabianga
P.O.Box 2030 - 20200
KERICHO.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Analysis of factors affecting adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **Nandi County** for the period ending **17th October, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Nandi County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nandi County.

The County Director of Education
Nandi County.

THIS IS TO CERTIFY THAT:
MR. JOB KIPRUTO KOSGEI
of UNIVERSITY OF KABIANGA, 0-30100 Eldoret,has been permitted to conduct research in *Nandi County*

on the topic: *ANALYSIS OF FACTORS AFFECTING ADOPTION OF DAIRY CATTLE MILK PRODUCTION TECHNOLOGIES BY SMALLHOLDER DAIRY FARMERS IN MOSOP SUB COUNTY, NANDI COUNTY, KENYA*

for the period ending:
17th October,2019

Permit No : NACOSTI/P/18/33419/25837
Date Of Issue : 18th October,2018
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation