FACTORS INFLUENCING SMALLHOLDER DAIRY CATTLE PRODUCTIVITY IN TIGANIA EAST SUB-COUNTY, MERU COUNTY

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DECLARATION

I understand that plagiarism is an offence and I therefore declare that this thesis report is my original work and has not been presented to any other institution for any other award.

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DEDICATION

This Thesis is dedicated to my beloved wife Martha Kambura Atuna, my children and my aged father, for their prayers, patience, moral support, and encouragement to complete this work.

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ABBREVIATIONS AND ACRONYMS

A.I	**:**	Artificial Insemination
A.S.L	**:**	Above Sea Level
A.E.Z	**:**	Agro-Ecological Zones
C.G.S	**:**	Cattle Grazing Systems
S.L.P.O	**:**	Sub-County Livestock Production Officer
F.A.O	**:**	Food and Agriculture Organization
G.D.P	**:**	Gross Domestic Product
G.o.K	**:**	Government of Kenya
HA	**:**	Hectares
I.L.R.I	**:**	International Livestock Research Institute
N.K.C.C	**:**	New Kenya Co-operation Creameries
K.D.B	**:**	Kenya Dairy Board
KM	**:**	Kilometres
K.A.R.I	**:**	Kenya Agriculture Research Institute
K.E.B.S	**:**	Kenya Bureau of Standards
LTS	**:**	Litres
M.D.G	**:**	Millennium Development Goals
MoA	**:**	Ministry of Agriculture
MoLDF	**:**	Ministry of Livestock Development and Fisheries
MT	**:**	Metric Tonne
N.E.P.A.D	**:**	New Partnership for African Development
N.G.O	**:**	Non-Governmental Organization
^{0}C	**:**	Degree Centigrade
S.D.P	**:**	Smallholder Dairy Project
S.P.S.S	**:**	Statistical Package for Social Scientists
D.V.O	**:**	District Veterinary Officer
S.C.V.O	**:**	Sub-County Veterinary Officer
S.C.L.P.O	**:**	Sub-County Livestock Production officer
LH	**:**	Lower high land zone
U.M	**:**	Upper midland zone

DEFINITION OF TERMS (OPERATIONAL)

Agro-ecological zone : A land resource-mapping unit that is defined in terms of climate, land forms and having a specific range of potentials and constraints for land use. It can also be defined as a division of an area of land into smaller units, which have similar characteristics related to land use, suitability, potential production and environmental impact.

Grazing systems : This is a method of feeding cattle either extensively, semi-intensively or intensively on a piece of land.

Zero grazing : This is a grazing system where a dairy animal is confined in a stall or unit and feed is brought to it directly with limited movement within the confinement. It is also referred to as cut and carry stall-feeding. This method is common where land is limited due to human population pressure.

Semi zero grazing : The dairy animals are left to graze in small pasture fields within the farm but they are supplemented in confined sheds in the morning hours and later in the evening. Supplementary feeding is usually done during confinement.

Smallholder dairy farmer : This is a small-scale farmer practices dairy farming with a few numbers of cattle ranging between 1 to 10 animals.

Animal feed	**:**	Any agricultural feedstuff used specifically to feed domesticated livestock, such as cattle, goats, sheep, chicken and pigs. Most animal feeds come from plants and some from animal origin.
Cattle breed	**:**	A race or type of domestic cattle related by descent and similarity in certain distinguishable characteristics. There are two types the exotic breed; (Bos *taurus*) and the indigenous (*Bos indicus*) zebus. There are crosses between the two, which are well adapted to tropical climate.
Factor	**:**	A constituent or element that brings about certain effects or results on specific entity.
Social-economic factors	**:**	These are social factors in dairy farmers which have effect on dairy farming like age, education level, financial status, membership to groups, and experience in dairy farming.
Miraa tree	**:**	It is scientifically known *Catha edulis,* a flowering plant native of East Africa, Horn of Africa and Arabian Peninsula. Its leaves are chewed as a stimulant and it is widely planted as a cash crop in parts of Meru and Embu Counties of Kenya.

ABSTRACT

Dairy farming complements both food and cash crop farming in Kenya. Due to limited land sizes, smallholder dairy farming is popular and dominates the dairy sector in terms of milk production. Low milk production is a major constraint in Tigania East Sub-County despite the fact that the surrounding Sub-Counties produce high amounts of milk. A survey was carried out in Tigania East Sub-County involving 156 smallholder farmers randomly selected across three agro-ecological zones (AEZ1, AEZ2, and AEZ3) with each zone having 52 respondents. Purposive, stratified random sampling was used to select the respondents. These farmers were practising either zero or semi-zero grazing system and they were interviewed using structured questionnaire. The objectives of the study were-; Establishing social-economic factors influencing milk productivity in Tigania East Sub-County; Breeds and breeding factors influencing milk productivity; Dairy cattle management factors causing poor milk productivity in the Sub-County; Agro-ecological factors influencing milk productivity in the Sub-County. The data collected was analysed using SPSS version 21 and presented as percentages, means and standard deviations. Farmers who practised dairy farming as a major source of income were 27 per cent. Majority of the farmers (78.40 %) owned 1-2 dairy cattle with a mean experience of twelve years in dairy farming. The levels of income, the decision making on dairy farming, levels of education and the level of experience were the key socio-economic factors with significance p-values of 0.046, 0.030, 0.02 and 0.034 respectively. The type of breed used, the breeding strategies used such as Artificial insemination were significant with p-values of < 0.05. Farmers were likely to increase their milk levels through quality feeds, having adequate relevant knowledge, increasing the acreage under fodder and supplementing animal feeds, with Wald chi-square values of 0.01, 1.411, 0.637 and 1.73 respectively and p values of 0.01, 0.025, 0.01, and 0.005 respectively, indicating statistically significant factors. The grazing system, use of extension services and record keeping, with p-value of 0.005, 0.047 and 0.005 were significant. ANOVA for the AEZs had p-value of 0.58 indicating no significant influence on milk productivity. Improving on these significant factors would help improve dairy industry in the study area.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

The dairy sub-sector supports in one way or the other the livelihood of approximately 150 million farmers in the world whereby production, processing consumption of milk and dairy products can be used to achieve Sustainable Development Goals (FAO, 2010).

However, global milk production experienced a declining growth rate of 0.5% in 2018, lower than the average growth rate of 2.1%.per annum, (FAO.2018). The production decline in the major world exporters was partly due to: adverse weather conditions, low milk prices, herd size decline and individual yields per cow (FAO, 2018). However, the world global demand for milk is increasing due to population explosion, rising income levels and urbanization.

Though there has been an increase in milk production 'in the developing countries, this has been as a result of increased herd size rather than an increase in individual dairy cow productivity. In Africa, adverse weather condition and poverty has negatively affected milk production (FAO, 2018).

Though dairy sector in East Africa is important for poverty reduction and food security, its potential is unexploited resulting to low milk productivity. There are a number of challenges facing the sector such as lack of modern farming technologies, use of poor dairy breeds leading to low milk production compared to other parts of the world (Bingi, *et al*., 2015).

However, the number of farmers and the size of the improved dairy herd have increased considerably in East Africa especially in Kenya (Kurwijila *et al*., 2011). The dairy herd is mainly composed of pure breeds of Friesian, Ayrshire, Jersey, Guernsey and their crosses (Muriuki, 2002). Crosses constitute over 50 per cent of the total herd with Friesian and Ayrshire crosses being the most common breed (Kurwijila *et al*., 2011). The breed and breeding preference is dictated by the farmer's objectives, availability of feeds and the

AEZs climatic conditions (SCLPO, 2015). The countries with the highest production in Africa are Ethiopia, Kenya, South Africa and Sudan. Ethiopia has the highest number of dairy cattle and South Africa has the highest milk production per cow. It is only Ethiopia and Kenya that are self-sufficient in milk supply. (Ndambi *et al*., 2007).

About 80 per cent of the dairy cattle in Kenya are on mixed crop livestock smallholdings with 1-4 cattle and about 1-2 ha of land. About 60% of total milk production in Kenya is produced from less than 10% of the country landmasses. This is mostly in the central highlands of Kenya, where 80% of the dairy cattle are exotic crossbreeds (Staal *et al*., 1998).

Smallholder farmers do mixed farming where they keep other livestock, for example poultry, sheep, goats and pigs. They also grow crops like coffee, tea, bananas, maize, beans (Omore *et al*., 1998). In Tigania East, farmers plant *miraa (Catha edulis)* as a cash crop. Most small holder farmers do not keep any form of records making it difficult to estimate their profit margins. There is usually family labour, hired casual or permanent employment SCLPO, 2015). Dairying is usually considered as an important source of food and income for the family (Omore *et al*., 1998).

Kenya has one of the largest dairy sub-sectors in Sub-Sahara Africa (SSA), (MoLD, 2012), with the dairy industry playing an important role in food security, economic contribution to farmers, milk selling outlets, processors and consumers (Wambugu *et al*., 2011). There are also many stakeholders like Non-Governmental Organizations, extension agents, who benefit from this sub-sector.

The Kenya dairy cattle population is 70 per cent of the total herd in East and Southern Africa (Otieno *et al*, 2008). It is one of the fastest growing in the entire agricultural sector, contributing 14 per cent of the agriculture Gross Domestic Product (G.D.P.) and 3.5 per cent of the total Kenya gross domestic product. Kenya dairy cattle population is estimated at 4.3 million, with an estimated milk production of 3.43 million litres annually (Odero *et al*., 2017).

Kenya has a potential to produce 4.2 million litres of milk with a consumption rate of 3.5 million litres per year (MoLD, 2006). This clearly shows that the country is capable of not only meeting its domestic market demand but can also export the surplus, if the challenges facing the industry are well addressed. The country has the capacity to increase the estimated 4.2 billion litres to 5.0 billion litres per year (Muia *et al*., 2011). This can only be achieved if better dairy farming methods are employed. A part from producing milk, cattle manure is used to improve soil fertility, increasing crops, pastures and fodder production in smallholder farms hence improving food self-sufficiency (Jaleta *et al*., 2009).

In accordance to MoLD (2010), the National development goals emphasize on high priority in transforming subsistence and informal dairy production into a sustainable and globally competitive dairy value chain for wealth creation and high quality life, which can be achieved through more research. The dairy industry, like other agricultural sub-sectors is dominated by smallholder farmers who own an average of one to three dairy cows. They keep about 60-80 per cent of the total dairy herd (Staal *et al*., 2001). As a common means of livelihood, livestock is an integral part of smallholder farming system. These farmers are mainly concentrated in high potential areas around Central and Rift valley provinces (Nyanga *et al*., 2010).

Though most dairy farmers keep good quality exotic breeds and their crosses, milk production is low despite the potential (MoLD, 2011). Studies carried out indicate that average milk productivity in Kenya is 8-10 litres per day per cow, compared to production in South Africa, which is 12.7 litres per day per cow, and European Union, 18 litre per day per cow *(*Theron *et al*., 2008). This shows that, comparatively, Kenya milk production per individual cow is lower than its potential.

Milk production in Kenya ranges from 2,500 to 3,500lts per lactation period as compared to U.S.A. production levels of 9,000lts per lactation period, (EADDP, 2013). Dairy production in Kenya is therefore, below the international level and has not realized its full potential due to some challenges, which require to be addressed. Majority of smallholder

farmers consider dairy as a subsistence type of farming with low production and low income, generating a vicious poverty cycle. Smallholder farmer sell 3-5 litres of milk per day on average. However, a farmer can move out of the poverty line by selling more than 15lts of milk per day, (EADDP 2013) in order to make meaningful profit margin.

Due to the small land sizes, in Tigania East Sub-County, the animals are mostly kept under Zero and Semi-zero grazing systems, with low average milk production of less than 5lts per cow per day (SCLPO, 2015). There are a number of constraints facing the sector, which require to be investigated in order to come up with measures suitable for improving milk yield in this particular area.

Despite the important role the small-scale farmers play in dairy industry, milk production levels are lower than their potential. (Njoroge, 2017) This problem is experienced in Tigania East Sub-County which produces the lowest amount of milk in Meru County (MoLD, 2013), though it has the potential to produce more.

Smallholder dairy farming in Tigania East Sub-County is integrated with cash crops like coffee, tea, miraa and food crops like maize, beans and bananas. Napier grass (*Pennisetum purpureum*), crop residues, and especially from maize and beans are the most common source of livestock feeds. (SCLPO, 2014).

The climatic factors influenced by different ecological zones have an effect on milk production due to their varying potential to support pastures and fodder production (Wambugu *et al.*, 2011).

There is therefore, need to carry out research studies on those challenges facing the farmers in Tigania East Sub-County, in order specifically formulate better policy guidelines based on findings suitable for this particular area, for better milk productivity per cow per day.

1.2 Statement of the Problem

The smallholder dairy industry in Tigania East Sub-County has dismal performance as compared to other neighbouring Sub-Counties in Meru County. This has been mainly due to low milk productivity among the dairy animals there. For example, in 2013 the Sub-County produced 0.62 metric tons of milk with 3,045 dairy cattle as compared to Imenti central, which produced 26.1 metric tons per year with 51,322 dairy cattle population in the same County. The Sub-County has the lowest number of dairy cattle population and the lowest milk production among the eight Sub-Counties of Meru County, (MoLD, 2013). It is not self-sufficient in milk production and relies heavily from other neighbouring Sub- Counties. The average milk production is less than five litres per cow per day, (DLPO, 2010), which is below the national average level of ten litres per cow per day (Wambugu *et al.,* 2011).

Though the Sub-County has the potential to produce as much milk as other Sub-Counties in Meru County, the sector is faced with constraints leading to milk productivity. The aim of the study was therefore to establish the challenges facing the smallholder dairy farming in Tigania East Sub-County, which impact negative effect on milk productivity per individual dairy cow.

1.3 Purpose and objectives of the Study

1.3.1 Purpose of the study

The purpose of the study was to assess and analyse the challenges influencing milk productivity among the smallholder dairy farmers in Tigania East Sub-County in Meru County.

1.3.2 Specific Objectives

i. To assess how socio- economic factors contribute to the low milk production in the Tigania Sub-County, Meru County.
ii. To determine how the factors related to breeds and breeding methods affect milk production in Tigania East Sub- County, Meru County.

iii. To assess how management factors affect milk production in Tigania East Sub-County, Meru County.
iv. To establish how Agro- ecological factors affect milk production in Tigania East Sub County, Meru County.

1.3.3 Research questions.

The research study sought to answer the following questions.

i. How do socio-economic factors influence milk production in Tigania East Sub-County, Meru County?
ii. How do factors related to breeds and breeding methods affect milk production in Tigania East Sub-County, Meru County?
iii. How do dairy cattle management practices affect milk production in Tigania East Sub- County, Meru County?
iv. How do ecological factors affect milk production in Tigania East Sub-County, Meru County?

1.4 Justification of the Study

The study was undertaken to find out the factors contributing to the low milk productivity among the smallholder dairy farmers in Tigania East-Sub-County, by analyzing the following selected factors: Socio-economic, breeds and breeding strategies, general management, and agro-ecological influence on the dairy enterprise, with an aim of improving the sector. The Sub-County's smallholder dairy sector performs poorer than the other Sub-Counties in Meru County as per Ministry of MoLD Meru County data (2013). This is so despite the prevailing conducive environment for dairy production. This situation has persisted in this Sub-County for a longtime without any reasonable evidence of improvement, hence creating need and interest for this research and study. Improved milk productivity in the Sub-County can go a long way in achieving Millennium Development Goal (MDG) number one of eradication of extreme poverty and hunger. Due to the current decreasing land sizes caused by increasing human population, there is need to intensify dairy production to improve livelihoods among the smallholder dairy farmers in Tigania East Sub-County, through relevant research studies.

It is therefore important to carry out this study to find out the challenges the sector is facing in order to come up with good recommendation for improvement suitable for this Sub-County.

The stakeholders' in the sector can improve milk production levels among the affected smallholder dairy farmers can use findings from this study. Improved milk productivity among these farmers will lead to increased levels of income, improved food security, poverty alleviation and better standards of living.
Smallholder dairy farmers are also well placed to contribute towards the economic development of this country especially in a country where agriculture is the backbone of the economy, (Bidii, 2015).

The research findings can contribute to existing knowledge on dairy farming in general. The research findings will also give policy makers at National and County governments levels an opportunity to intervene in smallholder dairy production, as a commercial oriented sector which can address poverty levels among the farmers .(Atieno *et al*., 2008).

The findings will also fill the information gaps required by the extension agents and other stakeholders to improve dairy production among the targeted group through trainings and capacity building. Findings will also give guidelines on the training needs of the smallholder dairy farmers. Knowledge on factors influencing milk production Tigania East Sub-County will ensure development of appropriate intervention measures to benefit smallholder dairy cattle productivity. The information generated in this study will be useful in improving the dairy sector in line with Vision 2030.

The smallholder farmers will therefore, be the biggest beneficiaries from this study, once factors affecting this industry at their level are highlighted and remedial measures taken. By implementing the research findings and recommendations, Tigania East Sub-County can be a major milk producer in Meru County. More research in this field is required in

order to assist the National and County government's efforts to improve the dairy sector in general (Thorpe *et al* 2000).

1.5 Limitations of the Study

i. Suspicious respondents who were not willing to give certain information and hence required explanation to understand the essence of the interview.
ii. Female respondents not willing to part with some family information hence referring the researcher to their husbands.
iii. Absent responsible respondents who forced data collectors to come back for information.

1.6 Scope of the study

The study targeted the smallholder dairy farmers in Tigania East Sub County in Meru County with an aim of determining the factors that affect smallholder dairy cattle productivity.

The Sub-County was stratified into three regions using agro ecological zone one (AEZ 1), agro ecological zone two (AEZ 2) and agro ecological zone three (AEZ 3). Using a sample size calculation formula, a sample size of 156 was determined, upon an estimated population of 3,000 farmers. The study targeted the two most common grazing systems viz: Zero and Semi-Zero among the smallholder dairy farmers.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

Over 750 million people in the world practice dairy farming, majority being in the developing countries. The average global milk consumption rate ranges from 3.5 to 4.0 per cent. This shows that there is a ready market for milk and its products, and if the sector is well managed, it has the capacity to reduce poverty and improve food security in the developing countries, (FAO, 2010). The five leading milk producers in the world are India (20%), European Union (20%), United States (12%) and China (5%), (FAO, 2018).

There is a major opportunity for dairy farming in East Africa due to unmet demand for milk and its products especially in urban centers. There has been an increase of milk imports from outside East Africa since Kenya, which is the highest producer, does not have the capacity to fill the gap (Kurwijila *et al*., 2011).

Smallholder dairy farmers in Kenya produce the highest amount of marketed milk. Though they are the majority of producers, they are faced with myriad of challenges, which include: lack of technical knowledge, poor access to essential services, market accessibility, capital, and credit facilities (FAO, 2010).

Eastern African countries produce 68 percent of the continent's total milk output; Kenya, Ethiopia and Tanzania being the highest contributors. Due to the rising human population, urbanization, increase in average income levels, the sector is the fastest growing in agriculture (Bingi *et al.*, 2015). However, in East Africa, dairy productivity is low despite the potential and the prevailing favorable conditions, due to a number of challenges (Bingi *et al*., 2015) which include poor marketing channels, infrastructure, poor quality feeds, lack of credit facilities and socio-economic issues. For example, studies done in Embu County (Njiru *et al.*, 2015) found out that age, gender, distance to the market and herd size influence smallholder farmers' decision to join cooperative societies.

2.2 Dairy Farming in Kenya

Agriculture is a key player in the economic development in Kenya, providing food for the growing population, raw materials for industries and foreign exchange earnings (Nyanga *et al*., 2010). It contributes over 30 per cent of the Gross Domestic Product (GDP) and over 50 per cent of the foreign currency earnings (Muriuki *et al.*, 2004).

In Kenya, dairy cattle is usually milked twice per day and by hand. Milk production is low mainly because of low nutrition (Omore *et al*, 1998, Staal *et al*., 1998). The effect of low nutrition indicates a lactation curve that follows a logarithmic rather than a gamma function curve that characterizes milk production in temperate countries and farmers do not realize full milk potential in early lactation (Tanner *et al.*, 1998). Low nutrition is a constraint that impacts negatively on growth and viability of dairy farming in Kenya. Maintaining access to adequate quantity and quality of feed resource is crucial for milk production in dairy cattle (Njarui *et al*., 2011). Feeding is a management factor that can in one way or the other influence milk production.

Milk production studies conducted in Kenya show that dairy production is influenced by seasonality in feed availability and quality (Omore *et al*., 1998). The dairy sector has grown rapidly since its liberalization in 1992. This led to the development of informal milk trade, which deals with small-scale business, dealing in marketing of raw milk (Wambugu *et al*., 2011). Most consumers prefer and buy raw unprocessed milk because it is relatively cheaper. This preference is increasing in urban centres where processed milk sales were dominant before market liberalization (Omore *et al.*, 2000), which has led to increased demand for milk. This clearly shows that there is need to encourage farmers to improve milk productivity since there is readily available market for dairy products. With market liberalization, farmers have better chances of marketing their dairy products. (Omore *et al.*, 1998).

A high proportion of small scale farmers keep their animals under zero grazing. This type of farming system increases with decreasing land sizes especially in areas close to major urban centres. Grazing system is a type of cattle management method that can have some

influence on milk production. The most commonly planted fodder is Napier grass (*Pennisetum purpureum*) (Omore *et al*., 2000). Few farmers supplement natural feeds with commercial feeds like dairy meal, and milling by products such as bran and wheat Poland.

Kenya has the largest dairy industry in East Africa and there is great market potential within the region, for its milk and its products. Extra regional exports are still very significant in all the three countries, an indication of the great opportunity to increase production and processing. However, there is great need to motivate producers (Kurwijila *et al*., 2011) for higher milk production. However, dairy production in Kenya is faced with challenges that remain in place despite several efforts to tackle them.

2.2.1 Milk production trend in Kenya

There was milk production stagnation between 2002 -2004 due to shortage of rainfall, resulting to low pastures and fodder production (Muriuki *et al*., 2007). This clearly shows that it is important for farmers to start irrigation projects in order to have constant supply of natural pastures and stop being over reliant on rain fed agriculture, which is in many cases unpredictable and unreliable. Feeds fluctuations can also be checked through effective preservation methods especially during the wet seasons (Muriuki *et al*., 2007)

2.2.2 Milk production status in Meru County

Meru County has an estimated 180,000 head of dairy cattle with the smallholder dairy farmers dominating the sector. Milk production is low with 80 per cent of the farmers producing an average of 7 litres of milk per cow per day (Wafula *et al*., 2018). Dairy cattle population and milk production in metric tons per year across Meru sub-counties shows that Tigania East Sub-County has the lowest number of dairy animals and milk production among the other sub-counties in Meru County with 3,045 dairy cattle producing 0.62 metric tons of milk (per year); less than 5 litres of milk per cow per day (MoLD, 2013). Imenti South Sub-County has 40,000 dairy cattle with an average milk production of 2,100 litres of milk per cow per lactation period, which translates to 8 litres per cow per day. This is above the national average of 1,800 litres per cow per year

(Murithi *et al*., 2014). The average milk production in Naari area in Imenti North Sub-County is 7 litres of milk per cow per day (Muraya *et al.*, 2014). An overview survey carried out in Meru County shows that 60-70 percent of the dairy farmers produce an average of 5 litres of milk per cow per day. 20 to 30 percent produce 5 to 10 litres of milk per cow per day, and the elite commercial farmers comprising of 10 to 20 percent of farmers producing 10-18 litres of milk per cow per day (Wafula *et al*., 2018).

2.3 Socio-economic Factors

The social economic factors that have been found to influence dairy production include, level of education, membership to dairy production and marketing groups, income levels, age of the farmer, marital status, gender issues, resource availability, and cultural beliefs (Wambugu *et al*., 2011). Educated farmers are more likely to adopt new farming technologies and can make informed decisions based on individual research findings to network on dairy farming activities (Njarui *et al.,* 2011). Wealthy and knowledgeable farmers can afford better factors of production such as land, dairy cattle breeds, and extension services (Wambugu *et al.,* 2011).

Men generally make most of the decisions concerning dairy cattle, though women play direct role of taking care of the animals. Gitonga (2014) found out that in Kiambu females and males participate in nearly all activities in dairy farming. However, men are the heads of the family and they make the final decision especially on disposal of cattle and buying new ones. They also make decisions on income distributions including dairy farming.

A higher percentage of male-headed households had kept improved cows compared to their female counterparts. Female-headed households were more likely to have less information on new dairy technologies (Stall, 2001). Studies made in Bomet East Sub-County found out that there was male dominance in dairy farming (Cheruiyot *et al.,* 2017). In Imenti Sub-County, (Muriuki *et al.,* 2014) studies indicated that there was equal gender ownership of dairy farming and equal access to dairy benefits.

However, Kinyenje (2013) found out that there were more male farmers registered with Katheri Dairy Co-operative Society in Meru central than female farmers. Majority of farmers had primary level certificates as their highest level of education in Katheri Dairy Co-operative Society. However, research made in Embu and Igembe Sub-Counties in former Eastern province found out that education levels had no significant effect in milk productivity, (Mugambi *et al*., 2014), since farmers learnt and interacted with one another on dairy farming methods regardless of their education levels.

Studies made in Imenti Sub-County in Meru County (Muriuki *et al*., 2014), also found out that though majority of farmers had above secondary school level of education, they did not keep farm records, which was a necessary tool for improved milk productivity. However, farmer's knowledge on good animal husbandry practises, which required experience over time, had positive effect on milk productivity (Ndung'u 2014).

Different studies in various places have established that, as the farming household head becomes old, productivity declines (Mamo, 2013). However other studies have established that years of dairy farming experience is positively correlated to productivity, though studies made in Igembe South Sub-County in Meru County and Embu East Sub-County, Embu County (Mugambi *et al*.,2014) found out that there was no relationship between dairy farmers' age and dairy milk productivity.

There has been an increase in percentage of households keeping improved dairy breeds over the years in Kenya (Wambugu *et al.*, 2011). Male-headed households were higher compared to female-headed households. Households in higher potential areas keep more improved dairy breeds than in lower potential areas. In addition, high-income households keep more dairy cows than low-income households do (Wambugu *et al*., 2011).

Marketing and processing of milk plays a vital role in development and growth of dairy industry. There is market opportunity for milk and its products in Kenya due to population growth and improved income levels in rural and urban centres (Njarui *et al*., 2010).

Marketing of milk and its products in Kenya is dominated by informal sector, with the formal sector handling 14% of the total milk production (GOK. 2006). However, co-operatives and dairy self-help groups in the formal sector play an important role in collection, processing and marketing of milk and provision of quality milk to the consumers (MoLD, 2010).

Informal sector is classified into three major channels; direct sales by producers to neighbours, rural to urban sales through informal traders or brokers, rural to urban through farmers' organized groups (Ngigi, 2005). Formal sector players collect, process, and transport processed milk and its products to the consumers (MoLD. 2006). Marketing milk through formal sector gives security to farmers.

Before liberalization of milk marketing in 1992, Kenya Co-operative Creameries was the dominant player in formal milk marketing. Informal trade was minimal and unprocessed milk was limited mainly to farmers' neighbours (Muriuki, 2011).

There is strong competition between formal and informal milk marketing. Farmers prefer selling in the informal market due to preference to daily cash as opposed to formal sector, which pay at the end of the month (Ngigi, 2005).

In the formal sector farmers, have collective marketing channels, enjoy economies of scale, security, and offer farmer's monthly payments that enable them meet their obligations and give them a collective bargaining power for their products (Karanja, 2003).

There are institutions which include regulators, input suppliers, service providers, research and development organizations, farmers and the dairy co-operative groups and societies, Non- governmental organizations, Community based organizations and development partners (Muriuki, 2011) that have socio-economic impact on dairy production as a whole.

Most important institutions are:- The ministry of Livestock Development (MoLD), Kenya Dairy Board (KDB), Kenya Bureau of Standards(KEBS), Public Health department of the ministry of health, ministry of Trade (Weight and Measures), Kenya Police and County Governments department of livestock development is responsible for formulation and oversight of the dairy industry policy and legal framework (Kurwijila *et al*., 2011). These institutions have an impact on milk production in Kenya. Dairy self-help groups and Dairy cooperatives have contributed significantly to the development of smallholder milk marketing and provision of farm inputs at a relatively low cost due to economies of scale (Muriuki, 2011).

2.4 Breeds and Breeding Methods

The dairy herd in Kenya is mainly composed of exotic *Bos Taurus,* breeds; mainly Friesian, Ayrshire, Guernsey and Jersey as pure breeds and their crosses, which comprises of over 50 per cent of the total herd (Karanja, 2011). The dominance of *Bos taurus* breeds (78 per cent of the farms) over *Bos indicus* breeds (22% of the farms) indicate high priority to exotic breeds for high quantity milk production by smallholder farmers in the Kenya highlands (Muriuki, 2011). Dairy production is one of the leading enterprises in the livestock sub-sector and forms an important livelihood to most small-scale farmers (Wambugu *et al.*, 2011). These farmers meet this objective by keeping high quality dairy breeds (Bebe *et al.,* 2003). Studies made in Meru Central indicated that 55.2 per cent of farmers preferred Friesian breed over other breeds (Kinyenje, 2013). The type of dairy breed is associated with high milk yield as confirmed by studies done in Naari, Meru County, which showed that indigenous crosses had 23.7 per cent lower milk yield when compared to exotic breeds (Muraya *et al*.,2018). The most common breeds in Meru are Friesian followed by Ayrshire due to their milk production potential (Mugambi *et al.,* 2014). However, studies carried out in western Kenya (Lukuyu *et al*., 2019) indicate that Ayrshire breed is more popular than Friesian.

Generally, in Kenya, calving intervals are long, averaging 600 days (Odima, *et al*., 1994, Staal *et al*., 1998). Many farmers consider serving their dairy cows after milking for at least two hundred days, thus prolonging the calving interval (Odima *et al*., 1994). This

considerably reduces the total amount of milk a cow can produce during her lifespan. The cow's milk productivity and length of calving intervals are directly related (Tanner *et al*., 1998). Long calving interval and high calf mortality are serious constraints to dairy production (Gateau, *et al*., 1994). High calf mortality reduces the ability of farmers to select female replacements *(*Omore *et al*., 1997). Farmers frequently report incidences whereby their dairy cattle take 1-2 years before they come on heat for service (SCLPO, 2015). There are also cases of silent heat reported by the farmers to the extension agents (SCLPO, 2015).

Until 1987 there was a well-organized Artificial Insemination (AI) service-breeding programme in Kenya, subsidised by the government whereby farmers met less than 20% of the total cost. The programme was started in 1966 by the government through assistance from Swedish International Agency (SIDA) Ngigi, (2000). The programme contributed to the development of improved small-scale dairy cattle. It was used efficiently to upgrade local zebus during that time. There were established runs along roadside crushes (Karanja, 2011) where farmers took their animals for service. Due to budgetary problems in early 1980s, the project collapsed forcing farmers to revert to local bulls of unknown breeding value. This resulted to down grading the established dairy breeds, especially in smallholder herd leading to low milk productivity (Muriuki, 2011).

Private AI service providers started operating in 1993. However, private AI is, unreliable, and unaffordable to majority of the farmers. They charge between one thousand five hundred to three thousand shillings per insemination (SCVO, 2016). Repeats cases are equally charged, (SCVO, 2016), discouraging farmers, hence resulting to low quality bulls which lead to further downgrading of the existing dairy breeding stock. About 60 per cent of smallholder dairy farmers use local bulls resulting to genetically inferior breeds (Muia *et al*., 2011). However, studies carried out in Naari in Meru County indicated that artificial insemination was readily available and only 13 per cent of the farmers preferred bulls (Muraya *et al*., 2018).

Research done in semi-arid region of Eastern Kenya (Njarui *et al*., 2009) shows that there was poor breeding practices whereby majority of farmers used unproven bulls resulting in progeny of inferior quality. Between 21.7 per cent and 37.7 per cent, farmers had access to Artificial Insemination. Use of poor quality bulls and poor access to Artificial Insemination has negative long-term effect on herd genotype and use of natural methods lead to genetically inferior breeds, inbreeding depression and breeding diseases (Bebe *et al.*, 2003).

2.5 Dairy Cattle Management

Dairy production under small-scale farms is carried out on a few acres of land with pure or crossbred cows ranging from 1 to 5 animals. This is in close integration with food and cash crops, with 71% of the farmers keeping one to three cattle (Bebe *et al.,* 2003).

The following management systems are commonly used: - Zero- grazing system where the animals are completely confined in stalls. Feeds are directly brought to the animals in a cut and carry feeding method. Supplementary feeding is usually done during the milking session (Muia *et al.,* 2011; Ouma *et al*., 2014). It can also be described as the intensive dairy cattle rearing system. This system is mainly common in the Kenya highlands where population growth has led to reduction in household land sizes.

Semi-intensive or semi-zero is usually practiced where there is land availability in medium to high potential areas. In this system, zero grazing is combined with grazing outside the stalls. The animals are kept under the stalls in the morning and grazed outside in the afternoon (Muia *et al.,* 2011).

The third method is the extensive rearing management system where by dairy animals are grazed outside on pastures. This is practiced where land is not a limiting factor and it is common in Central and Rift valley areas in large-scale farms where farmers own large tracts of land (EADDP, 2013). This is a free range grazing system where more land and less labour is used per unit of output (Ouma *et al*., 2014). The animals graze on natural pasture on an expansive area. This is common in pastoral areas where there are common

grazing grounds and milk production is low. The most common cattle breed here is the zebu (Ouma *et al*., 2014). Milk production in Kenya is mainly based on forage, with minimum use of concentrates (Muriuki, 2007). It is also characterized by seasonality in production (Wambugu, *et al*., 2011).

Feeding is the most important constraint to achieving the targeted milk production. Due to heavy dependency on rain-fed forage and pastures production, and poor conservation methods of animal feeds to lessen seasonal fluctuations in milk production, there is a scarcity (GOK. 2010). Feeding of a dairy cow is important for milk production among other things. There is a positive relationship between quality of feeds and the performance of dairy cattle in terms of milk production (Kinyenje, 2013). Feeding contributes the highest level of the total cost in milk production. Dairy animals in Kenya are underfed resulting to low milk production (Muriki, 2011). If a cow is kept under zero-grazing, it completely depends on the farmer for her nutritional requirements. (GOK, 2010). Due to high population density in high potential areas, land for fodder and pasture production is limited and due to this reason, zero-grazing system is preferred.

Feeds can be divided into two categories, roughages and concentrates. Roughages are bulky feeds like Napier grass, maize stalks, leucaena spp, banana stems, sweet potato vines, and hay. Some feeds are low in protein content while others are high. For maximum milk, production roughages are supplemented with concentrates (GOK, 2010). There is poor knowledge on pastures, fodder production and conservation. Due to poor access to both public and private extension services, there is limited knowledge and skills on general animal husbandry.

Dairying was found to be challenging due to high cost of inputs and limited use of appropriate technologies, hence poor performance of the sector in general (Muia *et al*., 2011). The most common appropriate technology practiced in the study area includes silage making using polytubes and trenches. This has been a good method of preserving livestock feeds during the wet season when there is enough fodder crops especially Napier grass. However, this method is not widespread due to cost implications (SCLPO,

2015). Preservation of food crop residues like maize stalks, beans straws, and common grasses in form of hay is widely practiced. This is done immediately after harvesting crops in the months of May and June every year and preserved for use during the dry months of August and September, before the next rain season. Most dairy farmers have constructed hay barns for this purpose. Some farmers have motorised or manual chaff cutters to avoid feed wastage (SCLPO, 2015). However, dairy cattle feeding, in many cases, may not be sufficient for dairy animals (Njarui *et al.,* .2011), which can also be checked through effective preservation methods especially during the wet seasons.

Tick borne diseases like East Coast Fever and Anaplasmosis are prevalent, posing a major threat to dairy farming enterprise. There were 102 reported cases of East Coast Fever and 120 of Anaplasmosis in Tigania East in 2016 (SCVO, 2016). Vector-borne and infectious diseases are important but their incidences decreases with change from free range to zero-grazing systems because of lowered exposure to ticks (Gitau *et al.,* 1997). However, mortality rates do not vary with grazing system though a major constraint to dairy farming methods (Bebe *et al.,* 2003). Other diseases include intestinal worms, mastitis, pneumonia, and nutritional diseases like Downer Cow Syndrome and Milk fever. There were also reported cases of calf mortality caused by calf scouring due to poor management (SCVO, 2016). However, the impact of livestock diseases on milk production in the study area is not documented. Private and Government extension veterinarians and animal health assistants are the main livestock health providers. The role of the Government department of veterinary services is to provide routine vaccinations for major diseases like Foot and Mouth disease, Rabies, Lumpy Skin `disease, Black quarter and anthrax. P

2.6 Agro-Ecological Factors Influencing Milk Productivity

Environmental differences, within the agro-ecological or agro-regional zones that have influence on dairy cattle milk productivity. Holstein Friesian produces around 10 tons of milk per lactation in temperate countries, whereas in tropical countries it produces 3 to 4 tons due to mainly environmental and physiological stress (Tahir *et al*., 2013). Dairy cattle exposed to radiant heat produce less milk than those that are not, due to associated

stress. The agricultural potential in Kenya decreases with increasing AEZs. Lower agro-regional zones tend to have comparatively lower milk productivity per dairy cattle when other factors are held constant. However, this leads to decreased land sizes, number of dairy cattle per household, milk production per farm and increased use of land for other farm activities (Muia *et al*., 2011).

Milk production in Kenya also varies with different agro-regional zones. This is mainly due to their varying land carrying capacity, which depends on rainfall and soil fertility (Wambugu *et al.*, 2011).

Milk production in many parts of the country is weather dependant. Thus, milk production fluctuates with the rainfall patterns; characterized by low production during the dry season, and high production during the wet season, sometimes exceeding the market capacity. For example, Mirara *et al.*, (2013) reported that in the months of March and April 2010, there was milk glut due to over production, leading surplus to milk. Similarly, studies done by Mirara *et al*., (2013) in Muiga, showed that rainfall occurrence did not show any increase in milk production immediately. However, after one month, there was considerable rainfall influence on milk production due to availability of feeds in form of forages.

Milk productivity per cow per month between June 2009 and May 2010 varied, with the highest productivity in the Month of February 2010. The lowest productivity was in the dry month of September 2009 before the onset of October and November 2009 rains (Wambugu *et al*., 2011).

2.7 Conceptual Framework

The conceptual framework is a flow chart illustration showing the relation between independent variables and dependent variables. The independent variables comprises the target objectives which include the following factors:- social-economic, agro-ecological, breeds and breeding programs, levels of management within the grazing systems, which influence dairy cattle milk productivity in one way or the other. There are other intervening variables, which interact with independent variables such as: government policies, extension agents, cultural beliefs, climatic conditions, and alternative income generating activities in the flow chart. Dependent variables on the other hand include increased milk productivity per dairy animal, improved dairy farming methods and increased number of dairy cattle, which will lead to improved income and living standards. As shown in figure 1 below

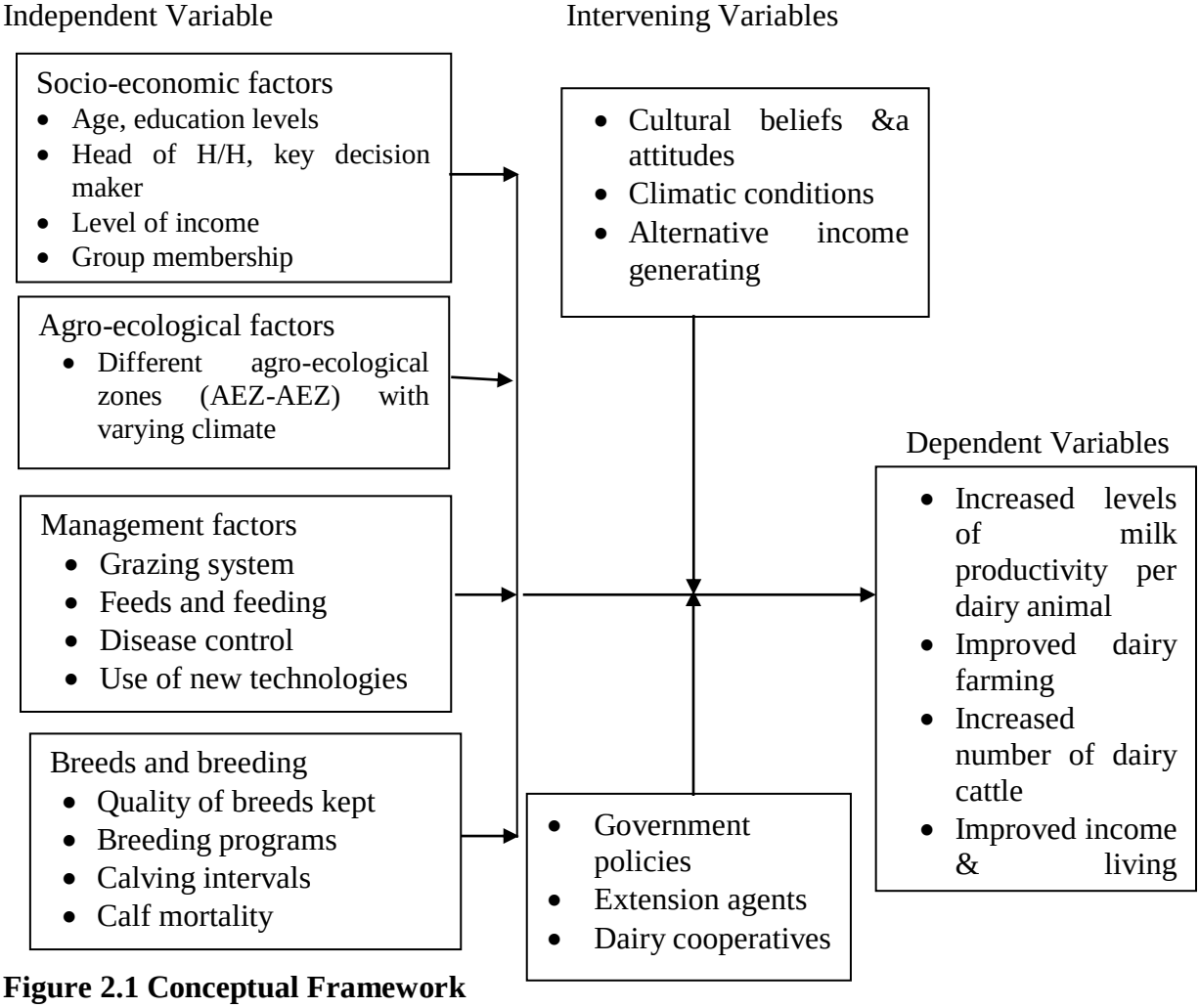

Figure 2.1 Conceptual Framework

CHAPTER THREE

3.0 METHODOLOGY

3.1. Study Area Description

The study was carried out in Tigania East Sub-County in Meru County, Kenya (figure 3.1). It borders Isiolo to the North, Igembe central to the East, Tigania West to the west and Tharaka District to the South. It is one of the ten Sub-Counties of Meru County. It covers an area of 723.4 km^2 and has a population of 157,746 people; Male 76,196, Female 81,050 (GoK 2009). It lies within latitudes 0^o and 40^o North, longitudes 37^o and 50^o East, with the south boundary lying along the Equator (GoK 2008-2012).

Generally, the Nyambene ridges form the main catchment area in the District, with two drainage areas, namely the Tana and Ewaso Nyiro River basins. There are four permanent Rivers within the District all originating from Nyambene hills, two drains into the Ewaso Nyiro while the other two join Tana River. The altitude ranges between 600 – 1,905 metres above sea level. It lies between Agro-ecological zone one and four (GoK 2008- 2012). Rainfall is bimodal with short rains in March – April while long rains between Octobers – December.

Rainfall ranges from 1250mm-2514mm on the eastern and southern slopes of Nyambene ridges to 380mm-1000mm annually on the low arid rangelands on the Northern part towards Isiolo County (GoK 2008-2012).

The climatic condition is determined by the topography of the Sub-County. The Nyambene highlands reduce the effect of high temperatures and the rate of evaporation. Temperatures range from 13.7^oC for high altitudes and 24.7^oC for low altitudes areas (GoK 2008-2012).

The physical features and the cool climatic conditions around Nyambene hills offer ideal conditions for dairy cattle farming. Rainfall is reliable especially in Agro-ecological zones 1, 2 and 3. (GoK (2010-2012).

The arable land covers 341.4km^2, forests 148 km^2 and the rangelands constitute 234 km^2. There are 5,240 managed farms comprising of 17,682 households (GoK (2010 -2012).

SITE MAP OF TIGANIA EAST SUB-COUNTY

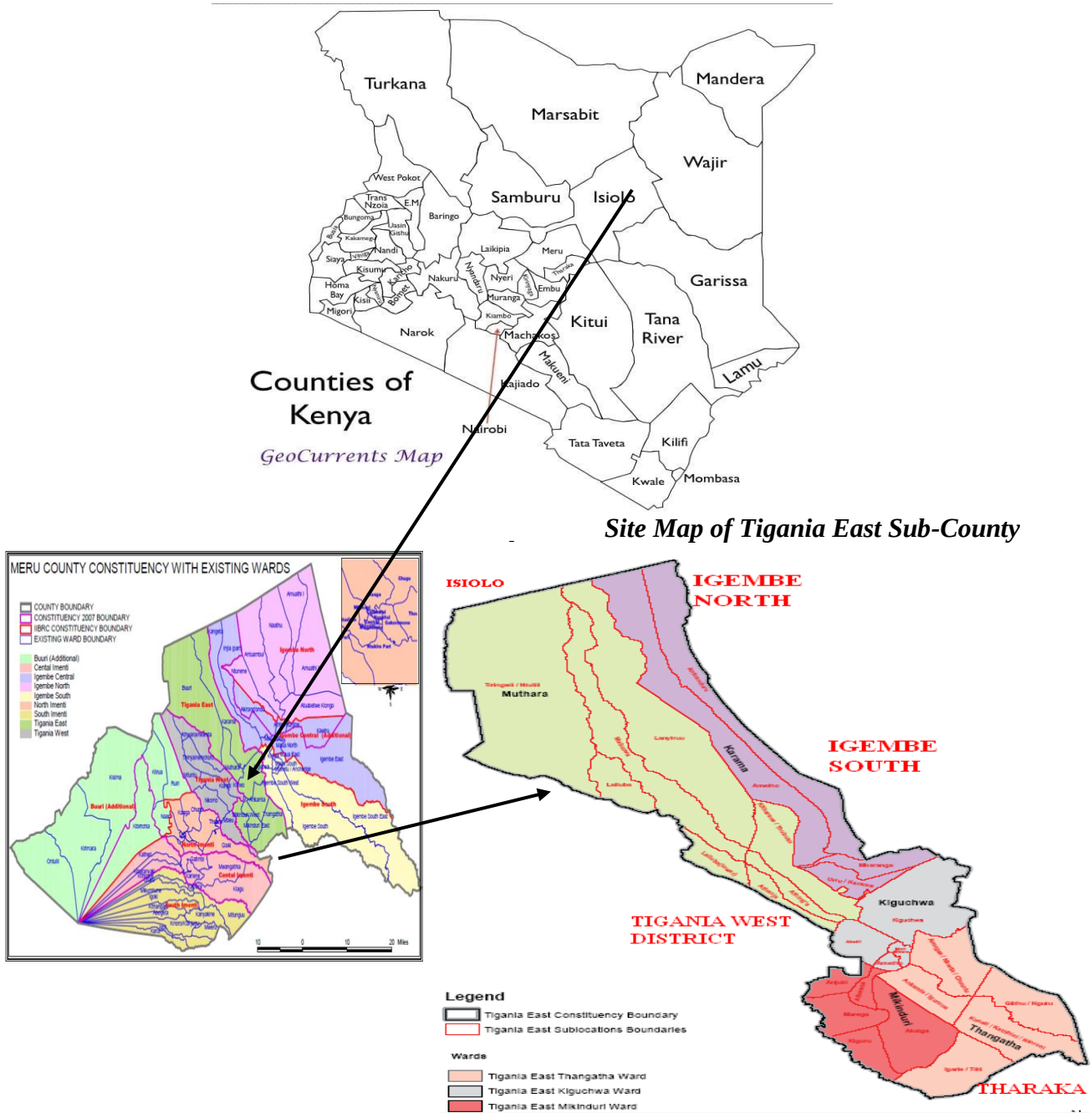

Figure 3.1 Maps of Kenya, Meru County and Tigania East Sub-County Site

3.2 Sample Size

Several methods were used to determine sample size. These included census for small population, using a sample size of similar studies, using published tables or using a formula to calculate sample size. This was also be influenced by a number of factors such as purpose of the study, population size, risk of selecting a sample that will give unreliable data, and the sampling error *(*Israel, 2012). The following was put into consideration:

3.2.1 The Level of Precision

The level of precision, also called sampling error is the range in which true value of the population is estimated, expressed in percentage e.g. (+ or - 10%).

3.2.2 The Confidence Level

Confidence level or risk level based on the idea that when a population is repeatedly sampled, the average value of the attribute obtained by those samples is equal to the population value.

This assumes the normal distribution where 95% of the sample values are within the two standard deviations (Israel, 2012). The sample obtained should represent the true value of the population with 95% confidence level.

3.2.3 Degree of Variability

Degree of variability in the attributes being measured refers to the distributions of attributes in a population. A heterogeneous population will require a larger sample size to obtain a given level of precision. A proportion of 50 per cent indicates greater variability than 20 per cent or 80 per cent; hence, a proportion of 50per cent (0.5) indicates maximum variability in a population. It gives a sample size larger than if the true variability of the attribute were used (Israel, 2012).

3.2.4 Sample Size Calculation

For this study, a formula was used to calculate the sample size. For a population that is large as in this case, the equation below was used to get a representative sample size (Israel, 1992)

$$N_0 = \frac{Z^2 pq}{e^2}$$

Where q = 1 - P

This is the same as;

$$SS = \frac{Z^2 P(1-P)}{M^2}$$

Where;

SS = Sample size

Z = Confidence level of 95% which is equal to 1.96 (area under normal curve). The Z value is obtained in statistical tables.

P = is the population attribute or proportion (expressed in decimal point). In this case i assumed:

P= 0.5 (50%) which gives maximum variability, since this would provide a larger sample size than when calculated using sample size of the mean (Israel, 2012).

M = sampling error or level of precision used to calculate differences among the strata. +or- 15% which is the level of precision desired (Muia *et al.*, 2011).

The obtained sample was multiplied by three to correct design effect and give a comparative analysis of the data (Muia *et al.*, 2011). To cater for recording mistake, farmers that could not be reached, non-response and interview bias it was increased by 20%. The sample size was rounded up to 156 smallholder dairy farmers which were divisible by the three agro-ecological zones (Muia *et al.*, 2011).There was an assumption that the farmers were evenly distributed within the Sub-County.

Calculation

$$SS = \frac{(1.96)^2 \, X \, 0.5(0.5) \, X \, 3}{0.15^2} \, X \, \frac{120}{100} \qquad = 155.8$$

155.8 is rounded up to 156 households.

SS -The sample size.

1.96- The area under normal curve representing 95% confidence level.

0.15 – 15% level of precision expressed in decimal points.

The sample was multiplied by three and increased by 20%.

The sample size was divided by the three strata in order to be distributed equally. Each stratum was allocated 52 smallholder dairy farmers and 26 per grazing system.

3.3.5. Sampling procedure

Purposive, stratified random selection procedure was used in the study area (Alvi, 2016). The sub-county was purposively selected based on its low milk production and low dairy cattle density, despite the favorable climatic conditions (MoLD, 2013). The study was also purposively restricted to three Agro-Ecological-Zones (AEZs):- AEZ1, AEZ2, AEZ3, because of their high concentration of dairy cattle under Zero and Semi-Zero grazing systems. The zones, which formed the strata, were used instead of the administrative boundaries.

The sample size of 156 smallholder dairy farmers was calculated using a formula (Israel, 1992). The population of dairy cattle in Tigania east sub-county is 3,045, kept by 1200 smallholder dairy farmers (MoLD, 2013). The sample size of 156 is above 10% of the target population as prescribed by Gay (1981), (Mugenda and Mugenda, 1999).

The study was confined to farmers who kept dairy cattle under Zero and Semi-zero management systems, and within the three AEZs. The zones were identified as follows, AEZ_1, (Tea-dairy zone), which is humid, AEZ_2, (Coffee-tea zone) which is sub-humid and AEZ_3 (Marginal-coffee zone) (Jaetzold *et al*., 1983).

The sample of 156 famers was equally divided among the three AEZs, where by each zone was represented by 52 farmers. To cater for grazing systems, the 52 farmers were further equally divided into two sub-groups; zero and semi-zero management systems. Therefore, each sub-group was allocated 26 farmers. A list of the target dairy farmers from each AEZ was compiled using private and government extension agents in the field, leaders of dairy self-help groups, co-operative societies and other relevant stakeholders. Through simple random procedure, the sample size was got from that list of respondents. AEZs were the focal points instead of administrative boundaries. All the three cut across the sub-county.

Table 3.1: Sampling frame for dairy farmers

AEZs (Strata)	**Target-population(Farmers keeping dairy cattle)**	**Sample size**	**Percentage ((%)**
1	380	52	35.5
2	350	52	32.7
3	340	52	31.8
Total	**1070**	**156**	**100**
	1070	**156**	**14.6% of the target population**

Source: Author 2018

3.3.6 Sampling Frame and Sample Summary

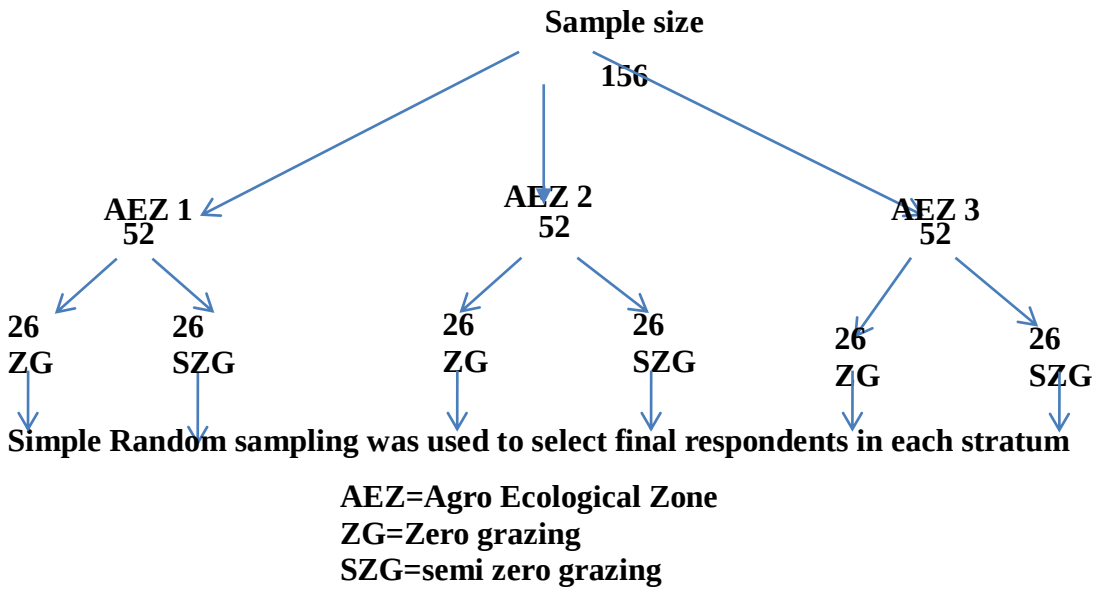

Figure 1.1 Sampling Frame Sample Summary

3.4 Research Design

The survey was carried out using interview schedule (structured questionnaires) in order to gather relevant information and generate data for the research objectives. The respondents were interviewed directly in their normal life situations on their farms using the interview schedule as a guide. Qualitative and quantitative data was generated for the research objectives.

3.5 Data collection

Data was collected from 156 smallholder dairy farmers within the sub-county and across the targeted agro-ecological zones using interview schedule (questionnaire). The data was collected from May to June 2014. The interview schedule was pre-tested and necessary amendments made before data collection. The information collected were in general household, farm characteristics, availability of livestock feed, production systems, disease incidences, infrastructure, market channels, adoption of appropriate technologies, environmental factors, animal management practises, breeds and breeding methods.

During the survey, data was collected from the household heads. There was also informal discussion and observations to verify the data. Secondary information on problems and challenges facing smallholder dairy cattle production and opportunities for improvement were obtained from livestock extension workers, prominent dairy farmers, chairpersons and management staff of dairy self-help groups, co-operatives and owners of milk selling outlets.

3.6 Data analysis

Data collected was coded and entered into excel spreadsheet to check for errors. It was then subjected to analysis of cross- tabulation, frequencies, mean, standard deviations, using Wald Chi= square and Statistic Package for Social Science version 21. The demographic information was analysed and presented using percentages, mean and standard deviation. In order to determine how the independent variables were affecting the levels of milk production, different analyses were carried out depending on the objective.

CHAPTER FOUR

4.0 RESULTS

4.1 Demographic characteristics

Table 4.1.1 depict gender, marital status, education levels and household characteristics of the smallholder farmers in Tigania East Sub-county. Majority of the farmers were males at 87.2 percent while females were 12.8 percent. AEZ 1 had highest percentage of males (96%) as compared to the other zones. The data also showed that about 86 percent were married, the rest were either unmarried single (about 3%) or divorced (about 1%). About 6 percent, 37 percent, 30 percent and 27 percent of the total population had below primary, primary, secondary and tertiary level of education, respectively. This showed that the literacy levels were low with only 37 percent attaining secondary school level. The study also showed that the size of the household was 5 members with AEZ1, AEZ2 and AEZ3 having a mean of 5, 5 and 4, members respectively. The mean age of the household heads were 45.5, 45 and 47 years for AEZ1, AEZ2 and AEZ3 respectively.

Table 4.1.1: Gender, marital status, education levels and household characteristics of smallholder farmers in Tigania East Sub-County

		AEZ1	AEZ2	AEZ3	Mean	St. dev.
Gender	**Male**	96.00%	85.70%	79.60%	87.20%	0.29
Marital status	**Married**	98.00%	85.70%	81.60%	88.50%	0.035
	Single	0.00%	2.00%	6.10%	2.70%	0.789
	Divorced	0.00%	0.00%	2.00%	0.70%	1.912
	Widowed	2.00%	12.20%	6.10%	6.80%	0.752
Highest education level	**Below primary**	8.00%	6.10%	4.10%	6.10%	1.266
	Primary level	52.00%	28.60%	28.60%	36.50%	0.822
	Secondary	28.00%	28.60%	34.70%	30.40%	0.758
	Tertiary	12.00%	36.70%	32.70%	27.00%	0.822
Size of house hold(Mean)		5	4.63	4.44	4.69	1.548
Age of household head (mean)		45.46	45.2	47.1	45.92	12.358
Sample size		**50**	**49**	**49**	**148**	

Source: Author2018.

The income levels, its major sources and number of dairy animals are shown in table 4.1.2. Out of the 148 farmers, representing 39.9 percent were earning Kenya shillings (Ksh.) 10,001-20,000 followed by those earning Ksh. 0-10,000 and 20,001-30,000 both representing 18.2 percent. Those earning Ksh. 30,001-40,000 represented 15.5 percent of the farmers and lastly those earning above Ksh. 40,000 being the least with 8.1 percent. A low number (27%) of farmers was practicing dairy farming as major source of income with AEZ1, AEZ2 and AEZ3 having 36.7 percent, 27 percent and 20.4 percent respectively while the rest had other activities such as cash crop, food crop, *miraa* farming as their main source of income. The study further found that 86.5 percent practiced subsistence type of farming as opposed to farming as a business with AEZ3 leading at 89.8 percent followed by AEZ2 at 87.85 percent and lastly AEZ1 at 82 percent whereby they grow crops like maize, beans and peas. Those who practiced *miraa* farming were 67.6 percent while those who grow other cash crop were 31.8 percent where they grew tea and coffee. Results showed that farmers with 1-2 dairy cattle were 78.4 percent, whereby those from AEZ1 were the majority at 87.8 percent followed by AEZ2 at 84 percent and then AEZ3 at 63.3 percent.

Table 4.1.2: Income levels, its major sources and number of dairy animals in smallholder farms in Tigania East Sub-County

		AEZ1	AEZ2	AEZ3	Mean	St. dev.
Income levels	**0-10000**	16.00%	14.30%	24.50%	18.20%	0.875
	10001-20000	42.00%	38.80%	38.80%	39.90%	0.633
	20001-30000	26.00%	12.20%	16.30%	18.20%	0.825
	30001-40000	8.00%	32.70%	6.10%	15.50%	0.875
	Above 40000	8.00%	2.00%	14.30%	8.10%	1.352
Major source of income	**Dairy farming**	36.70	27.00	20.40	27.00	0.436
	Other	63.30%	79.60%	76.00%	73.00%	0.456
Other farming activities	**Subsistence**	82.00%	87.80%	89.80%	86.50%	0.135
	Cash crop	42.00%	34.70%	18.40%	31.80%	0.821
	Miraa farming	54.00%	65.30%	38.80%	52.70%	0.568
Number of dairy cattle in the farm	**1 – 2**	87.80%	84.00%	63.30%	78.40%	0.356
	3 – 5	6.10%	16.00%	28.60%	16.90%	0.562
	Above 5	0.00%	6.10%	8.20%	4.70%	0.699
Sample size		**50**	**49**	**49**	**148**	

Source: Author2018.

Table 4.1.3 shows the key decision makers of the farm for different activities as well as the farm experience of smallholder farmers in Tigania East Sub County. Men in the study area generally control most of the major resources like land, cattle, family income, dairy farming and yet on the ground the bulk of dairy activities like feeding and milking were observed to be in the hands of women. They are also the key decision makers on most of the farm activities such income, management of the farm. Farmers' experience in dairy farming had a cumulative mean of 11.8 years and a standard deviation of 8.6. In terms of experience in dairy farming, those with the least number of years were 4.0 percent and the maximum number of experience was 40 years representing only 2.7 percent.

Table 4.1.3: Decision making and farmer experience of smallholder farmers in Tigania East Sub-County

		AEZ1	AEZ2	AEZ3	Mean	St. dev.
Key decision maker in the household	**Female**	2.00%	20.40%	16.30%	12.80%	0.382
	Male	98.00%	79.60%	83.70%	87.20%	0.29
Decision maker on dairy farming matters	**Man**	94.00%	63.30%	55.10%	70.90%	0.482
	Woman	6.00%	36.70%	44.90%	29.10%	0.43
Decision maker in cattle management	**Woman**	6.00%	24.50%	42.90%	24.30%	1.026
	Man	80.00%	63.30%	44.90%	62.80%	0.359
	Both	14.00%	12.20%	12.20%	12.80%	1.234
Decision maker on income from dairy farming	**Woman**	12.00%	22.40%	36.70%	23.60%	1.112
	Man	36.00%	49.00%	12.20%	32.40%	1.235
	Both	52.00%	28.60%	51.00%	43.90%	0.823
Experience in dairy farming (Mean)		13.45	12.39	9.68	11.84	8.615
Sample size		**50**	**49**	**49**	**148**	

Source: Author 2018

Key;

AEZ – Agro-Ecological Zone

St. Dev. – Standard Deviation

4.2 Socio-economic factors affecting the levels of production.

Wald log Chi-square linear analysis was developed to determine the relationship between the socio-economic factors and the dependent variable (Table 4.2). The analysis predicted the socio-economic variables fairly well at 89.9%. The small p-value (< .05) for the independent socio-economic variables in table 4.2 below implied that the five effects in the model were important for predicting their association with milk production levels. The tests for parameters suggest that each of those five effects in the model was significant at less than 0.05 significant level. The statistically significant variables using the significance levels were therefore the education levels, the income levels of the family, the decision maker on dairy farming, the major farming activity involved and the experience in dairy farming with 0.002, 0.046, 0.03, 0.045 and 0.003 p-values respectively.

Further, results showed that only age was negative with a value of -0.04 using the "β" factor reporting. Therefore, a unit increase in the age of the household head above the average, would lead to decrease in the levels of milk production by 0.04. The mean age for the farmers keeping dairy cattle was 46 years. A number of farmers above that age had declining interest in dairy farming. The following variables were not significant: size of the family, gender and marital status, number of cattle kept by the farmer, decision maker on the general family management and the decision maker on the family's income whose p-value were above 0.05. These variables had their coefficients of determination (β) values less than 0.1 probability of increasing milk production. The "β" factors for these results were 0.065, 0.007, 0.008, 0.091, 0.076 and 0.069 respectively. Further an increase in the levels of education, income and experience in dairy farming will lead to an increase of the levels of milk production by 0.59, 0.449 and 0.46 log odds respectively. Change of decision maker on dairy farming, farm management and expenditure in dairy farming on family income as well as change of subsistence farming activities involved by the farmer would affect the probability of increased levels of milk production with their exp (β) above 0.1. Further, the odds ratio indicated that gender, age and the marital status had the least probability of increasing milk production since their exp (β) values were less than 1.

The Wald log linear chi-square test results confirmed the output for the 'β' values as seen in table 4.2 above. The statistically significant results showed that education levels, the family's income levels, the decision maker on dairy farming activities and the subsistence farming activity practiced by the farmers and the experience gained in dairy farming had an association with the levels of milk production by 1.2, 0.589, 0.958, 1.75 and 0.88 values respectively. Whereas age of the dairy caretaker, size of the family, gender, marital status, number of dairy cattle kept, decision maker on farm management and the decision maker on the income of the family produced high Wald log linear chi-square values of 8.47, 5.63, 2.87, 3.87, 11.2, 2.89 and 8.42 respectively; indicating that the relationship is not significant.

Table 4.2: Socio-economic factors contributing to milk production in the three AEZ's, within Tigania East sub-County.

	B	**S.E.**	**Wald Chi-square**	**Sig.(p-value)**	**Exp (β)**
House hold size	0.065	0.163	5.63	0.688	1.067
Gender	0.007	1.560	2.87	0.920	0.170
Age	-0.040	0.028	8.47	0.151	0.961
Marital	0.008	0.362	3.87	0.473	0.297
Education level	0.590	0.348	1.2	**0.002**	1.347
Income level	0.449	0.245	0.589	**0.046**	1.567
Decision on dairy	0.247	0.824	0.958	**0.030**	3.480
Subsistence activities	0.142	1.067	1.75	**0.045**	8.512
Experience in dairy	0.460	0.034	0.88	**0.003**	1.039
Number cattle	0.091	0.433	11.2	0.833	1.095
Management decision	0.476	0.334	2.89	0.154	1.610
Decision on income	0.369	0.241	8.42	0.125	1.447
Constant	3.147	2.299	0.24	0.171	0.043

Source: Author 2018.
Key:
β beta coefficient
S.E. – Standard Error
Exp (β) – Exponential β. **Significant factors are highlighted.**

4.3 Breeds and breeding on milk production

The Wald log linear analysis showed that 79% of the variability can be explained by breeds and breeding variables in the model (Table 4.3). The equation was statistically significant for A.I., type of breed used, breeding service, and quality of breeding bull used, since their p-values ($p<0.05$) were, 0.02, 0.043, 0.001, 0.42. respectively, showing positive association with milk production. Further, the data showed that prolonged calving intervals and inbreeding did not influence milk production significantly with p-values of 0.885 and 0.510 respectively. A unit increase in adoption or usage of artificial insemination (AI) technology would increase the log odds of milk production by 0.812. A unit increase in the type of breed selected would increase the log odds of milk production levels by 0.212 whereas the breeding service increases the log odds of the milk production levels by 0.716. As well, a unit increase in the quality of breed selected for dairy milk would increase the log odds of milk production by 0.391. Use of bulls and prolonged length of calving inversely affect the milk production by 0.106 and 0.201 respectively. The items statistically significant with low Wald coefficients were the use of AI, the type of breed used, the breeding service and the quality of bull of 1.22, 0.222, 1.608 and 0.003 respectively, while inbreeding and prolonged length of calving had negative impact on milk production with 5.292 and 2.9 Wald values respectively. Results showed that the odds ratios of the usage of AI, breed type, breeding service and the quality of the breed had a lower probability of the variables affecting the milk production since their Exp (β) were less than 1 whereas the inbreeding and prolonged length of calving had their odds ratio with values above 1.

Table 4.3: Breeds and breeding factors affecting milk production in 3 AEZ's of Tigania East Sub-County.

	B	S.E.	Wald(Chi-square)	Sig(p-value)	Exp(β)
Usage of AI	0.812	0.523	1.22	**0.02**	0.745
Breed quality	0.212	0.118	0.222	**0.043**	0.809
Breeding strategy	0.716	0.504	1.608	**0.001**	0.180
Quality of bull	0.391	0.467	0.003	**0.042**	1.479
Inbreeding	-0.106	0.437	5.292	0.510	2.734
Prolonged length of calving	-0.201	0.101	2.90	0.885	1.597
Constant	0.267	1.457	0.034	0.854	1.307

Source: Author, 2018.

Key:

β beta coefficient

S.E. – Standard Error

Exp (β) – Exponential β

Significant factors are highlighted in the table.

4.4 Effect of feeds and feeding as a management factor on milk production

The Wald Chi-square analysis showed that feeds and feeding variables accounted for 74.3% of the variability in milk production in the model (Table 4.4). The equation was statistically significant since the p-value was 0.022 with a standard error of 0.852. All the variables showed statistically significant positive association with milk production. Use of supplement had the highest value of influence of 3.12 B odds ratio value on milk production and significance p-value of 0.005. The quality of feeds had zero coefficient of relationship with the milk production and a significance level of 0.008, while knowledge and acreage under fodder had 0.54 and 1.492 and significance p-value of 0.025 and 0.010 respectively. The Wald Chi- Square statistics showed that all the variables were good predictors of the milk production since their figures were all below 2.0.

Table 4.4: Feed and feeding factors affecting milk production in AEZ1, AEZ2, & AEZ3.of Tigania East Sub-County

	B	S.E.	Wald(Chi-square)	Df	Sig.(p-value)	Exp(B)
Quality of feeds	0.000	0.254	0.008	1	**0.01**	1.000
Knowledge	0.540	0.455	1.411	1	**0.025**	1.716
Area under fodder	1.492	0.579	0.637	1	**0.01**	4.447
Supplement use	3.118	1.122	1.730	1	**0.005**	2.610
Constant	-4.416	1.252	12.443	1	0.000	0.012

Source: Author 2018.

Significant factors are highlighted in the table.

4.5 Establishing the effect of management on milk production

Management factors such as the grazing systems used by the farmers, the use of extension services, whether the farmers kept records, the type of technology used and the level of management were analyzed using the Wald Chi-square to determine their impact on the milk production and the results given in table 4.5 below. The Wald Chi-square analysis explained 80% of the variability due to management variables used in the model. The equation was statistically significant since the p-value was 0.003 with a standard error of 0.592.

The coefficients from the 'B' column were all positive with the grazing system, the extension, records keeping, chaff technology and level of management having 0.787, 0.817, 1.578, 0.006 and 1.63 respectively and hence had direct relationship with the milk production. Results showed that use of chaff technology had the least relationship with the milk production having a coefficient factor of 0.006. In addition, the significance value was 0.575, which was not statistically significant in the model. The other predictors had significance values less than or equal to 0.05 hence being statistically significant. The Wald Chi-Square statistic values were all below 2 except for the use of chaff technology which had 4.314 implying that they were statistically significant and that the four predictors highly affected the depended variable, milk production.

Table 4.5: Management factors affecting to milk production in AEZ1, AEZ2 & AEZ3 of Tigania East Sub-County

Variables in the Equation					
Stem Item	B	S.E.	Wald(Chi-square)	Sig.(p-value)	Exp(B)
Grazing system	0.787	0.457	1.958	**0.005**	0.455
Extension	0.817	0.578	1.999	**0.047**	2.263
Records keeping	1.578	1.670	0.892	**0.005**	4.843
Use of Chaff Cutter	0.006	0.492	4.314	0.575	0.759
Level of management	1.630	0.617	0.974	**0.002**	0.196
Constant	3.178	2.200	2.086	0.149	23.997

Source: Author, 2018.

Significant factors are highlighted in the table.

4.6 Environmental and Ecological factors affecting milk productivity in Tigania East Sub-County

The analysis of the environmental and ecological factors was evaluated in relation to the levels of production using ANOVA analysis method. As shown in Table 4.6 below.

Table 4.6: Anova Table

Source of Variation	**SS**	**Df**	**Ms**	**F**	**p-value**	**F-CRIT**
Between zones	0.103	0.0	20.05	0.6	0.58	5.1
Within zones	0.52	0.0	60.08	0.2	0.58	0.0
Total	**0.62**	**0.0**	**80.13**	**0.8**	**1.06**	**5.1**

Source: Author. 2018.

The effect of Agro-Ecological Zones on milk productivity within the zones was insignificant as shown by p-value of 0.58, using ANOVA method of analysis. The respondents whose production per cow per day was below 3 litres were 44.6%, between

3-5 litres were 20.3%, 5.1-10 litres were 31.1% and above 10 litres were 4.1%. AEZ3 was leading at 74.2% in production of 'below 3 litres' per cow followed by AEZ2 at 19.7% then AEZ1 at 6.1%. High percentage of milk production of 3-5 litres was found in AEZ3 with 73.3%, while AEZ 1 and AEZ2 had 20.0% and 6.7% respectively. In the production of 5.1-10 litres category, the AEZ1 was leading at 58.7% followed by AEZ2 at 37% and then AEZ3 at 4.3%. Those whose one cow production was 'above 10 litres were majority from AEZ1at 66.7% then AEZ2 at 33.3% with no AEZ3 farmer having their cow produce the above 10 litres, in table 4.7 below,

Table 4.8 depicts that milk production was experienced in the ecological zones with AEZ3 leading at 40.2% followed by AEZ2 at 38.4% then AEZ1 was at 21.4%. AEZ1 was leading in milk production with 72.2% followed by AEZ2 with 16.7% then lastly the AEZ3 with 11.1%

Table 4.7: Milk Production percentages per AEZs within Tigania East Sub-County

	Milk production levels per AEZ				
AEZ	**Below 3 litres**	**3-5 litres**	**5-10 litres**	**Above 10 litres**	**Number of farmers**
1	6.10 %	20.00%	58.70 %	66.70 %	52
2	19.70 %	6.70 %	37.00%	33.30 %	52
3	74.20%	73.30%	4.30%	0.00%	52
Total	**100%**	**100%**	**100%**	**100%**	**156**

Source: Author, 2018.

Table 4.8: Cross-tabulation of production levels percentage within AEZs. of Tigania East Sub-County

Zone	**Low %**	**High %**
1	21.40%	72.20 %
2	38.40%	16.70%
3	40.20%	11.10%
Total	**100%**	**100%**

Source: Author, 2018.

CHAPTER FIVE

5.0 DISCUSSION

The study indicated that men, who were the majority of the farmers, were also in control of the smallholder dairy farming as the major decision makers. Men in the study area generally control most of the major resources like land, cattle, family income, dairy farming and yet on the ground the bulk of dairy activities like feeding and milking were observed to be in the hands of women. In Tigania East Sub-County, gender equality was lacking as far as smallholder dairy activities were concerned with men taking 87% of the farming decisions hence discouraging women who carried out the major farming activities. This was contrary to Kamau (2013) who found out high milk production was recorded in Mirangine, Nakuru County where both gender was involved in the actual practice and decision making on the dairy farming as a major economic activity. Mwangi (2011) also noted that though women perform most of the activities associated with milk production, they are less involved in decision-making process and are less likely to receive any income from dairy proceedings hence putting less effort towards its improvement. In Imenti South Sub-County, Meru County, where dairy farmers produce on average 21,000 litres of milk per cow per year, which is above the national 18,000 litres per cow per year, there is equal gender representation both in resource management and access to dairy management decisions, (Murithi *et al.*, 2014). In Naari ward of Meru North Sub-County where the average milk productivity is 6.0litres of milk per cow per day, 52.5 per cent of farmers directly involved in dairy farming are women (Muraya *et al*., 2018). However, involvement of Women in Tigania East Sub-County in dairy management is lacking and they can improve milk productivity if there input is encouraged and recognized.

The study showed that education levels had significant effect on milk production in Tigania East Sub- County. On average, educated farmers produced higher levels of milk than the less educated farmers. Kamau (2013), also found out that there was higher milk production in Mirangine sub County than in Mauche, since Mirangine farmers were more learned, exposed and innovative. Similarly, Njarui *et al* (2009) found out that education level of the household head could determine the adoption of improved technologies,

making informed decisions and applying technical advice more correctly. Wambugu *et al.*, (2011) also found that the farmers who were educated and had high levels of income were able to take good care of the dairy cattle through proper feeding, use of AI, buying supplements among others hence had high levels of production. Contrary to that, Kazanga (2012), established that the levels of milk production are not affected by levels of education provided that the farmer received proper trainings on the management of the dairy cattle, indicating that formal education is not necessarily the driver to increased milk production.

The study also indicated that there was a decline in milk production among the aged farmers. The average age of farmers in dairy production was 46years. Those farmers above 50 years were few with lower amount of milk production as compared to the younger farmers. Majority of the farmers were married indicating that unmarried youth were taking a low profile in smallholder dairy farming because land was under the control of their parents. In the USA, Bragg & Dalton (2004) indicated that older farmers were more likely to quit dairying. Kaaya *et al* (2005) also indicated age as negatively associated with use of AI in central Uganda. The finding was in agreement with Bidii (2015) who found that farmers with the age group of 55 and above in Cherang'any Sub County produced low milk. Studies made in Igembe, Meru County and Embu County found that age and experience of the farmer had no significant effect on milk productivity (Mugambi et al. 2014), contrary to the study findings.

Apart from dairy farming, the farmers grow food crops like maize, bananas, beans and peas and cash crops such as coffee, tea, macadamia, miraa (khat) as a form of diversification to spread risks and uncertainties in farming. This, however, increased competition for land as a factor of production with negative effect on dairy production.

According to the study subsistence, farming had a significant effect on stallholder dairy farming. Generally, in Tigania East Sub-County, farmers practiced subsistence type of farming as opposed to commercial farming. Majority of farmers, as per the findings, considered dairy farming as a minor source of income and hence given low priority in

resource allocation, thus affecting milk production. The low investment in dairy farming, resulted to low milk productivity wish cater for family needs with little surplus for sale. This is in agreement with Kamau (2013) who found out that higher yields of milk production are likely to be experienced by the farmers who consider dairy farming as a main economic activity.

Family income levels were found to have a significant effect on milk production in the study area. Farmers with high income levels had higher milk production than those in lower bracket because they could afford better factors of production like land, skilled and non-skilled labour and other resources which contribute positively to milk production. Generally, on-farm income levels are low in the area, consequently, contributing to the low milk production. This was in agreement with Wambugu *et al* (2011) who found out that high income households afford more improved dairy cattle breeds for more milk production.

Dairy farming experience was significant in dairy cattle milk production in the study area. The more experienced the farmer was, the higher the amount of milk produced. These farmers were better equipped in management skills like feeding, housing, breeding and disease control methods. Njarui *et al.,* (2009) also found out that farming experience empowers farmers on how to deal with risks and uncertainties.

The type of breeding service had a positive effect on milk production. These were either A.I. or use of bulls. There was positive relationship between adoption of A.I. technology and milk productivity. Those who practiced AI had better dairy cattle breeds and consequently higher milk production than those who did not. 41 percent of farmers in Tigania East Sub-County practiced A.I. with an average milk production of less than 5lts per cow per day as compared to Meru central (Kinyenje, 2013) with 97 percent A.I. adoption and an average milk production of 6 to10lts per cow per day. Majority of farmers in the study area used bulls whose dairy genetic value is unknown (unproven) for service with long- term negative effects on milk production.

Bebe *et al.,* (2003) indicated that use of unproven (unknown genetic value) bulls and limited use of A.I. Services have unfavorable long-term effects on productivity due to degradation of the herd genotype. Those bulls used for breeding do not undergo any professional selection procedure for breeding and the owners kept them as long as they wished, consequently, being given an opportunity to interbreed with close relatives, which can result to inbreeding in the long run and further lowering the quality of the existing breeds thus resulting to low milk production. Bebe *et al*., (2003) noted that in the Central Kenya highlands, very few farmers owned bulls. Those farmers breed their cows to bulls of unknown genetic value, which are self-bred or kept by their neighbors. Since few bulls were used in the area, there is an increased likelihood of inbreeding. Amunda, (2012) also noted that use of bulls of unknown genetic material may have unfavorable long-term effects on productivity through downgrading of the existing breeds leading to depression in milk production. Generally, the quality of dairy breeds kept in Tigania East Sub-County was poor as compared to the other regions where milk production was high. The most common dairy breeds are crosses between the exotic and the local cattle. The use of bulls remained the major breeding method in Tigania East Sub-County, which eventually led to poor breeds with low milk productivity. The unreliability of A.I. in terms of low conception rate, low semen quality, high cost and poor access encouraged the farmers to use bulls as an alternative. The farmers also experienced calf mortality, infertility and low conception rates due to poor nutrition, poor heat detection, silent heat, and poor insemination timing.

Production of milk is highly influenced by low calving rates, late age at first calving and long calving intervals, which are associated to low levels of nutrition and management (Ngongoni *et al*., 2006). Calving interval in Tigania East took an average of two years as opposed to recommended one year. Kinyenje (2013) found out that in Katheri-Meru central where milk production was high, majority of dairy cattle took one year to calf down, which translated to extended milk production. Several factors including diseases, genetics, climate and nutrition may influence estrus cycle, conception and calving rate. However, of these, inadequate level of nutrition is undoubtedly the most likely cause of low fertility in cattle within the tropics (Ngongoni *et al*., 2006).

Feeds and feeding management methods used by a farmer had significant effect on milk production. This may be attributed to the method of grazing, the availability of the feed and the season. Feeds and feeding methods was found to have direct influence on milk production in agreement with studies by Amunda, (2012) and Kashongwe *et al.,* (2017) who found out that dairy cattle feeding interventions increased milk production by 20 percent. It is acknowledged that feed is the most limiting factor in milk production. The main source of feeds in the three AEZs was natural pastures, fodder crops, and crop residues. However, the challenge of fodder and natural pastures not being enough during the dry spell was a major problem as reported by Njarui *et al.*, (2011). A big number of farmers supplemented the feeds though with a low rates of concentrate in kg/cow. This ranged between 1to4 Kg per cow per day during the milking session. (MoLD, 2015). Unless supplemented with a protein concentrate, cattle on natural pasture lose body weight thus cyclic ovarian activity ceasing (Ngongoni *et al*., 2006), hence affecting the rate of reproduction. Napier grass was the widely preferred type of grass grown by the farmers (Omore *et al.,* 2000).

The feeds were not enough whereas the quality of feeds was compromised with a low number of farmers preserving livestock feeds in constructed barns that were raised above the ground. Further, the study found that in most cases the preserved feeds were not well covered and therefore prone to being spoilt during rainy season and degradation through sun light radiation during the dry season. Ngongoni *et al*., (2006) noted that good quality forage and improved pasture provides sufficient nutrients for maintenance and production of approximately 5.0 kg/cow/day of milk. Kinyenje (2013) also noted that feeding was the major constraint to achieving the targeted milk production because of heavy dependency on rain-fed forage and pasture production while there are poor conservation methods to smoothen seasonal fluctuations in milk production. The mean area under fodder establishment was low (0.5 acres) in the area under the study. GoK Dairy Master Plan (2010) recommends farmers to increase acreage of adaptable high yielding and quality pastures and fodder for increased dairy production.

The management factors that were found to significantly affect milk production were the level of extension methods, record keeping, grazing system and management. Farmers, who were able to supplement their dairy cattle correctly, keep good records on all aspects of dairy as a management tool, select good breeds, administer the best feeds and have a veterinary officer for disease surveillance and control in the farm had higher milk production. There were two types of extension methods: Government and private extension agents. The private agents were more and readily available to the farmers but mostly offered veterinary clinical and AI services. Those who sought services from either private or Government extension agents had higher milk production due to better technical advice on management practices. Makori (2007) also noted that Farmers Field Schools extension approach increase smallholder famers' dairy productivity due improved knowledge and skills in dairy management.

Grazing systems had a significant impact on milk production with higher milk production under zero grazing than semi-zero, which could be attributed to better feeding and management. The practice was popular in high potential areas where land sizes were minimal due to human population pressure. These findings were in agreement with Njarui et.al. (2009) who established that zero grazing animals had minimum movements, hence conserving more energy for milk production. Wambugu *et.al*, (2011) also found out that milk production per cow per lactation period was higher in zero grazing system. Though record keeping had positive influence on milk production, few farmers practiced it. Record keeping was used as a management tool for monitoring dairy cattle performance in order to improve milk productivity.

There were variations in milk production across the agro-ecological zones, with AEZ1 producing more milk per cow per day. AEZ1 had the highest percentage of dairy cattle producing over 10lts of milk per day per cow. This could be attributed to the cool environment suitable for exotic dairy breeds such as the Ayrshire. The relatively higher amount of rain in that zone, sustained adequate pastures for dairy cattle. Consequently, there was improved nutrition through higher pastures and fodder production. Wambugu *et al.*, (2011) similarly found out that there was a higher level of milk production in

higher potential regions because of their conducive climatic conditions for rearing dairy animals. AEZ 2 and AEZ 3 were leading in terms of cattle population with the AEZ1 having a lower number due to smaller land sizes due population density. However, the analysis confirmed that the varying milk productivity among the dairy cattle across the different Agro-Ecological Zones was not significant. (0.58 p-value).

CHAPTER SIX

6.0 CONCLUSIONS & RECOMMENDATIONS

6.1 Conclusion

A low number of farmers in Tigania East were practicing dairy farming as a major source of income. There was no serious involvement in this farming as few were practicing it on commercial bases. The aim was to supply milk for family consumption and to sell any surplus to the nearest local markets with little commercial benefits.

Men were mostly the major decision makers in the family and the dairy farming activities. Their major role was to control family resources like land use and any income from the farm including the little from dairy farming. Women should be given an opportunity to contribute their views towards the management of family resources for better farm production levels.

Farmers who had experience in dairy farming performed better than the farmers who were practicing it for the first time. They had practical knowledge on all aspects of dairy cattle husbandry practices. The type of farming system on the farm influenced the resource allocation. Since dairy farming was less profitable, more resources were diverted towards more profitable enterprises like *miraa* cultivation, cash and food crops farming. This had a negative impact on overall milk production.

Few farmers above 50 years were engaged in dairy farming. There were also few farmers below 30 years of age in dairy farming. Though young farmers were more ambitious, enterprising and aggressive in dairy farming, land ownership issuers discouraged them from taking part in dairy projects since the resource in most cases was under the management of their parents.

Education and income levels highly influenced milk production in the area since this group of farmers was knowledgeable on the requirements for a productive dairy farming, they could as well afford factors of production such as land, capital, AI, extension services and keep records as a management tool. Dairy farming favoured financially

stable farmers. Milk production and reproductive performance of cattle breeds in these smallholder farms reflected inadequate nutrition, which is related to limited cash flow of resource poor farmers, leading to poor livestock feed supplementation.

The dairy breeds were generally of low quality because of prolonged use of poor breeding methods. The main breeding stock were low quality crosses between exotic breeds and the local zebu which could be attributed to prolonged use of local bulls in the absence of effective artificial insemination services. This contributed to low milk production since good quality breeds had positive association with higher milk production. Low percentage of farmers was practicing artificial insemination as opposed to use of inferior quality local bulls. Some form of inbreeding was noted with long-term negative impact on milk production. The quality of the breeding bulls was not professionally selected.

Artificial insemination can be viewed as a precursor for demand for continued extension services, as the improved dairy breeds require more extension knowledge and farming kills. The extension services in turn result into preference for improved breeding technology such as better A.I., use of molasses and better hay and fodder conservation. The farmers who used artificial insemination services had improved dairy breeds. Prolonged and extensive use of bulls led to poor dairy breeds with prevalent inbreeding incidences. The calving intervals of two years were generally long due to poor nutrition and failure to detect heat in good time and presenting the dairy animals for service at the wrong time, leading to underutilization of the same in the end.

The type of feeds and the feeding methods affected dairy production more than any other factor. Generally, there were inadequate levels of nutrition especially during the dry season. The quality and quantity of feeds fluctuated with seasons and the agro-ecological zones, where there was surplus production during the wet season. Quality feeds and adequate feed supplementation provide the dairy animals with the sufficient nutrients to increase milk production, health of the animal, and the vital reproductive activities such as ovulation. Dairy cattle fed on the concentrates get energy supplement and proteins that

contribute to increased milk production. Only lactating dairy animals were given concentrates during milking session, which was in most cases inadequate. The acreage under pastures and fodder was relatively low resulting to inadequate feeds for the dairy animals. The farmers were also not knowledgeable on dairy cattle feeding methods, pastures and fodder management skills.

Grazing system affected the level of milk production with the zero grazing system registering more milk production than in semi-zero grazing. This was mainly attributed to improved management, feeding and conservation of energy through minimal movements in Zero grazing units.

There were few extension workers. The whole sub-county had only two trained public livestock extension personnel. Their impact on the ground was minimal. There were private extension agents whose main aim was to make profit through veterinary activities such as livestock treatments with little extension package. However, farmers who sought extension services and kept good records had increased levels of milk production. However, majority of farmers did not keep any form of farm records. Due to few extension providers, most extension packages were delivered through organized farmers' groups, field days and public barazas.

Milk production varied with AEZs with dairy cattle in AEZ1 producing more milk than the rest. This was attributed to climatic conditions, which were conducive for dairy cattle farming. The upper agro-ecological zones experienced higher rain, which resulted to higher levels of pastures and fodder production. As a result of adequate feeds, in form of pastures and fodder, there was increased milk production in those zones. However, the noted variations were not significant.

6.2 Recommendations

The study revealed tremendous loopholes which if addressed would see Tigania East Sub County increase its milk production levels to those of other sub counties given the fact

that the sub- County has favorable agricultural conditions more so for dairy cattle keeping.

- Women in Tigania East should be empowered fully to participate in dairy production through better control of dairy farming resources.
- The existing breeding stock can be upgraded through active and effective A.I. services.
- Improvement of natural forage availability through increased acreage under pastures and fodder.
- Improvement of dairy cattle productivity through use of concentrates supplementation to improve nutrition.

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APPENDICES

Appendix 1: Questionnaire

Guide lines to the data collectors.

This questionnaire is for research purpose and seeks to establish the challenges facing smallholder dairy cattle production in Tigania East Sub-county. It should be administered to smallholder dairy cattle farmers only. Record the answers on the space (line), ticking appropriately on the choice given or writing brief answers. The decision to take part in this survey/research remains the choice of the respondent. The information given will be confidential. Get as accurate information as possible.

PART ONE.

BACKGROUND INFORMATION

Division..... Ward.....

Location..... Ecological zone.....

Name of the household (HH) key decision maker.....

Size of the household.....

Contact mobile No.....

Date data collected

D..... M..... Y.....

GENERAL INFORMATION

1. Gender of the house hold head

   Male ( ) Female ( )

2. Age of the house hold head

   Indicate years ( )

3. Marital status.

   Married ( ) Single ( ) Divorced ( ) Windowed ( )

4. Education level

   Below primary school ( )

   Primary school level ( )

   Secondary level ( )

   Tertiary level ( )

5. Level of income

   0-10,000 ( )

   10,001-20,000 ( )

   20,001 – 30,000 ( )

   30,001 – 40,000 ( )

   Above 40,001 ( )

6. **Who makes decisions concerning dairy farming?**

   Man ( ) Woman ( )

   Others ( )

7. **What other activities do you undertake in the farm to make a living?**

.....

8. H**ow many years (experience) have you kept dairy cattle?**

   State.....

9. **Reasons for keeping the dairy cattle.**

   Explain.....

10. **Major source of income.**

    Dairy cattle ( )

    Others ( )

11. **Number of dairy cattle in farm.**

    1-2 ( ) 3-5 ( ) others ( )

12. Who makes decision about general cattle management?

Man ( ) woman ( ) both ( )

13. Who makes decision on income received from the dairy cattle?

Man ( ) woman ( ) both ( )

PART TWO BREEDS AND BREEDING

14. What breed of cattle is kept by farmers?

Friesian ( ) Ayrshire ( ) Jersey ( ) Guernsey ( )

Crosses ( )

15. What type of breeding service does the farmer practice?

Artificial insemination ( )

Use of bulls ( )

16. Do you get the kind of milk calves you desire from artificial insemination (AI)?

Yes ( ) No ( )

Explain……..

17. What problems does the farmer experience with artificial insemination?

Too expensive ( )

Unreliable ( )

Not accessible ( )

Others ( )

18. Problem faced with bulls.

Poor quality ( ) not available ( ) Breeding diseases ( )

Others (specify) ( )

19. How long has the bull served cows in this area?

1year ( ) two years ( ) three years ( ) four years ( )

20. What type of bull breed is famer using?

Zebu ( ) cross ( ) pure breed ( )

21. What is the quality of the breed?

Good ( ) fair ( ) poor ( )

22. Is there any form of inbreeding among the bulls used?

Yes ( ) No ( )

23. How was the bull selected for this service?

Briefly explain……..

24. Where did the farmer source for the breeding bull?

Outside the area ( ) among his dairy cattle ( ) bought from a neighbour ( )

25. What is the quality of the animals being served by the bull?

Zebu ( ) Crosses ( ) pure breeds ( )

26. How long does it take to breed your dairy cow after calving down?

Two months ( ) three months ( ) others (specify) ( )

27. What is the calving interval?

One year ( ) two years ( ) three years ( )

Others (specify) ( )

28. What is the calf mortality rate?

80– 100% ( ) 50- 70% ( ) below 50% ( )

29. Does the farmer experience problems related to infertility and low conception rate?

Yes ( ) explain briefly.....

No ( ) explain briefly.....

PART THREE: FEEDS AND FEEDING

30. What is the main source of livestock feeds in the farm?

Natural pastures ( )

Fodder ( )

Crop residues ( )

31. What is the quality of feeds given to the dairy cattle in terms of preservation, stage of maturity and growth?

Explain……

32. What kind of problem does the farmer experience as far as the dairy cattle feeding is concerned?

No enough land for fodder production ( )

No enough fodder and pastures during the dry season ( )

Poor knowledge and resources for livestock feeds production and preservation ( )

All of the above ( )

33. What is the most common fodder grass or trees planted in the farm?

Napier grass ( )

Others (specify) ( )

34. What is the average farm acreage?

.....

35. How many acres are under fodder crop or tree cultivation?

.....

36. Do you do any supplementary feeding in the farm?

Yes ( ) No ( )

Rate of concentrate supplementation kg/cow per day

. .....

37. Feed conservation methods.

Hay ban ( ) silage ( ) others (specify) ( ) none ( )

38. Common feeds conserved.

Crop residues ( )

Grass hay ( )

Others (specify) ( )

39. Do you have seasonal fluctuations in feeds availability?

Yes ( ) No ( )

What is your coping mechanism?

.....

PART FOUR: MANAGEMENT ISSUES

40. What type of grazing system does the farmer practice?

Zero-grazing ( ) Semi-zero ( )

41. What is the most common extension service?

Government extension workers ( )

Private extension agents ( )

Others (specify) ( )

42. Does the farmer keep any form of management records?

Yes ( ) No ( )

Remarks.....

43. Do you have any form of chaff cutter to avoid feeds wastage?

Yes ( ) No ( )

44. What is the level of dairy cattle management in the farm?

Good ( ) Fair ( )

Poor ( )

Explain……..

PART FIVE: MILK PRODUCTION AND MARKETING

45. What is the average production per cow per day in terms of litres?

3-5Ltr ( ) 5.1-10Ltr ( ) others (specify) ( )

46. Does the farmer belong to cooperative society or dairy self-help group?

Yes ( ) No ( )

47. How much milk is marketed?

.....

48. How much is left for home consumption?

.....

49. Where does the farmer market his/her milk?

……..

50. What is the average price of milk per litre?

.....

51. What is the length of lactation period?

10 months (305 days) ( ) 12 months ( ) 18 months ( )

Others (specify) ( )

52. How does the type of cattle grazing system affect the level of milk production and Marketing in the farm?

……

53. Do you face any problem in milk marketing?

Explain.....

.....

54. How is the milk transported to the market?

.....

.....

55. Is there any problem in transporting milk to the market?

.....

.....

56. Do you have access to all weather roads?.....

PART SIX: DISEASE INCIDENCES

57. What are the common diseases that you encounter in your farm?

.....

.....

58. Who treats your animals?

Private vet ( ) Government vet ( ) others (specify) ( )

59. Do you take your animals for route vaccination?

Yes ( )

No ( )

60. Do you spray your animals against ticks and pest?

Yes ( ) No ( )

61. Do you have regular deworming programmes?

Yes ( )

No ( )

62. Do you give your animals recommended mineral supplements?

Yes ( )

No ( )

63. What appropriate technology do you use in your farm?

.....

.....

.....

64. Does the grazing system being used by the farmer predispose the animal to diseases?

Yes ( ) No ( )

65. Do disease incidences significantly affect the farmer's milk output from the dairy cattle?

Yes ( )

No ( )

Explain……..