DAIRY GOAT FARMING, SUPPORT SERVICES AND MARKET ACCESS ON HOUSEHOLD FOOD SECURITY AMONG SMALLHOLDER FARMERS IN KIRINYAGA COUNTY, KENYA

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DECLARATION

This thesis is my original work and has not been presented elsewhere for a degree or any other award

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DEDICATION

I dedicate this work to the all Almighty God for wisdom, knowledge, discernment and strength throughout the research process. I also dedicate this thesis to my whole family; my late father Stephen Njue, mother Mary Wanjiku Njue, and to my brothers John, Geofrey, Joseph and Zakaria, for their prayers, encouragement and support.

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LIST OF ABBREVIATIONS

ASAL	Arid and Semi-Arid Lands
ASDS	Agricultural Sector Development Strategy
ATT	Average Treatment Effect on the Treated
CIDP	County Integrated Development Plan
DGAK	Dairy Goat Association of Kenya
DGF	Dairy Goat Farmers
EAC	East African Community
FAO	Food and Agricultural Organization
FNSP	Food and Nutrition Security Policy
GDP	Gross Domestic Product
HDI	Human Development Index
HDDS	Household Dietary Diversity Score
IPC	Integrated Food Security Phase Classification
HPI	Heifer Project International - Kenya
KALRO	Kenya Agricultural & Livestock Research Organization
KES	Kenyan Shillings
KLPA	Kenya Livestock Producers Association
KNBS	Kenya National Bureau of Statistics
NDGF	Non-Dairy Goat Farmers
NNM	Nearest Neighbour Matching
OLS	Ordinary Least Squares
PMS	Propensity Score Matching
SDG	Sustainable Development Goals
SLA	Sustainable Livelihood Approach
SSA	Sub-Saharan Africa
SPSS	Statistical Package for Social Sciences
UNDP	United Nations Development Programme
VIF	Variance Inflation Factor

DEFINITION OF TERMS

Food security: The state of having physical and economic access to safe and nutritious food enough for the household at all times (FAO, 2014). This study considered food security as the ability of the household to consume a variety of foods with all the necessary nutrients to meet the nutritional requirements for sustainable lives.

Household Dietary Diversity: An indicator of diet quality that directly influences nutritional outcomes (FAO, 2011). Diversity was examined by taking into account different number of food groups and items consumed in the household for the past 7 days.

Market Access: Refers to the ability of sellers to reach markets and link with buyers (Kihiu & Amuakwa-Mensah, 2021). For the purpose of this study, market access was defined as the ability of dairy goat farmers to participate in formal and informal markets for goat milk.

Smallholders: These are farmers keeping dairy goats in farm sizes between 0.2-2 hectares and are also engaged in crop or other livestock production (Nyambok, 2015). The study considered all farmers with a flock of less than five dairy goats irrespective of breeds to be smallholders.

Support Services: Refers to services aimed at helping farmers improve production and increase income (Miller & Lu, 2019). This study took into consideration all services pertaining to goat breeding, financial aspects, extension services, marketing aspects, feeding management, and veterinary services.

ABSTRACT

In the central highlands of Kenya, dairy goat farming is highly practiced for milk production to promote food security, and as an income-generating enterprise. In addition, several support services are in place to promote improved productivity and marketing of dairy goats and their products. However, farmers continue to face challenges relating to market access and dairy goat management. Besides, the Food Consumption Scores are low and information on dietary diversity at the household level among smallholder farmers is scanty. Similarly, information on the effect of support services on dairy goat production and effect that market access has on household dietary diversity is insufficient. This study was thus, conducted to contribute to the existing literature by analysing dairy goat farming effect on household food security of smallholder farmers, determining the influence that support services for dairy goat farming have on production, and identifying how access to market for goat milk affects household food security of the smallholder farmers. Multi-stage sampling technique was used to sample 385 households in Kirinyaga East Sub-county. Structured questionnaires were used to collect data on household demographics, market access, support services, food security, and milk production. Household Dietary Diversity Scores (HDDS) was applied as a measure food security and Propensity to Score Matching was used to determine the effect of dairy goat farming on household dietary diversity of smallholder farmer. Results revealed that vegetables, cereals, beverages, fats and oils were consumed more compared to meat, fish and eggs. The Average Treatment Effect on the Treated (ATT) showed that dairy goat farmers had higher HDDS by 1.014, an implication of diversified diets. The results of the Cobb-Douglas production function revealed that group membership and extension services increased the litres of milk produced by 0.495 units and 0.646 units respectively. In the contrary, breeding services decreased litres of milk produced by 0.612 units. The Binary Logistic regression results showed that distance to the nearest market and milk marketing channel were the market indicators related to HDDS. The results suggest that dairy goat farming should be encouraged and improved among smallholder farmers in an effort to minimize malnutrition. More extension officers should be trained and deployed to assist farmers in breeding and other dairy goat management practices to promote increased milk production. Additionally, closer formal markets for goat milk should be established to reduce the negative influence that long distances have on household food security.

CHAPTER ONE

INTRODUCTION

1.1 Background information

Food security has been defined as the right to everyone having safe and nutritious food that is sufficient to meet their food preferences and dietary needs at all times, to lead an active and healthy life (WFS, 1996; FAO, 2014). Globally, about 800 million people are undernourished and approximately 20% of the population is represented by Africa (FAO, 2022). Previous reports on food security portray that Africa has an increase in the number of food insecure people at a rate of 26% between 2000 and 2019 (FAO, 2020). In comparison to other regions, East Africa comes second after West Africa in the prevalence of food insecurity with 65% of people experiencing moderate to severe food insecurity (FAO, 2021).

Particularly in Kenya, a report by Ngotho (2020) revealed that Kenya is among the countries with severe levels of hunger at position 86 out of 117. Besides, about 14.5 million people in Kenya based on the report were food insecure where 29% could not access the bare minimum of dietary diversity to maintain a healthy lifestyle. A consumption survey conducted by World Food Programme (WFP) showed that the central highlands have low Food Consumption Scores (FCS) of 15% and below (WFP, 2016). Additionally, 49% of the population is vulnerable to acute food insecurity (lack of capacity to consume adequate food) but acute malnutrition situation in the area is yet to be determined according to IPC (Integrated Food Security Phase Classification) analysis (IPC, 2021). A recent analysis confirm that about 4.1 million people in Kenya experience acute food insecurity, and deteriorating acute malnutrition is highly used as an early sign to emergencies and crises associated to nutrition deficiency (IPC, 2022).

Among the proposed interventions deemed to counter food insecurity world-wide, promoting animal agriculture among the smallholder farmers have been appraised to positively impact food security in terms of improved diets in the household levels (Kafle, 2014). The dairy goats are among the most essential animals kept for milk production second from cattle (Kikwatha et al., 2020). Similarly, dairy goats rearing has

gained popularity over time globally due to the highly nutritious milk, highly recommended by health professionals, and the practice is increasingly becoming common among smallholder farmers in mixed crop and livestock systems (Ondara et al., 2015). In Sub-Saharan Africa, dairy goat rearing is prominent given the increased population density and small farm sizes, resulting from land fragmentation (Miller & Lu, 2019).

In Kenya, dairy goat production is one of the livestock sub-sector, and is rendered as an important source of livelihood for smallholder farmers in terms of income from sale of milk, manure, meat and replacement stock (Mbindyo et al., 2018). Aside from milk production, the goats are kept for wealth accumulation, insurance, and meat, while manure and skins (fibre) are beneficial by-products. Following immense efforts between the government of Kenya and non-government institutions such as Farm-Africa and farmer-based organizations such as Dairy Goat Association of Kenya (DGAK) and, Kenya Livestock Producers Association (KLPA), dairy goats have continually been distributed in Kenya (Njagi, 2018). Where about 80 percent of dairy goats are in central highlands of Kenya (Mbindyo, 2014).

The total milk contribution of dairy goats in Kenya is approximated at 6.4 million litres based on the statistics done in 2021 (KALRO, 2021). The key challenges identified to affect dairy goat production are lack of access to facilities and services such as markets, extension agents, technical skills, financial services, and veterinary services (Mbindyo et al., 2018). Providing dairy goats smallholder farmers with support customized to their requirements, is likely to promote production of output that meet the quality standards in terms of nutrition and sanitary, translating to more economic benefits (Mbindyo et al., 2018). However, deficit of support services aimed at enhancing dairy goat performance is a critical issue to dairy goat milk production and requires strong and consistent organizations to be involved (Miller & Lu, 2019).

Selection of breeds to suit farm environments and breeding objectives can affect profitability of dairy goat production system (Woldu et al., 2016). This means that it is necessary for farmers to have appropriate knowledge on breeding practices. On this basis, establishment of breeding centres to aid farmers on breeding specification,

identification of biological traits influencing revenues and costs, production and marketing systems is highly advocated (Ondara et al., 2015). Also, inconsistent record keeping on the goats disease history, lineage, date of birth, milk production and other vital information among smallholder farmers has been identified to influence dairy goat production (Tiffanie, 2020). This is due to the fact that good record keeping encourages proper follow-up on goat performance by the smallholder farmers, animal breeders, and veterinarians, as important health and husbandry information of the goats from birth is easily accessible. Previous research in the central highlands of Kenya reveal that, exposure to extension services and formation of co-operatives among dairy goat farmers introduces them to better markets, new ideas, technical and logistic support; that gives them the capacity to carry out agricultural practices in a better and cost-effective way (Mburu et al., 2014; McCord et al., 2014; Richard, 2017). All these services translate to increased production subject to increased profits.

Linkage to market is a strategy to ascertain successful dairy goat development projects (Kikwatha et al., 2020). Providing dairy goat smallholder farmers with a ready market for their produce creates a good opportunity to enhance food security, given that farmers are assured of income from the sale of milk or replacement stock that can be used in food expenditure. Nevertheless, poor market infrastructures has been identified as one for the key reason why most farmers neglect dairy goat farming (Mburu et al., 2014). Literature shows that, organized dairy goat value chains are common in European markets since there are strategies in place to reinforce the capacity of the producers, processors and other essential actors in the system; ascertaining high quality milk and value-added milk products (cheese) that can easily access markets thus, improved income (Miller & Lu, 2019). In contrast, goat milk has gained recognition in Kenya, but a marketing strategy that exploits other business opportunities beyond the commonly adopted neighbours and fam-gate sale has not been successfully implemented (Kikwatha et al., 2020). Notable constraints affecting marketing of goat milk in the central highlands of Kenya have been associated to lack of distribution channels and poor linkages between the middlemen and the farmers (Mbindyo, 2014; Richard, 2017). Furthermore, issues underlying market access have been related to long distances to the

market or the cooling points, poor roads, and lack of transportation facilities (Ogola & Kosgey, 2019).

1.2 Statement of the problem

In Kenya, acute food insecurity is prevalent following the inability of some people especially in the rural areas to access adequate and nutritious food. Acute malnutrition rates also keep rising, evidenced by the rise in dietary-related communicable diseases like diabetes and cardiovascular disorders. Dairy goat farming in the central highlands of Kenya have highly been adopted to alleviate food insecurity, however, the Food Consumption Scores are still low. Kirinyaga County in specific have integrated dairy farming as one of the sectors aimed at eliminating food insecurity in their County Integrated Development Plan (CIDP) 2018-2022, (County Government of Kirinyaga, 2018). Nevertheless, information on acute food insecurity and malnutrition status at the household level particularly among dairy goat smallholder farmers has not been assessed. Besides, food security status, in terms of dietary diversity, that is, different food groups consumed at the household level for dairy goat farmers remains unknown.

Similarly, although there are several support service providers for dairy goat farming in aspects of veterinary, marketing, financial and extension, farmers continue to experience challenges based on management, breeding, and market access. Nevertheless, information on whether provision of support services has any effect on dairy goat production is scanty. Additionally, most smallholder dairy goat farmers sell milk to available informal channels, such as neighbour or at the farm gate. The aforementioned is opposed to formal channels such as, milk cooperatives; through which improved income can be generated translating to more income channelled to food expenditure. In light of this, there is limited information on how access to market for goat milk influences household food security of smallholder farmers. This study is therefore necessary in order to fill in these gaps.

1.3 Objectives

1.3.1 General objective

The general objective was to evaluate the effect of dairy goat farming, support services and market access on household food security among smallholder farmers in Kirinyaga County, Kenya.

1.3.2 Specific objectives

1. To analyse the effect of dairy goat farming on household food security among smallholder farmers.
2. To evaluate the effect of support services for dairy goat farming on production among smallholder farmers.
3. To determine the influence of market access for goat milk on household food security of smallholder farmers.

1.4 Research questions

1. How does dairy goat farming affect household food security of smallholder farmer?
2. What effect do support services for dairy goat farming have on production among smallholder farmers?
3. What influence does market access for goat milk have on household food security among smallholder farmers?

1.5 Justification of the study

Practicing dairy goat farming capacitates the smallholder farmers to purchase diversified food items from the income attained through sale of milk, manure and replacement stock (Alyamani, 2020). This might directly contribute to the attainment of Vision 2030 in Kenya; aimed at achieving a food secure and prosperous nation through a seven percent growth rate on GDP. In as much, dairy goats farming in Kirinyaga County have been envisioned to highly contribute to household food security and incomes due to short generation intervals and high adaptability as outlined in the Agricultural Sector Development Strategy (ASDS) 2010-2020 (GoK, 2010). Therefore, findings from the

current research are a great reference to understanding the current contribution of these support services to dairy goat production.

In terms of tracking progress, the research was resourceful in generating evidence on how Kenya is progressing in the fulfilments of Sustainable Development Goals (SDGs) 1 and 2 which are related to achieving food security, improved nutrition, and ensuring healthy lives. Similarly, examining household food security through the dietary diversity score, for smallholder dairy goat farmers is essential to gauge the food security aspects in the Big 4 Agenda relating to ensuring efficient and high nutrition food to all the people. On another note, the study also aligns with the overall objective of the Food and Nutrition Security Policy (FNSP) in Kenya, which is 'achieving good nutrition for the optimum health of all Kenyans' (Radeny, 2020). This is attributable to the fact that the study analyses the dietary diversity of smallholder farmers, providing valuable results to be used by policy makers for policy review and amendments. Lastly, information generated by this study will be useful to service providers and policy makers in efforts to make effective and informed decisions pertaining allocation of resources and policy amendments aimed at improving and sustaining dairy goat farming industry.

CHAPTER TWO

LITERATURE REVIEW

2.1 Food security situation

The issue of food security came to be during the World Food Summit (WFS) organized by FAO and held at Rome in 1996, to discuss on possible interventions aimed at eradicating hunger, malnutrition and achieve sustainable agricultural production (WFS, 1996). Acute malnutrition is not only caused by lack of access to food, but also less intake of enough food that will allow a person to meet their daily dietary requirement (undernourishment). From previous analyses, the prevalence of undernourishment has been on the rise globally since 2001 to 2021 and stands at 9.8% currently (FAO, 2021).

In addition, the recent report on food security and nutrition in the world show that approximately 670 million people will still be affected by hunger in the year 2025 (FAO, 2022). Asia has reported the highest undernourished people while Africa has the highest prevalence of undernourishment due to health and the socio economic impact of Covid 19 pandemic (FAO, 2020). A prior study conducted to analyse the relationship between population number and domestic consumption revealed that more than 250 countries globally have their specified consumption habits and population densities, where, milk, meat, cheese, and eggs are some of the most used food products (Stancu, 2015). However, many rural household are unable to diversify food intake due to several challenges such as lack of capital, information and inputs (Silvestri et al. (2015).

Food security discussions became more popular in Kenya after the passage of Constitution of Kenya 2010, which explicitly acknowledge the right for every individual to be free from hunger, have enough food of good quality, and the right to access clean and safe water for use (Republic of Kenya, 2012). Furthermore, food security is complex issue of sustainable development in Kenya, that is linked to environment, trade, economic growth, as well as health through improved nutrition (Ogutu et al., 2020). Challenges that have been identified to obstruct food security in Kenya include climate change, poverty, land-tenure, and limited empowerment of smallholder farmers (Muigua, 2014). The prevalence of undernourishment in Kenya as of the year 2021 was

26.9% (FAO, 2021). On the other hand, the acute malnutrition situation continues to worsen according to Integrated Food Security Phase Classification (IPC) analyses done in 2022. The IPC report further reveals that, deteriorating acute malnutrition in Kenya is attributable to the compounding food insecurity subject to limited milk availability, inadequate water and increased food prices. In spite of the above analyses, the levels acute malnutrition situation in Kirinyaga County has not been established.

2.2 Dairy goat farming in Kenya

Dairy goats are significant part in the livestock sub-sector in Kenya as they play a critical role in social and economic life of people. Most communities that keep dairy goats are in the mixed crop-livestock production systems which are characterized by small farm sizes and low yields of crop and animal products. The population of smallholder farmers that currently keep dairy goats in Kenya is about 251,000 (Makini et al., 2019). Dairy goats were introduced in central highlands of Kenya in the mid 1990's by Non-Government Organizations (NGOs) such as FARM Africa, and the population continues to increase given the efforts to upgrading indigenous breeds with imported exotic breeds such as German Alpine (Mbindyo et al., 2018).

The common regions where dairy goats are reared in Kenya include Western, Central, Rift Valley, Nyanza, Eastern, and Coast. About 85% of the total flock of dairy goats in Kenya, are in Central, Eastern and Rift Valley regions given the relatively favourable climate for the dairy goats (Makini et al., 2019). Kenya has two indigenous goat breeds, the East African and the Galla mainly found in the Northern parts of the country. However, following the poor performance of these breeds in terms of growth and milk productivity, crossbreeding with the exotic breeds (Saanen, Toggenburg, Alpine) has since been initiated (Mureithi et al., 2022).

2.3 Contribution of dairy goat farming to food security of smallholder farmers

Dairy goat products have rapidly gained popularity worldwide despite the fact that most of the organized dairy goat infrastructures are situated in developed nations such as Europe, particularly in France (Liang & Paengkoum, 2019). In developing countries (China, New Zealand, Africa, and United States), the goats have been considered as an

essential part of livelihood attributable to the rising consumer demand and higher prices of the products related (Silanikove et al., 2014; Peacock, 2005). This corresponds to FAO report that growth and transformation of the livestock sector highly contributes to agricultural development, food security and poverty alleviation (FAO, 2014). Based on the livestock context, a study conducted by Nyambok (2015) particularly on contribution of dairy goat to household income and dietary diversity showed that, most of the smallholder farmers kept dairy goats anticipating to earn income from sale of milk or goat (often replacement stock for breeding), and also benefit nutritionally by consuming milk. However, this report had less to show on how availability of developed market infrastructure and support services promotes household food security.

In another study to assess the contribution of dairy goats to food security of farmers in Ethiopia, small ruminants (sheep and goats) were mainly kept by women for food security purposes, as opposed to men who were identified with large ruminants (Wodajo et al., 2020). From the study, women preferred to keep small ruminants owed to; high nutritive content from milk and meat to achieve their dietary needs, accessibility for sale or exchange in cases of cash requirement. Literatures also reveal that, dairy goats have short gestation periods and increased resistance to erratic weather (Ogola & Kosgey, 2019) which, promotes consistent income flow, milk and meat availability translating to enough food for the household. Nonetheless, the studies above had less to show on how access to market for goat milk influence household food security of the smallholder farmers. Hence, this study sought to provide that information.

2.4 Effect of support service provision on dairy goat productivity

Support services for dairy goats are related to training on adopting updated technologies, breeding, marketing, health management, and financial. In Kenya dairy goat support services are provided by recognized organizations like the Dairy Goat Association of Kenya (DGAK), Heifer Project International (HPI), FARM-Africa among others, all aimed at enhancing dairy goat performance among smallholder farmers (Mureithi et al., 2022).

Limited access to credit facilities, market information, and contact with extension services negatively affect farming operations of smallholder farmers which in turn

influence production (Gani & Adeoti, 2011). Similarly, from Gani and Adeoti's study, smallholder farmers who received visits from extension agents highly participated in marketing of produce, in contrast to those who did not receive extension services. Besides, Ajayi and Olutumise (2018) reported that when farmers are provided with adequate and timely market information from social groups or other farmers, they are able to report immense success Besides, the Heckman-Probit Model results of Ajayi and Olutumise's study showed that, lack of extension agent, and access to credit restricts farmers from gaining improved skills and adopting new technologies. Yet, the aforementioned studies were carried out in Nigeria, but the current study aimed at analysing the effect of these support services among dairy goat smallholder farmers in Kirinyaga County, Kenya.

Poor farm-level feeding and breeding strategies impact the quality of milk to be marketed (Duncan et al., 2013). However, it is so unfortunate that the high cost of concentrates and high valued fodder results to most rural smallholder farmers preferring to use crop residues which are of low quality, and negatively on the quality of milk produced. Use of improved forages has the potential of enhancing production among smallholder farmers through improved goat's nutrition which translates to increased yields and consequently better household income (Kebebe et al., 2017). Dairy production can be on the low due to inadequate feeds and scarcity of production factors especially land for fodder provision Njonge (2017). The recommendation from Njonge's study was that there is need for smallholder farmers to access extension services to be able to overcome most of the challenges in dairy production. Similarly, financial limitations among smallholder farmers results to inadequate technical capacity which, translates to poor animal husbandry and reduced access to veterinary services (Migose et al., 2018). To add up to the above mentioned studies, the current research sought to evaluate how availability of varied support services impacted dairy goat production and household food security in the same region.

A study by Kariuki and Place (2005) in central highlands of Kenya revealed that farmers perceive belonging to a group as essential in marketing of agricultural products, in addition to deriving support on social and human capital. Another study by Munyua

(2011) in Kirinyaga County on flow of agricultural knowledge and information among smallholder farmers showed there were more than 150 primary actors in provision of support services. However, Munyua's reports showed that most interviewed dairy goat farmers depended more on traditional (oral) method for information on animal husbandry, feeding, and pest or disease control, compared to modern communication channels such as social media. Nonetheless, above mentioned studies failed to address how group membership and market information influence production among smallholder dairy goat farmers.

2.5. The role of access to market access on food security

Taking account of smallholder farmers, linkages to markets where they can profitably sell their produce and have good relationship with the buyers can be associated to improve household food security. According to Kihiu and Amuakwa-Mensah (2021), the results of the inverse probability weighted regression-adjustment estimator showed that access to organized markets directly impacts on the household dietary diversity. A study by Migose et al. (2018) showed that farmers are not able to achieve high input-high output systems because they lack a chance to sell milk at higher prices in informal markets. From the same study, farmers near urban market sold milk at relatively higher prices compared to farmers in rural areas. However, the study was conducted among dairy cattle farmers, but not dairy goat farmers.

One of the reasons for greater differences in adoption of new technology is poor access to output market (Kebebe et al., 2017; Ajayi & Olutumise, 2018). Smallholder dairy farmers encounter several challenges that hinder growth and ability to contribute effectively to food security, in contrast to commercial farmers. Most smallholder farmers are located in rural areas that are characterized with finite institutional and physical infrastructures that curb farm development and access to markets (Nyambok, 2015). Similarly, a study to examine market participation among smallholder farmers in Limpopo showed that, most rural households do not participate in commercial market due to volatility in market prices, inefficient marketing institutions resulting to significant risks, and ultimately less income assigned to food expenditure subject to limited earnings from produce sale (Ramoroka, 2012). But, the above-stated studies did

not specifically consider the influence of distance to nearest markets as the primary aspect determining access to market for goat milk.

2.6 Methodological review

There are several measurements that have been used to analyse food security, Chege (2014) used the Household Dietary Diversity Score together with a 7 day calorie intake to assess the effect of export horticulture on food security of smallholder. Woldu et al. (2016) while optimizing the contribution of dairy goat farming to food security in various production systems in Ethiopia, they employed Household Dietary Diversity Scores HDDS. Also, Adeoluwa and Dinbabo, (2018) used the Food Consumption Score (FCS) in terms of dietary diversity, nutrient intake and frequency of consumption to determine the food secure smallholder farmers in North West Nigeria. This study considered HDDS to determine the household food security of the smallholder dairy goat famers through a 7-day recall period.

Regression-Adjustments are often used to estimate the average effect in a non-random sampling procedure. For instance, as study by Kihiu and Amuakwa-Mensah (2021) used Regression Adjustment to determine the relationship between market linkage and household food security. This study however, sought to determine the average effect of dairy goat farming on household food security using the Propensity to Score Matching method that compares two groups in a randomized sample.

The output elasticity in a Cobb-Douglas production model is mainly the response that output has to a proportionate change in a number of inputs (Praveen et al., 2019). The Cobb-Douglas production function has previously been used to analyse some of the factors affecting dairy goat farming in Keiyo, Kenya (Kipserem et al. (2013). In another study, the model was applied to assess the economic efficiency of dairy production systems (Kibiego et al., 2015). In the contrary, Cobb-Douglas was applied in this study to assess the effect dairy goat farming support services have on milk productivity.

The analysis Binary Logistic regression method is applied when the dependent variable is dichotomous (Y = 1, implying occurrence of an event, or Y= 0 implying otherwise) (Midi et al., 2010). A study by Ahmed et al. (2017) used the logistic model to determine

the role of market access in enhancing household food security among small farming households. In this research, the regression method was be used to evaluate the association between HDDS and market access for goat milk among smallholder dairy goat farmers.

2.7 Research gaps

There are four main research gaps in the literature the current study addressed. Firstly, scant information on household food security of smallholder farmers keeping dairy goats in central highlands of Kenya. Available literature related to aforementioned have identified positive relationship between keeping dairy goats and household food security (Kariuki et al., 2013; Wodajo et al., 2020; Woldu et al., 2016; Nyambok, 2015). However, these cited studies had less to show on the effects dairy goat farming on household food security in central highlands of Kenya where this study was mainly based. Secondly, inadequate assessments in central highlands of Kenya, on the impact that support services for dairy goat farming have on the level of production. This is in-spite of several institutions in place to provide various services. Thirdly, previous studies have analysed the influence of market access for dairy goat milk on household income and poverty eradication, but, very few have considered the impact on nutritional aspects. For instance, Kihiu and Amuakwa-Mensah (2021) focused on market access among smallholder farmer in general, while Migose et al. (2018) focused on access to market for cow milk as opposed to goat milk. Finally, the above-mentioned studies did not narrow down to the dairy goat smallholder farmers in the Central highlands of Kenya, to specifically consider effects of market access for goat milk on household food security which was one of the objectives in this study.

2.8 Theoretical framework

2.8.1 Entitlement approach for food security

The study will adopt the Entitlement approach to food security to provide a basis of how smallholder farmers enhance food security status in terms of dietary diversity by keeping dairy goats. Amartya Sen came up with a new argument that food security can be more related to food access rather than supply (Sen, 1982). According to Sen, the entitlement

approach for food security holds that starvation is the outcome of people having limited ability to access food through means available to them. Sen categorizes the approach into two primary aspects; endowment set and entitlement set. Endowment set refers to assets that a person legally possesses and can be sold or transformed into food. Entitlement set on the other hand is alternative commodity bundles that a person can access using their legal endowments. A combination of goods and services selected by a person is regarded as the most optimum considering it has been obtained on the basis of their endowments.

Taking note of the Entitlement approach; the endowment set was used in the study to evaluate the effect of dairy goat farming on household food security. Furthermore, the entitlement set category was employed to explain the ability of the smallholder dairy goat farmers to purchase diversified food with the income obtained from dairy goat farming following established market accessibility. The major drawback of Entitlement Approach to food security is that it only addresses the accessibility aspect, but fails to consider the utilization aspect. However, this study takes into account the food utilization dimension by determining the diversity of diets among the smallholder farmers.

2.8.2 Production theory

Production is the process of transforming inputs or resources into outputs or commodities. To understand the economic relationship between the resources used and the output to be achieved in a production process, production theory is applied, where inputs may constitute of fixed, variable, or stock resources. In this study, production theory was used to show the relationship between the total goat milk produced and the selected support services. Production function is a representation of the maximum output that can be produced with a given amount of input (Rasmussen, 2012). The research adopted the following production function equation in situations where inputs are variable (Kalimantan et al., 2020);

$$Y = f\ (x1_1, \dots\ x_n) \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .. (1)$$

Where, Y is the total physical product (TPP) of goat milk, x_1 ... x_n are the specific variable inputs or resources to be used in the production process. This may include but not limited to veterinary services, extension services, feeds, financial and transport facilities. The theory was used to help analyse goat milk production among the smallholder farmers and explain its relation to the support services offered, as one of the study's objectives. The Cobb-Douglas function, a model proposed to estimate the output level based on the inputs (Kipserem et al., 2013) was applied with an assumption that the milk output was as a result of joint application of the various dairy goat farming support services.

2.9 Conceptual framework

The relationship between the variables as elaborated in the literature review was inferred in a conceptual framework as shown in Figure1 below. The independent variables comprised of dairy goat farming, market access and support services are denoted by (X). Household food security and production were the dependent variables and are denoted by (Y). Government policies, economic condition, and climate change appeared as the surface between the dependent and the independent variables.

Dairy goat farming corresponded to keeping goats for the sale of milk, meat, skins, or a sign of wealth. Market access was determined by variables like distance to the market, distance to the main road, time taken to reach the market, and transportation facilities. Dairy goat farming support services included marketing services, credit services, veterinary services, and extension services. Alliance of the independent variables was conceptualized to directly contribute to increased income through which smallholder farmers were able to purchase diversified food groups that kept them food secure under the utilization aspect. Besides, income generated subject to market access, effective support services and the dairy goat enterprise itself, tend to capacitate farmers to comfortably incur the respective cost of production. Improved consumption of diversified food groups and increased dairy goat production promote poverty alleviation, food security, increased incomes, and sustainable livelihoods.

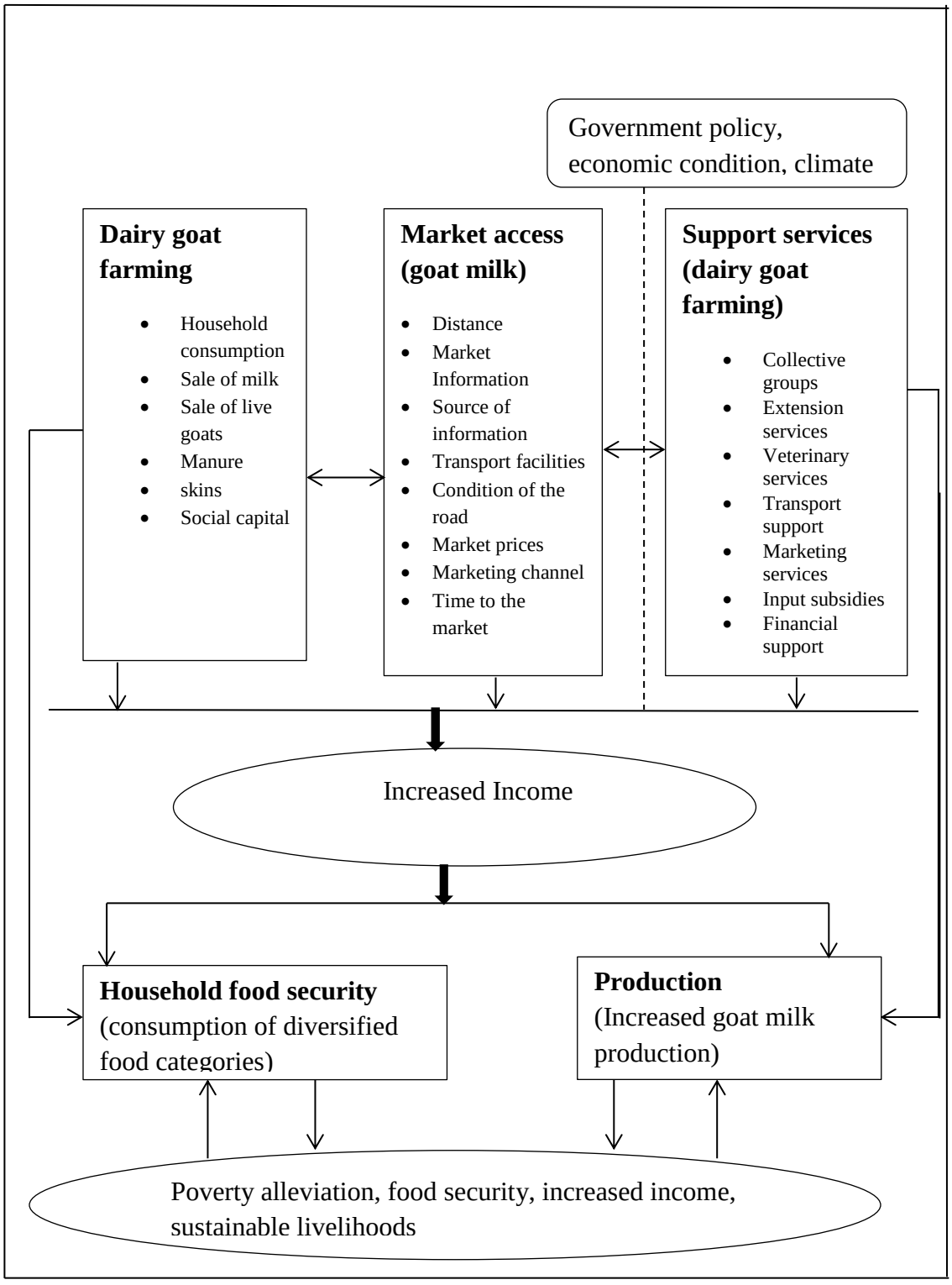

Figure 2.1: Conceptual framework (Source: Authors conceptualization)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study area

The study was conducted in Kirinyaga County, in the Central highlands of Kenya (Figure 3.1). The County lies between 1,158 m a.s.l.(above sea level) in the South and 5,380 m a.s.l. at the peak of Mt. Kenya; at a latitude of 0^{o} - 40^{0} S, and longitude of 37^{o} - 38^{o} E and covers about 1,487 km^{2}. The total population of the County is estimated at 610,400 (KNBS, 2019). There are five sub-Counties in this County (Kirinyaga Central, Kirinyaga East, Kirinyaga West, Mwea East and Mwea West). The County receives bimodal rainfall with a long rainy season from March to May and a short rainy season from October to November. Agriculture is the most important economic sector in the County and, due to the small farm sizes and the high population density, it is mainly undertaken by smallholder farmers who practice both arable farming and livestock keeping (Wambui, 2014). The County also has seen unprecedented growth in dairy goat farming (Njagi, 2018).

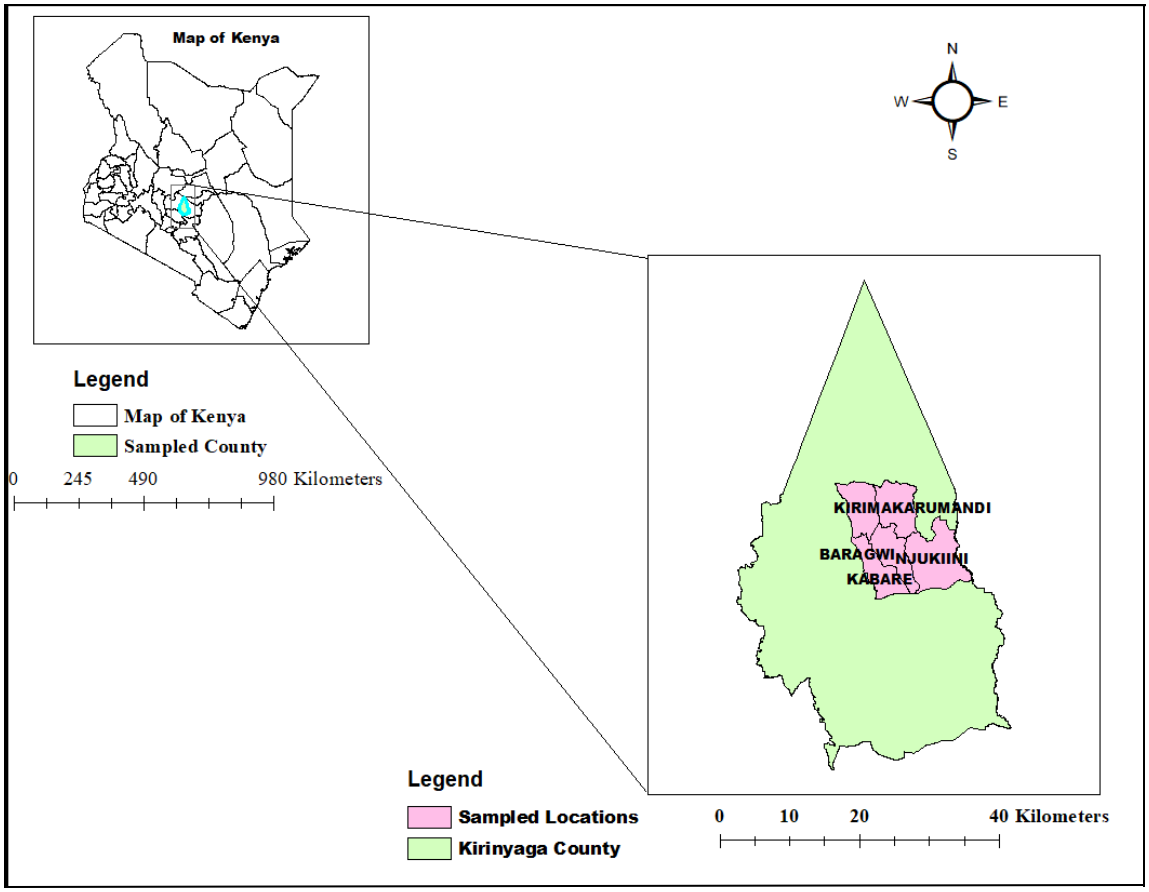

Figure 3.1: Map of the study area

3.2 Research design

The study used a cross-sectional survey design because it permits selection of participants in an inclusion or exclusion manner, and is also cost-effective in terms of data collection (Wang & Cheng, 2020). Additionally, collecting data on all variables at once and observing precision while selecting samples to account for the whole population resulted to few errors.

3.3 Target population and sample size

The target population for this study was 9521 dairy goat smallholder farmers in Kirinyaga East Sub-County (KNBS, 2019). To get the sample size, n, a method suggested by (Kothari, 2004) was used. The suitability of the formula in the study was attributable to the fact that the population was finite. The formula mainly takes into account precision of parameters in a study and the confidence level. Kothari defines

precision as a range where values for the answer may vary but are still correct, while the confidence level shows the likelihood of the answer lying between the selected ranges. The general formula to calculate the sample size in a finite population is:

$$n = \frac{z^2 * p * q * N}{e^2 (N-1)} + z^2 * p * q \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

n is the sample size, N represents the total households (9521), z is the value of standard deviation at a specific confidence level 95% (1.96), p is the sample proportion (0.5), q = 1-p = 0.5, and e denotes the error term or precision rate (0.05).

$$n = \frac{1.96^2 * 0.5 * 0.5 * 9521}{0.05^2 (9521-1)} + 1.96^2 * 0.5 * 0.5 = 385 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

3.4 Sampling design and procedure

The study adopted multi-stage sampling technique to obtain a sample of 385 households. Firstly, Kirinyaga County was purposively selected given that it is one of the Counties in the central highlands of Kenya where exotic dairy goats are promoted by development agencies (Mbindyo et al., 2018). Secondly, Kirinyaga East sub-County was purposively selected from the five sub-counties owing the increased embracement of dairy goat rearing (KNBS, 2019). In the third stage, four wards namely; Ngariama, Karumandi, Kabare-Baragwi, and Njukiini were selected within the sub-County. In the fourth stage, five locations were selected from the four wards based on concentration of dairy goat farmers. The selection was also aided by the register maintained by the Ministry of Agriculture and Livestock in Kirinyaga County. The fifth stage entailed randomly selecting one sub-location from each location (Table 3.1). In the sixth stage, a village was randomly selected as well from each sub-location, totalling to five villages (Table 3.1). Lastly, proportion to size formula was used to derive the number of households to be interviewed per village.

The following proportion to size formula adopted was to obtain the sample size per village:

$$M = \frac{n}{N} * 385 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where; *M* is the number of total households who answered the questionnaires, *n* is the total number of dairy goat farming in the selected village and *N* are all the dairy goat farmers in all the villages sampled. Eventually, the sample comprised of 271 dairy goat farmers (DGF) and 114 non-dairy goat farmers (NDGF).

Table 3.1: Household sampled and interviewed in each village in Kirinyaga East Sub-County

Wards	Location	Sub-location	Village	No. of farmers	Sample size
Karumandi	Karumandi	Thumaita	Kangai	76	72
Njukiini	Njukiini	Kanjuu	Mirichi	68	65
Kabare	Kabare	Kimunye	Kiangombe	112	106
Baragwi	Baragwi	Kathungu	Raimu	102	97
Kirima	Kirima	Gachigi	Kathoge	47	45
5	5	5	5	405	385

3.5 Data collection instrument

Data were obtained by administering structured questionnaires to the selected households. The questionnaires comprised of socio-demographic characteristics of the smallholder dairy goat farmers, questions related to household food consumption to provide information on dietary diversity, and questions concerning market access, availability and contribution of various support services to their daily operations.

3.6 Reliability and validity of the data collection instrument

According to Sullivan (2011), reliability is mainly ascertaining whether the assessment tool gives consistent and dependable results, while validity refers to the process of providing evidence-based argument to verify that the selected tool measures the study expected outcome. To determine the reliability and validity of the data collection instrument, the questionnaire was pre-tested among 15 smallholder farmers (both DGF and NDGF) in Kimandi sub-location, Kirinyaga Central sub-County.

In this study, reliability of the instrument was determined using the Cronbach Alpha test which calculates correlation between answers to various questions in the assessment tool, thus, determining the internal consistency (Sullivan, 2011). The Cronbach's alpha test has coefficient ranging from 0 and 1, where a coefficient closer to one implies high reliability. In this study, the least Cronbach's Alpha coefficient was 0.7, a suitable goal for the instrument.

Table 3.2: Reliability statistics

Objective	Title	Cronbach's Alpha	No. of items
Objective 1	Household food security status variables	0.921	29
Objective 2	Support services on dairy goat farming	0.704	50
Objective 3	Access to market for goat milk on household food security	0.861	36

Pre-testing the questionnaire ascertained construct validity by recognizing and addressing any misunderstanding, inadequacies and ambiguities in the assessment tool. To inflate validity further, enumerators were trained in-detail on how to administer questionnaires before proceeding to collect data.

3.7 Data analysis

Data were coded in Statistical Package for Social Sciences (SPSS) version 25. Afterwards, STATA version 15 was used in running the regression models while SPSS version 25 software was used obtain the descriptive and inferential statistics. The continuous variables (age and household size) were evaluated in means and Standard Deviation, and a two tailed t-test was done to compare any difference in the average values between DGF and NDGF. Percentage and standard deviation were on the other hand generated to examine the categorical variables (gender, farm size, education, title deed ownership, land ownership status, main occupation and household monthly income) for both DGF and NDGF. Chi square test was used to test the significant difference between DGF and NDGF for the various categorical variables to judge the goodness of fit.

3.7.1 Determining effect of dairy goat farming on household food security

The Household dietary diversity score (HDDS) was used to examine food security, since it is an indicator commonly used to show access to food and dietary diversity at the household level (Sibhatu & Qaim, 2017). Besides, the count is one of the recommended techniques by FAO. According to FAO guidelines the recommended food groups for HDDS are 12 including: cereals, legumes, meat, eggs, fruits, vegetables, sugars, oils and fats, beverages, fish, milk, and tubers (Kennedy et al., 2010).

In the current study, the HDDS was constructed with reference to the aforementioned food groups, which also reflect the commonly consumed food groups in Kirinyaga County. Responses were based on what participants recall to have consumed in the selected food groups for the past one week. The seven days recall period was considered to avoid biases that may occur because of shorter reference periods (24 hours), thus, not revealing the correct habitual diets, or longer recall periods, which are prone to errors (Kafle, 2014). The definition of the different consumers was done as follows; in the case a household had consumed a certain food group in the last seven days, the specific category was assigned the value of one (1) and zero (0) if otherwise (Kennedy et al., 2010). The cumulative scores from all the households were then divided in quartiles where the first quartile was considered as high HDDS, the two middle quartiles were combined to indicate medium HDDS, and the last quartile showed low HDDS. In the high HDDS households consumed more than 8 food groups, medium, and 5-7 food groups, while in the low HDDS, 4 and below food groups were consumed. Besides, means were generated for the different quartiles to show the food groups consumed more by households.

3.7.1.1 Propensity score matching

In an effort to measure the impact of the treatment (dairy goat farming) on the outcome (dietary diversity), selection bias might arise due to the non-random assignment between the treated (DGF) and the control (NDGF) groups (Gebrehiwot & Veen, 2015). The Propensity Score Matching (PSM) was used to minimize this estimation bias from the observable variables (Gitonga et al., 2013). The PSM comprised of two stages following Akuffo and Quagrainie (2019). The first stage involved estimation of demographic and

socio-economic variables that may affect the likelihood of practicing dairy goat farming. The second stage further determined the treatment effect by comparing the outcome between the treated and the control groups. To estimate the impact on deciding to adopt dairy goat farming on the outcome variable, the net impact of adoption on the household dietary diversity was calculated (Nazifi et al., 2021). The respective probit equations were;

$Y_1 = \beta_1 X + \varepsilon_1$ ……. (3)

$Y_0 = \beta_0 X + \varepsilon_0$ …….. (4)

Where: Y_1 is the outcome variable for the treated group and Y_0 is the outcome variable for the control group; X are the observable households' characteristics for both groups; β_0 and β_1 represent the effect that X has on the outcome; while ε_1 and ε_0 are the error terms. The difference between treated (DGF) and the control (NDGF) showed the net impact as a result of dairy goat farming.

$Net\ impact = Y_1 - Y_0$ …….…… (5)

3.7.1.2 Nearest neighbour matching

The nearest neighbour matching (NNM) algorithm was used to estimate the average treated effect on treated (ATT) (Nazifi et al., 2021). The NNM creates a causal effect by using the propensity score of similar individuals (with matching observable characteristics) in both the treated and the control group. The matching assumption adopted in this study was that for each treated observation, there is a nearest match in the control observation with similar characteristics (Akuffo & Quagrainie, 2019).

Similarly, according to Wang and Cheng (2020), cross-sectional surveys are subject to confounding, when a variable directly influence the outcome and is also associated with the treatment. The variables used to predict HDDS in this research were also associated with the likelihood of being a dairy goat farmer. Rosenbaum and Rubin (2006) propose matching of propensity scores between treated and control to reduce the bias. Therefore, use of NNM served the purpose of controlling confounding factors and calculation of ATT.

3.7.2 The effect of support services for dairy goat farming on production

Since the study was aimed at understanding the economic relationship between support services and dairy goat milk production, a Cobb-Douglas production function was used. Log-linearized Cobb-Douglas production function was used to determine the correlation that exists between support services and goat milk production. Dairy milk production per doe (output) acted as a function of various support services (inputs) such as marketing, veterinary, transport, credit, and extension.

The general logarithmic Cobb-Douglas production function described by Praveen et al. (2019) was adopted as shown below:

$$log\, Y_j = log\, \alpha_1 + \alpha_2\, log\, X_{2j} + \alpha_3\, log\, X_{3j} + \cdots + \alpha_n\, log X_{nj} + \varepsilon_j \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where: Y_j is total goat milk production per day (in litres), $X_2 \ldots\ldots X_n$ are input variables (various support services), j is the number of observation (1,2,3…n), α_1 is a constant, where as α_2,α_3 , …α_n are input elasticity regression co-efficient, and ε is the error term.

3.7.3 Effect of access to market for goat milk on household food security

Binary logistic regression model was used to analyse effects that access to market for goat milk has on household dietary diversity of the smallholder farmers. The underlying event in this study was whether household was dietary diversified (high HDDS). The value of Y was dependent on a number of predicting variables $x1 \ldots\ldots\ldots\ldots\ldots xk$ (equation 7).

The general logistic model showing the relationship between Y and X was:

$$Log\, \left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_k x_k + \mu \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Where P was the predicted probability that Y = 1, 1-p represented a farmer who was consumed less number of diversified food, $\beta o \ldots . \beta k$ were the estimated parameters, $x1 \ldots xk$ were the independent or explanatory variables, and μ signified the error term or unexplained variables. In this study a household was considered have high dietary

diversity if more than 8 food groups were consumed, and low or poor dietary diversity if 7 and below food groups were consumed a period of seven days.

3.8 Multicollinearity test

Multicollinearity tests were carried out in the Probit, Cobb-Douglas, and Logistics regressions before analysis. Multicollinearity exists when two or more explanatory variables are highly associated, and the Variance Inflation Factor (VIF) helps to show the level of variance of the coefficient estimate resulting from multicollinearity (Midi et al., 2010). The rule of thumb according to Midi et al's report implies, when the VIF value is more than 10, multicollinearity of great concern and should be addressed. On the basis of this study, the VIF values in all the regression values ranged between 1 and 7, an indication that no multicollinearity was detected.

3.9 Operationalization of the study variables

Table 3.3 in the next page shows a summary of the variables used in the study, their description, measurement, and expected signs.

Table 3.3: Operationalization of the variables

Variable	Indicator	Measurement	Expected sign
Dependent variables			
Household food security	If a household is able to score at least 8 and above in HDDS	1 if a household is food secure, 0 if otherwise	
Milk production	Total amount in litres/doe/day	Total amount of milk produced per doe per day in litres	
Market access	-Distance to the nearest market -Time to the nearest market	Distance in Km and time in hours	
Independent variables			
Age	Number of years	Age in years	+
Gender	Gender of the respondent	1)Male 0) Female	+
Education	Education level of the respondent	1)Primary 2)Secondary 3)College 4)University	+
Household income	Monthly income of the household	Income in Kenyan shilling (KES)	+
Household size	Number of people in the household	number	+
Extension	Frequency of extension visits to goat farming households	Number of visits	+
Market information	If a farmer has access to any information on goat milk market	1 if a farmer has access, 0 if no access	+
Government support on dairy goat farming	If a farmer receives government subsidies on feeds	1) Yes 2) No	+
Access to credit	If a farmer have access to credit	Amount of credit received in Kenyan shilling	+
Group membership	If a farmer is a member of any group associated to dairy goat	1) Yes 2)No	+
Title deed	If a farmer has a title deed	1)Yes 2)No	+
Farm size	Farm acreage occupied	In Hectares (ha)	+
Veterinary Services	If a farmers receives any veterinary service	1)Yes 2)No	+
Breeding services	If a farmer receives breeding services	1)Yes 2)No	+
Distance to the nearest market	Distance covered to the nearest market	In Kilometres	+

CHAPTER FOUR

RESULTS

4.1 Overview

This chapter presents the descriptive and inferential statistics of various variables from data collected during the household survey. The chapter comprises of demographic and socio-economics characteristics of the sampled smallholder farmers; summary of dairy goat characteristics and milk productivity, consumption level of different food groups among households, reasons for rearing dairy goats, major challenges experienced in dairy goat farming, support services received for dairy goat farming, and description of market access indicators in the study area. The chapter also presents the Probit regression results showing the factors determining the decision to adopt dairy goat farming and the average treatment effect on the treated (DGF). Furthermore, the chapter presents results of Cobb-Douglas production function showing the effect that support services for dairy goats provided by various agencies have on milk production of dairy goats, and the Binary Logistic regression results on the effect of access to market for goat milk on household food security among the smallholder dairy goat farmers.

4.2 Demographic and Socio-economic characteristics of smallholder farmers

Demographic and socioeconomic characteristics of both dairy goat and non-dairy goat farmers on the basis of age, gender, marital status, household size, farm size, type of land ownership, title deed availability, main occupation as well as monthly household income followed a similar pattern (Table 4.1). The respondents were between the ages of 42 to 49 years, and the variable was significantly different by 1% between the two groups. There was no difference in the average household size between DGF and NDGF households. Male-headed households dominated in both groups at 58% in the dairy goat farming households and 60% in the non-dairy goat farming households. The highest level of education attained by the respondents was secondary school, followed by primary and colleges. Very few farmers had university level education, 2.2% DGF and 2.6% NDGF respectively. Farm size varied between the two groups (p=0.079), where a large percentage of households (52%) DGF and (63%) NDGF occupied less than one

hectare of land. From the total sampled farmers, 92% of farmers owned farms though inheritance, 7% as private property and 0.9% as communal land. Title deed ownership among the DGF and NDGF was uneven (p=0.000), where a larger portion (83%) of DGF held a title deed for the land they occupied compared to NDGF (67%). The main occupation embraced by most of the respondents (68%) DGF and (57%) NDGF was agriculture. Besides, although the difference was not significant more of the NDGF engaged in casual labour or self-employment in contrast to DGF. Lastly, the monthly household income for most of the sampled farmers 64% DGF and 65% NDGF averaged between Kenyan shillings (KES) 10, 001 to 20,000.

Table 4.1: Demographic and socio-economic statistics of dairy goat farmers and non-dairy goat farmers

	DGF (N=271)		NDGF (N=114)		Difference test
Variables					
Continuous variables	*Mean*	*Std.Dev.*	*Mean*	*Std.Dev.*	*T-Test(p-value)*
Age of HH head (years)	48.58	9.82	42.34	9.09	0.000***
HH size	5.27	0.582	5.24	0.886	0.425
Categorical variables	*(%)*	*Std.Dev*	*(%)*	*Std.Dev*	*Chi square(X^2) (p-value)*
Gender		0.90		0.78	0.686
Male	58.3		60.5		
Female	41.7		39.5		
Education		0.77		0.73	0.588
Primary	28.8		27.2		
Secondary	48.0		54.4		
College	21.0		15.8		
University	2.2		2.6		
Farm size (ha)		0.56		0.51	0.079**
<1	52.0		63.2		
1-2	44.6		36.0		
>2	3.3		0.9		
Land ownership		0.59		0.58	0.961
Inheritance	91.5		92.1		
Private	7.7		7.0		
Communal	7.0		0.9		
Title deed		*0.37*		*0.47*	*0.000***
Yes	83.4		66.7		
No	16.6		33.3		
Main occupation		0.77		0.87	0.208
Agriculture	67.9		57.0		
Self-employed	18.8		23.7		
Casual labourer	11.4		15.8		
Formally employed	1.8		3.5		
HH monthly income(KES)		0.97		0.98	0.135
5,000-10,000	21.8		27.2		
10,001–20,000	63.5		64.9		
20,001 and above	14.8		7.9		

***=1% significance level, **=5% significance level, N= number of respondents, DFG=dairy goat farmers, NDGF= non-dairy goat farmers, Std.Dev.= standard deviation, HH=household KES=Kenyan Shillings

4.2.1 Characteristics of dairy goat farming in Kirinyaga-East Sub-County.

Findings showed that 90% of the respondents kept 1-3 dairy goats (Table 4.2). The maximum level of experience in dairy goat farming (in years) reported among dairy goat farmers was eight and higher, with majority of farmers (46%) having at least seven years of experience. The commonly reared breeds were Kenya Alpine and Toggenburg, and the highest total daily milk output per doe was 3-5 litres per day, but a relatively high number (43%) of dairy goat famers reported to produce 1-2 litres per doe per day. Only 25% of the respondents sold milk, while 75% consumed milk, and implication that milk in the study area was primarily for household consumption. The natural mating method using bucks was common at 99% among the DGF households. Bucks were mainly borrowed or hired from the neighbours, group-owned, own-rotated, or communally-owned (Table 4.2). The goats were reared in zero-grazing systems in most farms as opposed to tethering. Natural pastures and crop residues were used by relatively more farmers than planted fodder manure was utilized for on-farm fertility to enhance crop productivity and for sale. Ultimately, more than half of the respondents (65%) indicated the total monthly income generated from dairy goat from sale of milk, live goats, or manure to be between 3,000-5, 000 KES.

Table 4.2: Results of dairy goat farming characteristics in the Kirinyaga-East Sub-County

Variable	*Frequency (N=271)*	*Percentage*
Number of dairy goats kept		
1-3	246	90.2
4-6	22	8.1
7-9	3	1.7
Experience in dairy goat farming (years)		
1-2	119	43.9
3-7	124	45.8
8 and above	28	10.3
Milk output in litres/day		
1-2	116	42.8
3-5	155	57.2
Type of breeds kept		
Kenyan Alpine	189	43.0
Toggenburg	143	32.5
Saanen	72	16.1
East African	36	8.1
Production system		
Zero-grazing	252	92.3
Tethering	19	7.7
Type of breeding used		
Bucks	269	99.2
Artificial Insemination	2	0.8
Source of Bucks		
Neighbours	166	61.3
Group owned	60	22.1
Communal	28	10.3
Own rotated	17	6.3
Type of feed commonly used		
Natural pastures	245	48.9
Crop residues	189	37.7
Planted pastures	67	13.4
Sale of milk		
Yes	69	25.4
No	102	74.5
Use of manure		
On-farm fertility	118	56.7
Selling	153	43.3

Total monthly income from dairy goats (KES)		
< 3,000	67	24.7
3,001-5,000	271	63.1
5,001 – 10,000	22	8.1
> 10,001	22	4.1

4.3 Household food security status of dairy goat farmer and non-dairy goat farmers

The dietary diversity scores showed that both DGF and NDGF households were food secure with both being under the medium and high HDDS (Table 4.3). However, the difference in HDDS between the groups was significant at 1% with the average HDDS for DGF been 10.6 while that of NDGF was 9.6. This implied that farmers who choose to adopt dairy goat farming had diversified diets compared to those who did not.

Table 4.3 Household dietary diversity scores of dairy goat and non-dairy goat farmers

	DGF (N=271)		*NDGF (N=114)*	
Parameters	*Frequency*	*Percent*	*Frequency*	*Percent*
Medium HDDS *(5-7)*	10	3.7	31	27.2
High HDDS *(8 and above)*	261	96.3	83	72.8
Mean	10.6		9.6	
Standard deviation	1.08		1.47	
Maximum	12		12	
Minimum	7		6	
Pearson Chi-square	X^2=46.5840		p-value = 0.000***	

DGF=dairy goat farmers, NDGF=non-dairy goat farmers, HDDS=household dietary diversity, N=number of respondents, ***=1% significance level

4.3.1 Consumption of the selected food groups

With consideration to the past seven days, households in both groups consumed vegetables, beverages, fats and oils (Figure 4.1). Consumption of sugar and cereals was

also high in both groups. The DGF were prominent ($p>0.05$) in the consumption of dairy products, fruits, wheat products, root and tubers. The consumption of meat, eggs, and fish was low in both DGF and NDGF households. However, consumption of these food items in DGF households was higher than in NDGF households ($p<0.05$) (Figure 4.1).

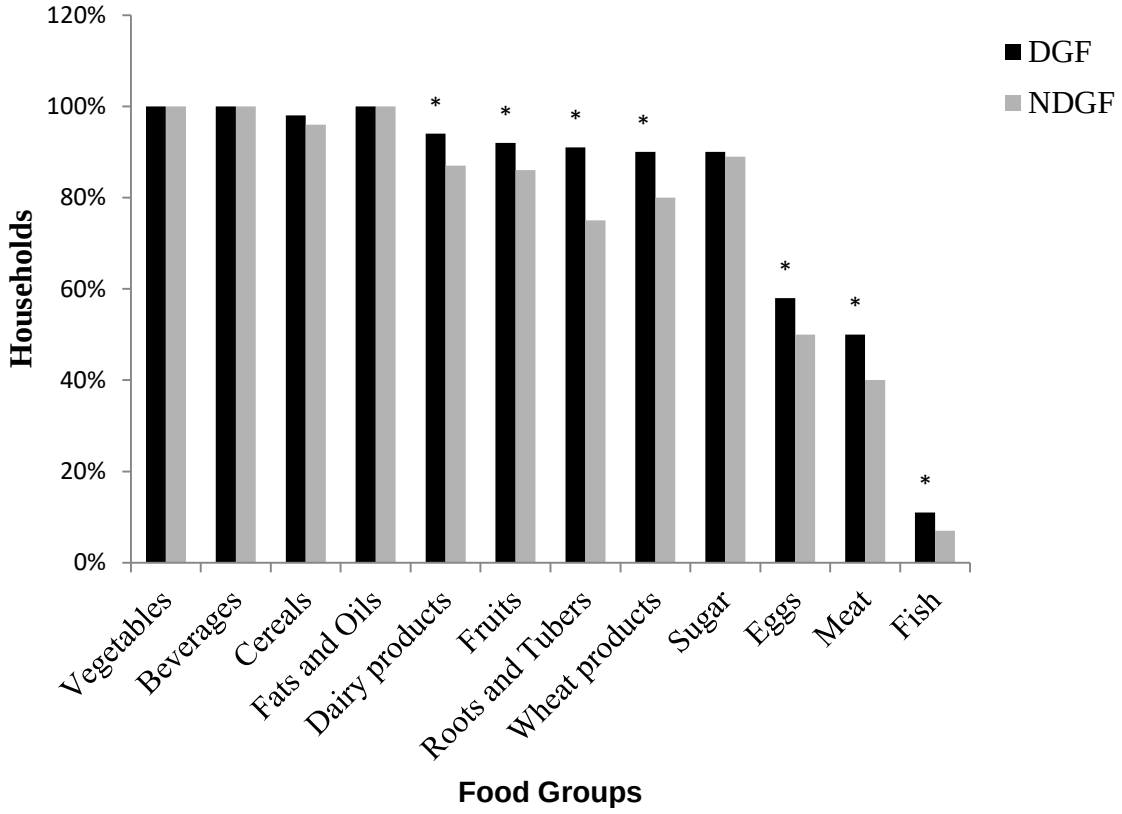

Figure 4.1: Food groups consumed by the sampled DGF (dairy goat farmers) and NDGF *(non-dairy goat farmers) households in the last seven days. (*denotes $p<0.05$ for comparison between DGF and NDGF in consumption of specific food groups).*

4.4 Factors influencing participation in dairy goat farming

The PSM matching held a conditional assumption that the outcome was completely independent on the treatment. The results of the estimated coefficients from the probit model are presented in Table 4.4. The R^2 value show that 15% variation in the dependent variable was explained following inclusion of the independent variables in the model. The goodness of fit measure in the model was indicated by the 1% level of significance in the likelihood ration Chi square value. From the explanatory variables

included, age, gender of the household head, farm size, main occupation and household income significantly impacted participation in dairy goat farming (Table 4.4). Increase in the farmer's age increased the likelihood to adopt dairy goat farming by 5% at 1% level of significance. This implies that dairy goat farming is mainly practiced by older age farmers (above 41 years). The 1% level of significance reported from the gender variable is an implication that, male-headed household had a higher influence on the decision to practice dairy goat farming in the study area. The level of education attained by the household head also positively determined the adoption of dairy goat farming at 10% level of significance. This result suggests that a farmer who has attained at least secondary education level in the study area is more likely to rear dairy goats (Table 4.4). Holding a title deed for the occupied land influenced participation in dairy goat farming at 1% level of significance. Finally, the total household income positively affected the possibility of keeping dairy goats at 1% significance level.

Table 4.4: Results of the probit regression showing the factors affecting participation in dairy goat farming

Variables	*Coefficient*	*Std. err.*	*z*	*P>z*
Age	0.0527***	0.0083	6.32	0.000
Gender	0.5486***	0.1656	3.31	0.001
Household size	0.0582	0.1061	0.55	0.583
Education	0.1870*	0.1108	1.69	0.091
Farm size	0.1905	0.1418	1.34	0.179
Land ownership status	-0.0125	0.1183	-0.11	0.916
Title deed	0.4807***	0.1757	2.74	0.006
Household Income	0.2276***	0.0825	2.76	0.006
-cons	-4.1408	0.9231	-4.49	0.000
Number of observations	385			
LR $Chi^2(9)$	67.98			
Pseudo R^2	0.1453			
$Pro>Chi^2$	0.000			
Log likelihood	-199.908			
Region of support	0.193262,0.981365			

*******=1% significance level, *=10% significance level, Std. err=standard error

4.5 Assessing the matching quality

To determine whether there is any overlap in the common support region, figure 4.2 and 4.3 were plotted. The two graphs also validate the assumption that 'for each treated observation, there is a nearest match in the control observation with similar characteristics'. Figure 4.2 showed a very strong common support given the overlap in larger amount of the population. The blue line represented the empirical distribution of propensity scores for the treatment group (dairy goat farmers) and the red line represented the empirical distribution of the control group (non-dairy goat farmers). Figure 4.3 further revealed the quality of propensity scores distribution among the

treatment units, and their comparison at every point. The histogram implied that most of the propensity scores for both groups were within the region of common support.

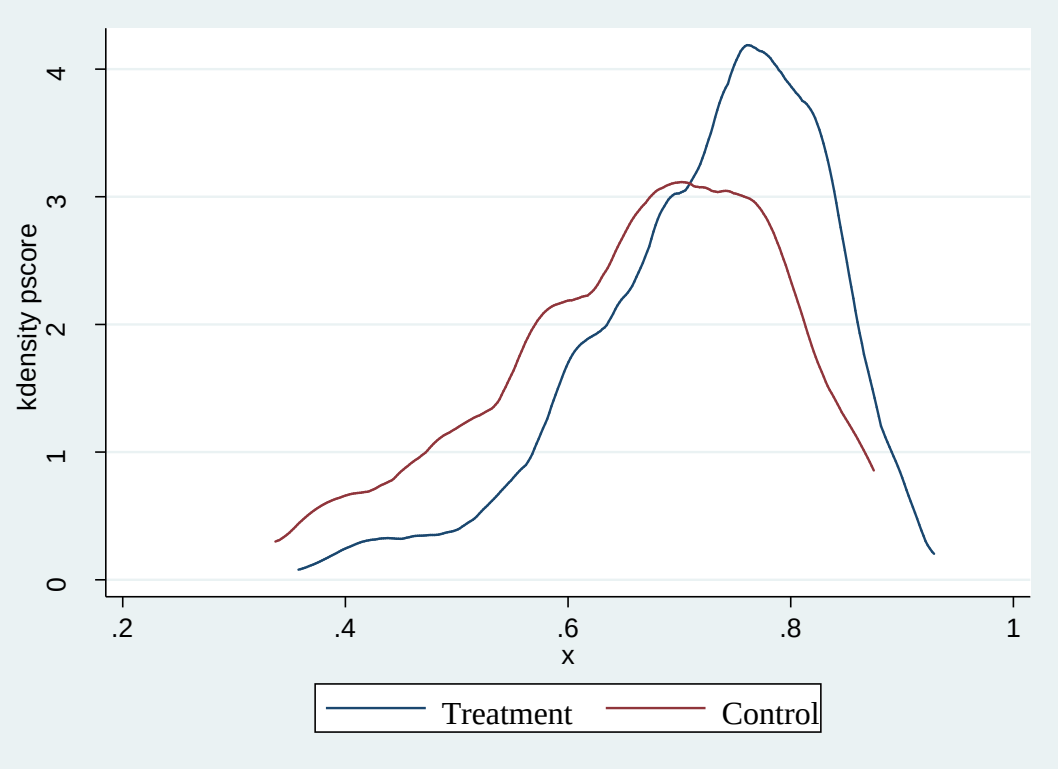

Figure 2.2: Common support region of propensity score

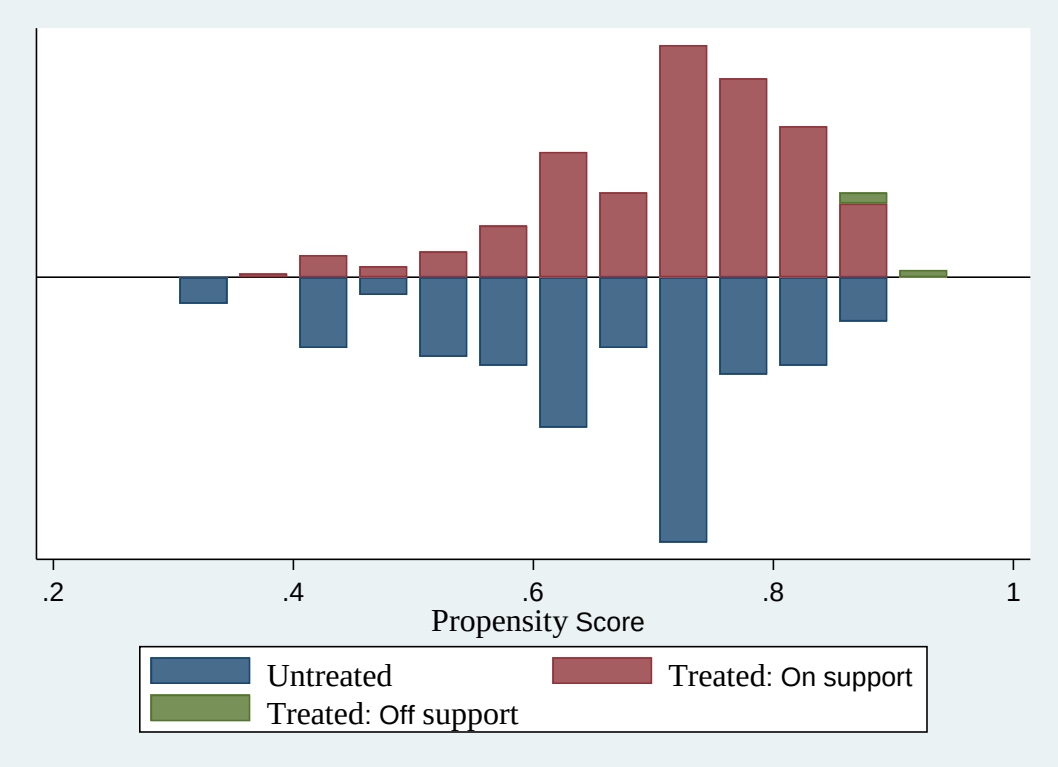

Figure 4.3: Propensity score distribution for the dairy goat and non-dairy goat farmers.

4.6 Average effect of dairy goat farming on household dietary diversity

The NNM results revealed that DGF had higher HDDS by 1.044 (ATT), at 1% significance level (Table 4.5). The ATT implies that farmers who practiced dairy goat farming increased their dietary diversity scores by 1.044 compared to non-dairy goat farming households.

Table 4.5: Results of the NNM showing the Effect of Dairy Goat Farming on HDDS

Outcome	Coeff.	St.Err.	t-value	p-value	Interval]	Sig
HDDS	1.044	.196	5.33	0	1.428	***
Mean dependent var	10.335		Std.Dev dependent var		1.291	

****p<0.01, **p<0.05,*p<0.1,* HDDS=household dietary diversity score, Coeff.=Coefficient, St.Err.=Standard Error, Std. Dev=Standard Deviation, Var=Variable.

4.7 Reasons for rearing dairy goats in Kirinyaga East Sub-County

The findings in current study showed that 39% of smallholder farmers chose to rear dairy goats to generate milk for home consumption (Figure 4.4). Another reason for keeping dairy goats was for sale of manure according to 23% of the respondents. Approximately 14% of the farmers reported that small farm sizes made them rear goats. Also, 10% of the farmers indicated that their reason for practicing dairy goat farming was for sale of goats either to brokers or in the available open markets. With regard to keeping dairy goats for the sale of milk, only 10% of the respondents accounted for that. Proportion of farmers who kept dairy goats for meat was low (2%), and no farmers reported dowry payment as a reason for keeping dairy goats.

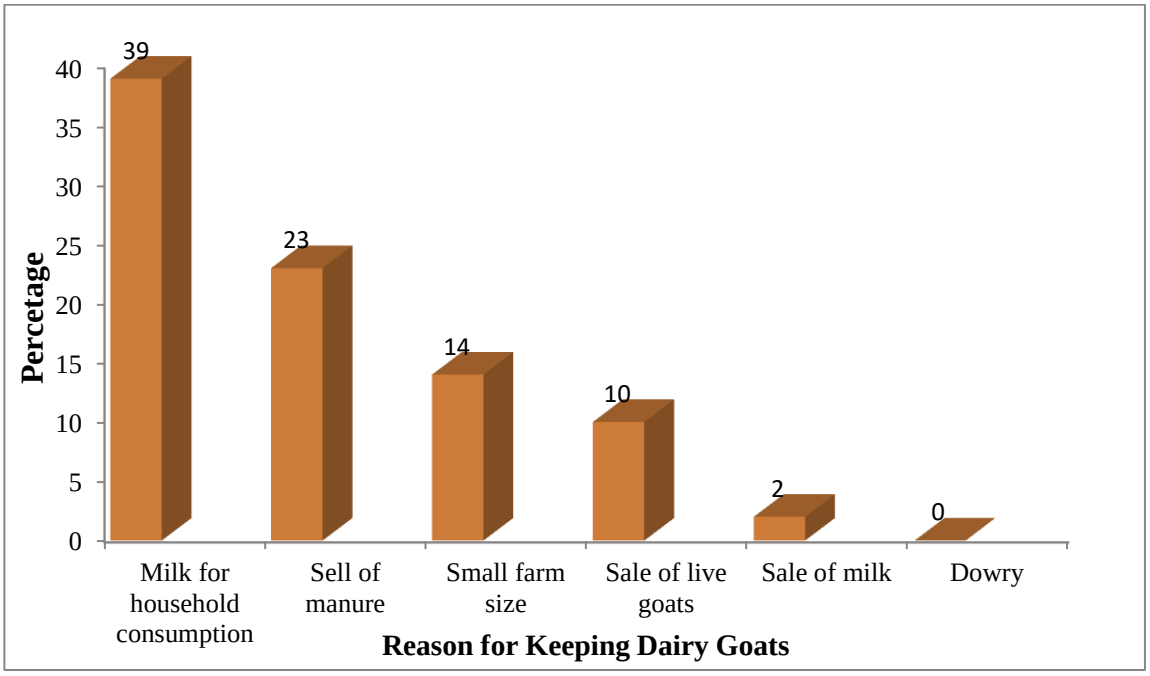

Figure 4.4: Reasons for participating in dairy goat farming

4.8 Challenges encountered by smallholder farmers in dairy goat farming

In order to understand the effect of support services on dairy goat farming, this research sought to enquire about the major problems faced by smallholder famers (Figure 4.5). Lack of extension services was indicated by 26% of farmers. In adequate feed for goats including both natural pastures and supplements was also a problem faced by 20% of respondents. Results also showed that 18% of respondents did not have a readily

accessible market for goat milk. High cost of veterinary services was another drawback indicated by 16% of respondents. Results also showed that 9% of respondents lacked sufficient knowledge about markets, while 11% of respondents agreed that pests and diseases were a concern that affected dairy goat farming enterprise.

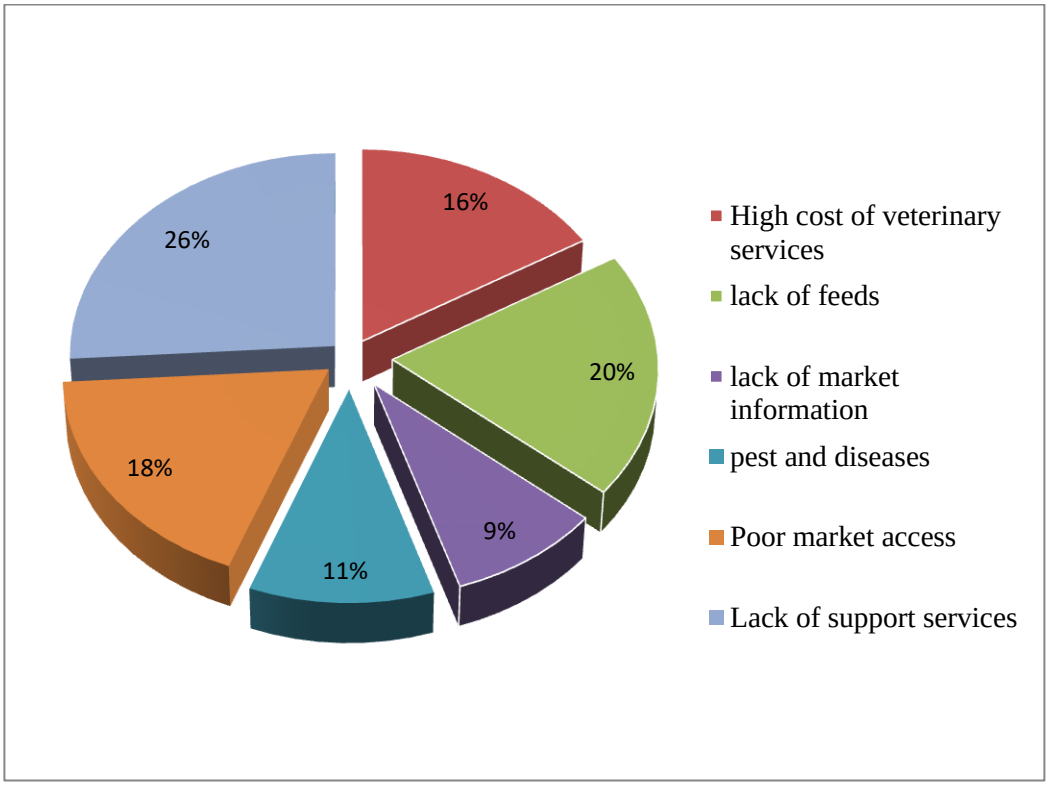

Figure 4.5: Common challenges experienced by smallholder dairy goat farmers

4.9. Support services received by smallholder dairy goat farmers

The findings revealed that most of the farmers did not receive supports services such as extension, marketing, breeding, and financial assistance (Table 4.7). Only 4% of dairy goat farmers received government assistance through feed subsidies; 10% received extension visits primarily on dairy goats; and 17% of the respondents had access to market information. Group membership was reported by 41% of the respondents, where most groups available were registered under DGAK. The results further showed that 41% of the farmers received veterinary services. Breeding services were available to 27% of respondents, where farmers in the respective DGAK groups benefited more.

Finally, only 15% of the farmers reported to have received financial assistance expressly for dairy goat farming.

Table 4.6: Access to support services among dairy goat farmers in Kirinyaga East Sub-County

Variable (Support service)	Mean	Frequency	Percentage	Std.Dev.
Feed subsidies from the Government	0.03			0.159
No		261	96.3	
Yes		10	3.7	
Extension services	0.29			0.456
No		245	90.4	
Yes		26	9.6	
Marketing information	0.03			0.159
No		226	83.4	
Yes		45	16.6	
Group membership	0.07			0.260
No		159	58.7	
Yes		112	41.3	
Veterinary services	0.41			0.288
No		160	59.0	
Yes		111	41.0	
Breeding services	0.91			0.493
No		199	73.4	
Yes		72	26.6	
Credit services	0.14			0.348
No		233	85.0	
Yes		38	15.0	

4.10 Effects of support services on dairy goat milk production among smallholder farmers

From the log-linearized Cobb-Douglas regression results, the R^2 was 0.541 (Table 4.7). This implies that 54% variation in the dependent variable (dairy milk output) was explained by the independent variables (various support services). The F-statistic was significant at 1% implying that the regression model was good for the analysis of both the dependent and independent variables. Furthermore, the mean VIF among the independent variable was 1.18, suggesting that no multicollinearity was detected (Table 4.7).

At 1% level of significance, membership in collective groups had a positive effect in total milk production. This means that farmers' enrolment in a groups increased milk production by 0.495 units. The coefficient for extension services was also positive and significant at 1%; where increase in extension visits by one visit increased milk production by 0.646 units. Furthermore, breeding services negatively influenced milk production at 1% level of significance. This implies that, when one doe is served by a buck, milk output decreases by 0.612 units.

Table 57: Effect of support services on goat milk production among smallholder farmers

LnDaily milk output per doe (in litres)	Coeff.	Std.Err	t-value	p-value	VIF
Government subsidies on feeds	-0.035	0.152	-0.23	.818	1.10
Group membership	0.495	0.12	4.12	0.000***	1.19
Extension services	0.646	0.14	4.63	0.001***	1.03
Veterinary service	-0.267	0.21	-0.13	0.901	1.39
Breeding services	-0.612	0.203	-3.01	0.005***	1.11
Financial service	0.067	0.167	0.40	0.690	1.23
Marketing support	-0.052	0.116	-0.45	0.658	1.20
Constant	3.746	0.192	19.55	0.000	

*** p<.01, ** p<.05, * p<.1, Ln= natural logarithm, R^2= 0.541, Prob>F= 0.000; Coeff.=Coefficient, St.Err.=Standard Error, VIF=Variance Inflation Factor, Mean VIF= 1.18

4.11 Effects of access to market for goat milk among the dairy goat farmers

Majority of the farmers (68%) indicated that they travelled 5 to 10 kilometres to the nearest market (Table 4.8). Similarly, approximately 68% of farmers spent 4-5 hours to the nearest market. A large number of smallholder farmers (73%) accessed informal milk marketing channel where milk was sold to neighbours, 20% sold milk at the farm gate, and 7% sold milk in hospitals.

Table 68: Indicators of market access reported by dairy goat farmers

Variable	Frequency (N=271)	Percentage
Distance to the nearest market (Km)		
1-4	63	23.3
5-10	183	67.5
>10	11	9.2
Time taken to the nearest market (Hrs.)		
1-3	76	28.0
4-5	184	67.9
>5	11	4.1
Milk Marketing Channel (N=69)		
Neighbours	50	72.5
Farm gate	14	20.3
Hospitals	5	7.2

4.12 The effect of access to market for goat milk on household food security

The binary logistic regression results as presented in Table 4.9 shows the determinants of food security (household consuming diversified diets) with regard to access to market for goat milk. The overall predictive power of the model was indicated by Pseudo R^2 at 44%, while the Chi square (X^2) value (157.88) was significant at 1% (p=0.000) an implication that the model was fit for this analysis. The VIF of all the considered variables was $\leq$ 6, where the mean VIF was 2.39, an implication that there was no perfect collinearity between the independent variables included in the model.

On this study, market access for goat milk was determined by two indicators namely time to the nearest market, and distance to the nearest market. The time to the market had a positive effect but did not significantly influence the household food security status in terms of the food groups consumed. On the other hand, distance to nearest market was significantly related to the number food groups consumed in a household with the expected odds ration being negative 0.03 units, that is, an increase in distance to the nearest market by 1km decreased the ability to score high HDDS by 0.03 units.

The other control variables that influenced HDDS included, marketing channel used, experience in dairy goat farming, flock size, household size and gender of the household head. The marketing channel variable had a negative but significant coefficient at 5%. This implies the choice of marketing channel did not enhance the purchase of diversified foods. The experience of farmers in dairy goat farming had a positive influence on dietary diversity at 10% level of significance, implying that increase in experience on dairy goat farming by one year increased HDDS by 1.17 units.

Flock size was also positively related to HDDS of smallholder farmers. This means that, increase in the flock size by one goat increases the likelihood of varied food categories being consumed in the household. Finally, household size and gender of the household head were also significant at 10% with a positive coefficient. This means that as the number of members in the household increased by one the HDDS of the farmers increased as well. Lastly, the male heads in the household positively increased the number of farmers scoring high HDDS. This implies that male-headed household had more HDDS by 0.46 units compared to female-headed households.

Table 79: Association between access to market for the goat milk and HDDS of smallholder dairy goat farmers

Variable	β	Standard error	p-value	VIF
Market Indicators				
Time to the nearest market (Hrs.)	0.994	1.400	0.997	7.62
Distance to the nearest market (Km)	-0.029	0.041	0.012**	7.61
Road type	1.137	0.350	0.678	2.47
Milk marketing channel	-1.773	0.433	0.019**	2.45
Control Variables				
Experience in the DGF	1.172	0.107	0.082*	1.60
Monthly household income (KES)	1.372	0.276	0.116	1.29
Number of dairy goats kept	0.596	0.117	0.008***	1.23
Main occupation	1.089	0.283	0.744	1.22
Farm size(Ha)	1.141	0.387	0.697	1.17
Household size	1.723	0.520	0.071*	1.14
Age(Years)	0.970	0.020	0.138	1.12
Gender	0.457	0.185	0.053*	1.09
Constant	53.102	116.713	0.071*	1.05

Log likelihood = -100.55

LR chi2(12) = 157.88

Prob > chi2 = 0.000

Pseudo R^2 = 0.440

*** p<.01, ** p<.05, * p<.1, Mean VIF=2.39

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter provides detailed discussion of the results presented in chapter four, followed by the study's conclusions and recommendations. The section relates the study findings with prior research on the basis of dairy goat farming and household dietary diversity, the association between support services and goat milk yield, as well as contribution of access to market for goat milk on HDDS among smallholder farmers.

5.2 Summary of the descriptive statistics

The findings of the social and demographic statistics show that majority of the respondents were males aged 42 and above (Table 4.1). This is an indication that most of the households in the area were headed by men as the major decision makers as opposed to women. The difference in age among the DGF and NDGF age explains the more number of years in dairy goat farming seen in Table 4.2. The results show that the average household size was 5, the reason why the most of the farmers opted to produce milk for family consumption as opposed to sale (Table 4.2). The highest level of education attained was primary and secondary, meaning that the farmers were literate and could easily read on various farming practices. The results also reveal that majority of the farmers occupied less than 1ha and 1-2ha of land (Table 4.1). The small farm sizes reported accounts for less number of dairy goats kept and increased adoption of zero-grazing production system contrary to tethering (Table 4.2). Besides, the small flock size translates to limited income specifically from dairy goat farming (Table 4.2) and overall household income (Table 4.1).

The findings on the status of land occupation showed that majority of the farmers had inherited their land, and held the respective title deeds. The fact that most of DGF had title deed compared to NDGF (Table 4.1) explains the association of title deed possession to economic benefits from the dairy goats (Sabila, 2014), in terms of sale of milk and manure. The main occupation adopted by most farmers was agriculture (Table

4.1) which affirms why a good number of the DGF used manure in their farms to improve fertility (Table 4.2).

The results further established that Kenyan Alpine and Toggenburg were kept by most of the farmers and the bucks were dominantly for breeding. The bucks were obtained from the neighbours or various groups where farmers had registered. Farmers preferred natural mating method because of the less household income (Table 4.1), given that, use of bucks is generally cheaper (Maitho & Kinyua, 2018). Similarly, results show that the commonly used type of feed was natural pastures and crop residues (Table 4.2). This preference as well resulted from the less income (Table 4.1) that cannot support purchase of supplements, thus, reduced milk output per doe per day (Table 4.2).

5.3 Contribution of dairy goat farming to household dietary diversity

Results from study revealed that DGF households had diversified diets compared to NDGF given the higher HDDS (Table 4.3). This is because DGF generated extra income from the sale of milk, manure and goats, which might have complemented the food expenditure. Besides, the use of goat manure in cultivating land (Table 4.2) is likely to increase crop production among the DGF, ensuring enough food for household consumption and surplus for sale (Kafle, 2014). This result is consistent with the concept of the study and also in line with Nyambok (2015) who observed that farmers regularly consumed a greater variety of food groups after adopting dairy goat farming. The mean HDDS observed for DGF households was, however, higher than the average score of 5.7 reported by Woldu et al. (2016) for the highlands of Ethiopia. This variation could be due to the fact that in this Kenyan region more households consumed milk, fruits and wheat products in relatively higher proportions, as opposed to dairy goat farmers in the Ethiopian highlands where these food items were taken in low proportions.

Diversified diets from DGF households as compared to NDGF households were realized through an increased intake of fruits, wheat products, roots and tubers. Increased consumption of wheat products, fruits, and root and tubers food items among DGF is because as aforementioned, the extra income earned from the dairy goat enterprise capacitated the purchase of these food items, while the use of manure increased the fruits, roots and tubers productivity in the farm. These findings agree with Workicho et

al. (2016) who reported that, the frequently consumed food items among the high HDDS households were tubers and fruits. Besides, the overall number of consumed food groups was above five which is an indication that this region has met the minimum dietary intake as recommended by FAO, with five being the cut-off point in any dietary diversity assessment (FAO, 2014).

The absolute consumption of vegetables, cereals, and beverages by both groups is a direct result of agriculture being the dominant occupation. This confirms the findings of Rozy et al. (2016) also made in Kirinyaga County that vegetables and especially African leafy vegetables, such as pumpkin leaves, cowpea, amaranth, and nightshade, were consumed by most farmers. Additionally, the region dominates in production of rice (Evans et al., 2018), and tea (Leshamta, 2017), which could contribute to the high consumption of cereals and beverages, respectively. The findings are further in agreement with Woldu et al. (2016) and Kalavathi et al. (2010) who found that the food categories consumed by most dairy goat farming households were vegetables and cereals.

The results also indicate that a large number of households consumed sugar, fats and oils (Figure 4.1). High consumption of sugars, fats, and oils in probably due to the fact that household income enable purchase of these products. Moreover, the consumption of tea is mainly accompanied by the use of sugar as a sweetener (Fadlillah et al., 2020). However, high proportion of (saturated) cooking oil and sugar in diets is in contradiction with the dietary guidelines for humans, considering such diets may result to heart diseases due to increased cholesterol level or diabetes attributable to increased intake of sugar (Herforth et al., 2019). The WHO fact sheet advocates higher intake of unsaturated fats, for example, from fish, nuts and avocado to promote a balanced diet (WHO, 2018). Also, FAO's national dietary guidelines for Kenya shows that fish, meat and eggs are under the category of the protein-rich food to be consumed at least twice a week to assure a balanced diet (FAO, 2014; Herforth et al., 2019). The findings show that, fish, meat and eggs were poorly consumed by both DFG and NDGF households. The low consumption of fish, meat and eggs could be explained by the continuous rise in prices of fish and meat over in Kenya (Korir et al., 2020), thus, limiting access. Also, most of

the farmers rearing goats among the participants failed to acknowledge meat production as a major reason for keeping dairy goats (Figure 4.3). Similarly, very few farmers sold milk and this might have contributed to less income from goat enterprise (Table 4.2), to support purchase of meat fish and eggs, and ultimately low consumption. Results in this research work are in line with the findings of Woldu et al. (2016), where dairy goat farmers in Ethiopia also consumed eggs, fish and meat in lower quantities.

The observed difference in milk consumption among DGF and NDGF is because most DGF households decided to keep goats for domestic milk consumption (Table 4.2). Keeping dairy goats to obtain milk for household consumption also improved intake of dairy products among smallholder farmers in Thika sub-County in Kiambu, Kenya (Kagucia et al., 2020). Ultimately, the findings show that dairy goat farming is positively associated with dietary diversity of smallholder farmers considering the positive ATT value of 1.044. This conclusion is in agreement with Tiffanie et al. (2020) who also found that keeping dairy goats promoted improved household nutrition. Besides, in estimation of ATT for a given treatment, the t-value obtained should be greater than 2 to conclude whether a satisfying match between the treated and the control observation was made (Isaboke et al., 2016). This study found a t-value of 5.33, which indicates that a suitable match between the DGF and NDGF was achieved.

5.4 Determinants for participation in dairy goat farming

The decision to participate in dairy goat farming was determined by gender, age and formal education, title deed ownership and household income (Table 4.4). Majority of respondents in DGF households in the study area were men (Table 4.1). Male-headed households might have dominated the decision to practice dairy goat farming because men are more likely associated with highly valued assets in the households and have complete control over such assets (Kariuki et al., 2013). Based on the aforementioned, it is evident that dairy goats are kept for income generation through sale of milk, manure, and replacement (Nyambok, 2015). The findings are in agreement with Woldu et al. (2016) who also found that males accounted for the highest number of dairy goat farmers' participants in his study. The results are however, contrary to Mureithi et al. (2022), who reported females as the greatest population that determined DGF in Nyeri

County, Kenya. As such, dairy goats being an income generating livestock assets explains the great embracement among the male-headed households. Besides, according to Jaza et al. (2018) men are more physically strong and active to care and manage livestock activities compared to women.

The study findings revealed that age of the household head was associated with the decision to keep dairy goats. This is because, older age comes with increased awareness of the role of dairy goats in production, nutritional benefit (related to the goat milk), and economic importance. The findings closely relates to Mataveia et al. (2018) and Maitho and Kinyua (2018) who found that most of the dairy goat farmers were 45 years and 48 years respectively. Attainment of formal education also determined whether to keep dairy goats. The results agree with the study by Maitho and Kinyua (2015), where most of the DGF had attained at least secondary education in Laikipia district, Kenya, which consequently impacted some know-how to manage the goats. Besides, Musyoka et al. (2017) reports that dairy goat farmer in Kitui County, Kenya had attains at least primary education, which capacitates mental attitude to welcome new practices and technologies aimed at improving production.

Income is also an important consideration for the decision to practice dairy goat farming as sufficient financial resources are required to cover the costs of purchasing goats as well as veterinary, breeding and feeding expenses (Mbindyo et al., 2018). The probit regression underpinned these findings where overall household income increased the probability to rear goats. The affirmative impact of income on the decision to rear dairy goats was in agreement with Kipserem et al. (2013) and Musyoka et al. (2017) that, households that have more income are assured of capital to start up dairy goat farming activity, and also manage the activity in terms of feeds and veterinary costs involved.

Ultimately, the ownership of title deed, positively contributed to the decision to adopt dairy goat farming. The result also showed that most DGF respondents had a title deed for the land owned which assured secure land tenure. The findings are in support of Saravia-Matus et al. (2016) that land tenure allows farmers to establish a zero-grazing system with a small stable, and put more land under forage. Similarly, Aravindakshan et

al. (2020) found that secure land tenure was associated with increased agricultural productivity and land improvement among famers in Bangladesh.

5.5 Reasons for farming dairy goats

Results indicated that most of the respondents decided to rear dairy goats to have milk mainly for household consumption (Table 4.2). This can be attributable to the goat milk being rich in vitamins and proteins (Mburu, 2016). Goat milk is a good source of Calcium which is essential in physiological activities in the body; as well as proteins which can prevent occurrence of chronic conditions like blood pressure and cardiovascular diseases (Nyambok, 2015). Similarly, another reason behind increased milk production for household consumption could be less milk output per doe, per day which mainly averaged at 0.5-1 litre for most farmers. As such, quantities left for sale are low. Additionally, a global overview on dairy goat productivity conducted by Miller and Lu (2019) confirm that dairy goats are mainly kept for milk and meat\ production in Africa, Asia, and Latin America, where the goat's ability easily adapt in arid and dry areas relatively increases their importance.

5.6 Constraints to dairy goat farming

Increasing constraints in the dairy goat sub-sector continue to cause losses among the smallholder farmers (Mbindyo et al., 2018). The results revealed that, challenges experienced by majority of dairy goat farmers were lack of support services, lack of feeds, poor market access for goat milk and high cost of veterinary services (Figure 4.3). This was because livestock extension officers were reported to be few in the area, and were often overwhelmed in efforts to cover a larger scope and assist more farmers; besides, the visits were founded on high fees, and most of the smallholder farmers could not afford them (Munyua, 2011).

These results are further consistent with the findings in Zanzibar where fodder shortage, inadequate extension services, in addition to diseases were challenges to dairy goat farming (Tiffanie, 2020). On the contrary, in Kahi and Wasike (2019) report, lack of supplementary feeding containing specific rations required by dairy goats, and poor quality of the fodder due to edaphic and climatic factors which consequently impact the

dairy goat performance negatively, were the challenges impacting dairy goat farming in sub-Saharan Africa. Lack of milk market has also been identified by a number of previous studies where it is directly linked to poor distribution channels especially to the urban centres or organized market structures (Mbindyo et al., 2018; Mburu et al., 2014; Richard, 2017).

5.7 Determinants of milk productivity in dairy goats

Milk output is attributable to several support services provided to the smallholder farmers. The results from the present study showed that, group membership (cooperative societies or self-help groups) had a positive correlation to dairy goat milk yield (Table 4.7). This is because, famers in the groups are likely to benefit from services like training on improved production, health management, as well as bulk purchases of inputs (for instance deworming and vaccination doses). The results agree with Mureithi et al. (2022) who found that farmers involved in group membership were in a better place to uptake updated dairy goat farming technologies, and as well be exposed to new and improved ideas to enhance their enterprise. Similarly, in another study group membership increased the sense of belonging among the dairy goat farmers; through which economic and social motivation was in-built, and they all aimed at improving performance as a group rather than individually (Haryadi et al., 2016). Contrary, Miller and Lu (2019) reported that, while involvement in dairy goat producer groups enhanced one voice in the procurement of inputs and linkage to markets for their produce, the impact of these groups in the United States was less felt because they were small in size and completely self-funded.

Provision of extension services also had a positive correlation to dairy goat milk output (Table 4.7). This relationship can be attributable to the fact that, dairy goat smallholder farmers who receive extension visits are educated on wide range of activities from feeding, breeding and health management; thus addressing some of the misconceptions pertaining dairy goat farming and as well increasing knowledge and experience in the sub-sector (Haile, 2012). The results are also in line with Kagucia et al. (2020) where dairy goat productivity was determined by the presence of animal health extension officers; who assisted in the diagnosis of major health conditions such as affecting

animals such as helminthosis, mastitis, coccidiosis, and pneumonia. Another study assessing improved goat breeding in the East Africa reported that, extension support is necessary to offer specialized knowledge on how to handle crossbred goats, hence improved performance (Amati & Parkins, 2011). The current results as well reported about 90% of the respondents who did not receive extension support. The findings are in line with a policy research conducted in Zimbabwe on the role of extension in dairy production where; specialized extension services were limited, and well-structured mechanisms to reinforce linkage between dairy smallholder farmers and extension service providers was lacking (Mujeyi & Mutodi, 2021).

Additionally, the study findings disclose that breeding services (that is breeding programs to impact farmers with improved cross breeding initiatives) had a negative effect on milk yield. This is because very few farmers acknowledged of receiving breeding services (Table 4.6), implying that they proceeded to borrow or hire the bucks from neighbours (Table 4.2), without adequate knowledge on genetically improved goats to be used in their breeding system. Insufficient know-how on breeding management is the major cause of low output among dairy goat farmers (Amati, 2011). Correspondingly, Duncan et al., (2013) reported that, improved and well managed breeding techniques are associated with increased milk productivity, likely to attract high quality markets. Ultimately, results are also in agreement with Mbindyo et al. (2018) who reported that, less information on dairy goat husbandry, such as better breeding practices among the farmers increased rotation of the buck without upholding the correct selection criteria (for instance body size, growth rate, disease resistance).

5.8 Relationship between access to market for goat milk and household dietary diversity among dairy goat smallholder farmers

Results indicated that HDDS of smallholder farmers is associated with access to market for goat milk when proxied by distance to the nearest market as opposed to time taken to the nearest market (Table 4.9). This could be because long distances make it challenging for farmers to access quality markets with favourable milk prices (Migose et al., 2018), and other food products not produced in the farm. The results agree with Usman and Haile (2019) who found that expenditure on food decreased as distance to the market

increased in Ethiopia and Tanzania. Also, Sibhatu et al. (2015) recorded similar results where longer distance to the market resulted to low dietary diversity among smallholder farmers in Indonesia, Kenya, Ethiopia and Malawi.

Regarding the other explanatory variables employed in the model, the majority of the smallholder farmers who sold milk primarily used the conventional channel such as neighbours and farm gate (Table 4.8), which explains the negative connection between HDDS and the marketing channel selected. Commonly, traditional channels have little exposure to the market, hence, farmers are less likely to access diversified foods or generate more profits to account for food expenditure. Furthermore, the study conducted in Indonesia by Toiba et al. (2020) supports these conclusions because smallholder farmers who participated in modern marketing channels were more likely to be food secure than those who engaged in traditional produce output channels. According to the current results, farming experience in dairy goat farming was linked to HDDS. This is due to the fact that majority of the farmers have been engaged in dairy goat farming for at least seven years, which, when viewed from food security perspective, translates to greater expertise and information on dairy goat farming as well as food consumption. The results are consistent with those of Huluka and Wondimagegnhu (2019), who found that household heads with more experience in farming had higher HDDS by 0.4% than those with less experience.

The results showed a positive association between HDDS and flock size (Table 4.9). This is because goat milk, one of the 12 food categories covered by the study, was primarily consumed at the household level (Figure 4.1). The findings are in line with prior research which confirm that a key determinant of household food security is the quantity of livestock held (Megersa et al., 2014; Regassa & Stoecker, 2012). In this study, household size and HDDS were correlated (Table 4.9). This is owed to the fact that households had at least 5 members, and consumption heterogeneity might arise, resulting to intake of diverse food products. The outcomes are consistent with Usman and Callo-Concha (2021)who reported high HDDS by 8% as the household size increased.

Given that men made up the majority (58%) of the study's respondents (Table 4.1), and a positive association between gender and HDDS was reported, means that, households led by men were more likely to consume varied diets. The results are in line with the findings by Woldu et al. (2016), who reported that HDDS was high among households with male heads than households with female heads. This is because males are often the source of income in household, decisions makers on different household expenditures including food, and the ones in charge of managing finances (Kihiu & Amuakwa-Mensah, 2021). The results are however, contrary to Workicho et al. (2016), who reported that women are associated with high HDDS more compared to men, because if their great concern on the different foods taken in the family in terms of protein-rich and quality. Therefore, it is essential to note that, although men are the major decision makers, HDDS would be higher if joint decisions on food consumption are made at the household level.

5.9 Conclusion

This study aimed at determining the contribution of dairy goat farming to household food security, effect of support services on dairy goat milk production, and the effect that access to market for goat milk has on the household food security of smallholder farmers. The contribution of the research findings to the existing literature three fold. Firstly, the findings provide more information on the relationship existing between dairy goat farming and dietary diversity. Secondly, the results give an insight of how availability of support services affect production. Finally, further evaluation on the effect of market access to HDDS among smallholder is determined.

In this study, HDDS was used as a measure of food security, where the dietary diversity scores were based on consumption of 12 food items in the past seven days. The findings suggest that both DGF and NDGF had diversified diets, but, the DGF scored higher HDDS implying that they were more diversified in their diets. Nonetheless, the results suggest that, although the households were food secure, their diets are not optimal considering a higher percentage of food intakes is composed vegetables and staples. To understand the relationship between dairy goat farming and household food security, the study compared the HDDS of dairy goat farmers and non-dairy goat farmers using the

PSM method. The findings showed that dairy goat farming is positively associated with dietary diversity at the household level evidenced by the positive and significant ATT value.

The research also revealed that group membership, extension services and breeding services were some of the support services that directly affected dairy goat milk production. The study established that, membership in groups provided a ground for training on feeding and health management while extension officers were critical in development of dairy goat farming to improve farmers' knowledge and skills in dairy goat husbandry through advisory services. Finally, inadequate know-how on the breeding method used among smallholder farmers was negatively related to milk yield.

Lastly, in efforts to find out how household dietary diversity is affected by market access to goat milk. Market access was proxied by travel time and distance to markets. The findings highlighted that market access is positively related to food consumption and food security at the household level. Further, factors like flock size, experience in dairy goat farming, marketing channel, household size, and sex of household head also impact on HDDS of the farmers.

5.10 Recommendations

Since keeping dairy goats resulted in a positive ATT, smallholder farmers should be encouraged to continue adopting dairy goat farming to increase food security. With more smallholder farmers adopting the practice, diet diversity and consequently nutritional security is ascertained. Besides, high consumption of starchy foods and low consumption of protein-rich foods in the study area is noteworthy. As such, more research is needed to identify specific causes of the low intake fish, meat and eggs food items.

Given that group membership and extension services resulted in increased milk yield, dairy goat farmers should consider joining formal or informal livestock groups to benefit from the services offered, which are related to improved milk yield. On the other hand, to ensure that services are provided to farmers in a broader context, it is essential for the national government and other development agents to engage more livestock

extensionists who are experts in dairy goat farming to rural smallholder farmers. The study also revealed that limited breeding support when using bucks can results to less milk production. As such, modern breeding methods like Artificial Insemination (AI) should be introduced to the farmers besides natural mating. This is because AI promotes use of genetically improved goats and minimizes the cost of keeping bucks and monitoring the breeding process.

Considering the elevated issue on goat milk market access, evidenced by long distances in the present study. Closer bulk milk collection points can be opened in the rural areas. This would motivate farmers to produce more milk and set aside some amount from their daily production for sale. Besides, the milk collection points will reduce transaction costs that might be deterring smallholder farmers from participating in contemporary marketing channels.

5.11 Areas for further research

The current study only took into consideration the household food security status as opposed to individual. This is as a result of the uneven distribution of intra-household dietary diversity. However, individual dietary diversity intake is different to household level of diversity; therefore, there is need for further research to examine how dairy goat farming, support services and market access for goat milk can lead to improved nutrition among the elderly or a child's growth rate. Additionally, the data reflected the Central highlands of Kenya; therefore, it would also be necessary to examine the contribution of dairy goats to dietary diversity in other agro-ecological zones.

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APPENDICES

Appendix 1: Matrix of correlation

Variables	Age	Gender	HH size	Education	Land ownership	Title deed	Farm size	Main occupation	HH income
Age	1.000								
Gender	-0.010	1.000							
HH size	0.117	-0.071	1.000						
Education	-0.209	-0.213	-0.034	1.000					
Land ownership	0.104	-0.013	-0.022	0.040	1.000				
Title deed	0.105	-0.097	0.013	0.081	0.003	1.000			
Farm size	0.143	-0.125	0.086	-0.022	-0.070	0.216	1.000		
Main occupation	-0.081	-0.070	0.042	0.263	0.060	-0.157	-0.054	1.000	
HH income	-0.090	-0.160	0.108	0.304	0.071	0.042	-0.025	0.314	1.000

Appendix 2: Raw results of the models

2.1 Propensity score matching

****
Algorithm to estimate the propensity score
****
The treatment is Dairy_goat_farming

Dairy Goat

Farming	Freq.	Percent	Cum.
No	114	29.610	29.610
Yes	271	70.390	100.000
Total	385	100.000	

Estimation of the propensity score
Iteration 0: log likelihood = -233.89786
Iteration 1: log likelihood = -200.58175
Iteration 2: log likelihood = -199.90971
Iteration 3: log likelihood = -199.9085
Iteration 4: log likelihood = -199.9085
Probit regression Number of obs = 385
LR chi2(9) = 67.98
Prob > chi2 = 0.0000
Log likelihood = -199.9085 Pseudo R2 = 0.1453

Dairy_goat~g	Coef.	Std.Err.	z	P>z	[95%Conf.	Interval]
Age	0.053	0.008	6.320	0.000	0.036	0.069
Gender	0.549	0.166	3.310	0.001	0.224	0.873
HH_size	0.058	0.106	0.550	0.583	-0.150	0.266
Education	0.187	0.111	1.690	0.091	-0.030	0.404
Farm_size	0.190	0.142	1.340	0.179	-0.087	0.468
Land_Owner~p	-0.013	0.118	-0.110	0.916	-0.244	0.219
Title_deed	0.481	0.176	2.740	0.006	0.136	0.825
HH_income	0.228	0.082	2.760	0.006	0.066	0.389
_cons	-4.141	0.923	-4.490	0.000	-5.950	-2.332

Note: the common support option has been selected

The region of common support is [.19326157, .98136467]
Description of the estimated propensity score
in region of common support

Estimated propensity score

Percentiles		Smallest		
1%	.2328777	.1932616		
5%	.354006	.2050675		
10%	.4275692	.23081	Obs	382
25%	.5888268	.2328777	Sum of Wgt.	382
50%	.7537118		Mean	.708356
		Largest	Std.Dev.	.1842712
75%	.8524048	.9676992		
90%	.9168908	.972645	Variance	.0339559
95%	.9456987	.9760654	Skewness	-.7116464
99%	.9676992	.9813647	Kurtosis	2.660994

****

Step 1: Identification of the optimal number of blocks
Use option detail if you want more detailed output
****

The final number of blocks is 5

This number of blocks ensures that the mean propensity score
is not different for treated and controls in each blocks

****
****

Step 2: Test of balancing property of the propensity score
Use option detail if you want more detailed output

****
****

The balancing property is satisfied

This table shows the inferior bound, the number of treated
and the number of controls for each block

Inferior of block of pscore	Dairy No	Goat Yes	Farming Total
0.193	0	1	1
.2	21	10	31
.4	33	37	70
.6	38	93	131
.8	19	130	149
Total	111	271	382

Note: the common support option has been selected

****
***
End of the algorithm to estimate the pscore
****
***

2.2 Log linearized Cobb Douglas regression results

Daily_milk_produce~e	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Government_supppport	-.035	.152	-0.23	.818	-.343	.273	
Collective_groups	.495	.12	4.12	0	.252	.739	***
Extension_service	.646	.14	4.63	0	.364	.929	***
Veterinary service	-.267	.21	-.13	.901	1.39	2.328	
Breeding_service	-.612	.203	-3.01	.005	-1.024	-.2	***
Finacial_service	.067	.167	0.40	.69	-.272	.406	
Marketing_suppt	-.052	.116	-0.45	.658	-.287	.183	
Constant	3.746	.192	19.55	0	3.358	4.134	***
Mean dependent var		3.511	SD dependent var				0.506
R-squared		0.541	Number of obs				271
F-test		7.471	Prob > F				0.000
Akaike crit. (AIC)		44.235	Bayesian crit. (BIC)				56.882

*** *p<.01, ** p<.05, * p<.1*

2.3 Binary logistic regression results

log_FS	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Time_to_the_market	.994	1.4	-0.00	.997	.063	15.718	
Distance_to_the_ne~t	-.029	.041	-2.51	.012	-.002	.458	**
Road_type	1.137	.35	0.42	.678	.621	2.08	
Milk_marketing_cha~s	-1.773	.433	-2.34	.019	-1.098	2.861	**
Experience	1.172	.107	1.74	.082	.98	1.402	*
HH_income	1.372	.276	1.57	.116	.925	2.035	
Dairy_goat_kept	.596	.117	-2.65	.008	.407	.875	***
Main_Occp	1.089	.283	0.33	.744	.654	1.813	
Farm_size	1.141	.387	0.39	.697	.587	2.219	
Title_deed	1.108	.553	0.21	.837	.417	2.948	
HH_size	1.723	.52	1.80	.071	.954	3.113	*
Age	.97	.02	-1.48	.138	.933	1.01	
Gender	.457	.185	-1.94	.053	.207	1.009	*
Constant	53.102	116.713	1.81	.071	.715	3944.106	*

Mean dependent var	0.429	SD dependent var	0.337
Pseudo r-squared	0.440	Number of obs	271
Chi-square	157.881	Prob > chi2	0.000
Akaike crit. (AIC)	229.103	Bayesian crit. (BIC)	279.481

**** p<.01, ** p<.05, * p<.1*

Appendix 3: Questionnaire

Dairy goat production, support services and market access on food security among smallholder farmers in Kirinyaga County, Kenya.

Introduction

The following questionnaire is meant to help the researcher collect data which will impact on the understanding of how dairy goat production, support services and market access contribute to household food security of smallholder farmers in Kirinyaga East Sub-County. All information you will provide on this schedule will be used for the research purpose only, and absolute confidentiality will be observed.

A. GENERAL INFORMATION

HH_No: _____

Enumerator's Name: _____

Location: _____ Village: _____

Date: _____

B. SOCIO-ECONOMIC AND DEMOGRAPHIC INFORMATION

1. Name of the dairy goat farmer…….. …….
2. Mobile Phone No. of the farmer ……..
3. Name of the Household head …….
4. Respondent's relationship to the household head? a) Head [ ] b) Spouse [ ] c) Child [ ] d) parent [ ] e) Niece [ ] f) Nephew [ ] g) Worker [ ]
5. Gender of the farmer ; Male [ ] Female [ ]
6. Age of the farmer (Yrs.) …….
7. Marital status of the farmer? a) Single [ ] b) Married [ ] c) Windowed [ ] d) Divorced [ ] e) Other (Specify) …….
8. Household size.....

9. Highest level of education of the farmer? a) Primary [ ] b) Secondary [ ] c) College [ ] d) University [ ]
10. Farm Size (Ha) a) < 1ha [ ] b) 1-2ha [ ] c) >2ha [ ]
11. Land Ownership status? a) Private [ ] b) Lease c) Communal [ ] Inheritance [ ]
12. Do you have title deeds? Yes [ ] No [[
13. What is your main Occupational?
    a) Agriculture [ ]
    b) Self-employed [ ]
    c) Formally Employed [ ]
    d) House Wife [ ]
    e) House Maid [ ]
    f) Casual Labour [ ]
    g) Student [ ]
    h) Retired/Not active [ ]
    i) Others (Specify) ……
14. Total monthly household income a) 5,000-10,000 [ ] b) 10,001–20,000 [ ] c) 20,001 and above

C. Information on Dairy Goat Production

1. Does this household keep dairy goats? i) Yes [ ] ii) No [ ] *(If **NO** skip to **section F** on Food security)*
2. If yes, how many dairy goats do you keep? ……..
3. How long have you been engaged dairy goat farming ……. (Years)
4. What are the reasons for keeping dairy goat? (Tick all applicable)
    a. Small farm size [ ]
    b. Milk production for household consumption [ ]
    c. Milk production for sale [ ]
    d. Sale of live goats [ ]
    e. Meat production [ ]
    f. Dowry [ ]
    g. Manure [ ]
    h. Others (specify) …….

5. Which production system do you practice? a) Zero grazing [ ] b) Tethering [ ]
6. What is your average monthly income from dairy goats? a) < 3,000 [ ] b) 3,001-5,000 [ ] c) 5,001 – 10,000 [ ] d) > 10,001 [ ]
7. What other livestock do you keep?

Livestock Type	**Number**
i. Cattle	
ii. Sheep	
iii. Poultry	
iv. Donkey	
v. Pigs	
vi. Rabbit	
vii. Others (Specify)	

8. What type of breeds do you have in your farm? a) Kenyan Alpine [ ] b) Saanen [ ] c) Toggenburg [ ] d) East African [ ] e) Galla [ ] f) Other (specify) …….
9. For the breeding practice, what do you use a) AI[ ] b) Bucks [ ]
10. If you use the AI services, where do you get them? a) Government Extension agent [ ] b) Private organization [ ]
11. If you use the bucks, where do you get them from? a) Neighbours [ ] b) Communal [ ] c) Own rotated [ ]
12. Do you pay for the breeding services? I) Yes [ ] ii) No [ ]
13. If Yes, how can you rate the payment a)Very Expensive [ ] b) Very expensive [ ] c) Moderate [ ] c) Cheap [[ ] d) Very cheap
14. What are the types of feed do you use for your goats?
    a) Natural Pasture [ ] b) Crop residues [ ] c) Planted fodder (Napier grass, oat) [ ] d) Dairy meal [ ] e) Others (specify) [ ]
15. Do you use any supplements a) Yes [ ] b) No [ ]
16. If yes, which supplements do you use? a) Dairy meal [ ] b) Mineral licks [ ] c) Vitamins [ ] d) Fodder [ ]
17. Comment on the quality of these supplements

a) Good [ ] b) Very good [ ] c) Moderate [ ] d) Poor [ ] e) Very poor

18. If your answer is No, give a reason

a) Too expensive [ ] b) No reason [ ] c) Not necessary [ ] d) Others (Specify) [ ]

19. If your answer is Yes, how often do use supplements?

a) Once/day [ ] b) More than once/day [ ] c) Every 2-4 days [ ] d) Others (specify)[ ]

19. Do you sell manure? i) Yes [ ] ii) No [ ] If Yes, what is the quantity sold (Kg)……. and amount received…….. (KES)

20. Which diseases have you encountered in your flock? i) …… ii) …… iii) …… iv)……..

21. Have your flock received any vaccination in the last one year? i) Yes [ ] ii) No [ ]

22. If yes, against which diseases? ……..

23. If No, what is the reason? i) Vaccination being expensive [ ] ii) Lack of information on any scheduled vaccination [ ] iii) Lack of awareness on the need to vaccinate [ ]

24. Do you have any information on how to control tick and worms in your goats i) Yes [ ] ii) No [ ]

25. If Yes, where do you get the pest control products i) I purchase [ ] ii) Provided by the government [ ] iii) Group procumbent [ ] iv) Others (specify) …….

26. Kindly indicate the frequency you use to control the following a) Ticks …… b) Worms ……

27. What is the lactation period of your goats in months i) < 3 [ ] ii) 3-4 [ ] iii) 5-6 [ ] iv) > 6 [ ]

28. How many times do you milk your goats in a day i) Once [ ] ii) 2 times[ ] iii) 3 times [ ]

29. What is your average dairy goat milk production per doe/ per day (Litres)? i) < 1 [ ] ii) 1-3 [ ] iii) 4-3 [ ] iv) > 5 [ ]

30. Do you sell the goat milk? a) Yes [ ] b) No [ ]

31. How much do sell the milk (KES/litres)? ……..

32. From your total milk production, what amount (in litres) do you allocate for sale?

a) ¼ [ ] b) ½ [ ] c) ¾ [ ] d) All the milk [ ]

33. How do you receive payment on milk sold?

a) Daily [ ] b) Weekly [ ] c) Monthly [ ] d) Annually [ ]

34. Have you sold live dairy goats in the last one year i) Yes [ ] ii) No [ ]

35. If yes, what is the amount (in KES/goat) i) < 3000 [ ] ii) 3000-5000 [ ] iii) > 6000 [ ]

36. Which records do you keep? a) Milk production [ ] b) Birth weight [ ] c) Health [ ] d) None [ ] e) Others (specify) [ ]

37. What do you think are the main challenges pf keeping dairy goat in Kirinyaga County? a) High cost of Veterinary services [ ] b) Poor access to market [ ] c) High cost of inputs [ ] d) Pest and diseases [ ] e) Lack training/support services [ ] f) Other (Specify)

D. Information on Support Services

1. Have you ever attended any training on dairy goat production? i) Yes [ ] ii) No [ ]
2. When was the last time you attended? a) 2-3 days ago [ ] b) 1 week ago [ ] c) 2-4 weeks ago [ ] d) 1-4 months ago [ ] e) More than 5 months ago [ ]
3. What training did you specifically get? a) Marketing [ ] b) Record keeping [ ] c) Feeding practices [ ] d) Breeding [ ] e) Value addition d) Pest and diseases control [ ] e) others (specify) ……..
4. Who provided the training? a) Extension agent [ ] b) Organized programs [ ] c) Others (Specify) ……..
5. How can you rate the skills obtained from the training? a) Helpful [ ] b) Very Helpful [ ] c) Moderate [ ] d) Not helpful [ ]
6. Did you pay anything to be trained i) Yes [ ] ii) No [ ]
7. If Yes in (question 5) above, how can you rate the payment made? a) Cheap [ ] b) Very cheap [ ] c) Average [ ] d) Expensive [ ] e) Very expensive [ ]
8. Do you receive any government subsidies specifically on feeds? i) Yes [ ] ii) No [ ]
9. If you answer was yes, how would you rate the subsidies? a) Very helpful [ ] b) Helpful [ ] c) Moderate [ ] d) Not helpful [ ]

10. Are you a member of any Dairy Goat Association i)Yes [ ] ii) No [ ]
11. What is the name of the association? …….
12. How did you come to know about association?
    a) From friend [ ] b) Market place [ ] c) Church announcement [ ] d) Through Barraza's [ ]
13. How many meetings are held by the association in a month

    1-2 meetings [ ] b) 3-5 meetings [ ] c) more than 6 [ ]

14. What type of services do you receive? a) Breeding [ ] b) Improved milk production [ ] c) Record keeping [ ] d) Health management e) Market information [ ] f) Credit services g) Subsidies on inputs h) Market access g) Others (specify) [ ]
15. Have you received any extension visit to aid in dairy goat farming in the last 1 year i) Yes [ ] ii) No [ ]
16. If yes, where were they from? a) NGO [ ] b) Government [ ] c) Other (specify) ……
17. When did you receive the last visit a) 2-3 days ago [ ] b) 1 week ago [ ] c) 2-4 weeks ago [ ] d) 1-4 months ago [ ] e) More than 5 months ago [ ]
18. Which services did you receive? 1) Training on dairy goat management [ ] 2) contracts [ ] 3) Organizing workshops/seminars [ ] 4) Transport [ ] 5) Giving market information [ ] 6) Credit [ ] 7) Looking for buyer [ ] 8) Other (specify) ……..
19. Have you at any time visited an extension worker? i) Yes [ ] ii) No [ ]
20. When was the last time you visited an extension worker? a) A week ago [ ] b) 2-4 weeks ago [ ] c) 1 month ago d) 2-6 months ago [ ] e) Other (specify) ……
21. What assistance were you seeking? a) Breeding [ ] b) Feeding [ ] c) Dairy goat health management [ ] d) Marketing aspect [ ] e) Other (specify)…….
22. Have you applied for a credit or loan in the last 1 year for dairy goat production i) Yes [ ] ii) No [ ]
23. If yes where did you obtain credit from? a) Banks [ ] b) Sacco [ ] c) Friends [ ] d) AFC e) Others (specify) [ ]

24. How much was the credit ……. (KES)

25. What amount was used in dairy goat farming? ……

27. What challenges did you experience acquiring the loan? a) High interest rate [ ] b) lack of collateral [ ] c) Too may processes [ ] d) Other (specify) ……..

E. Information on Market Access for goat milk

1. What is the distance (in Km) to the closest goat milk market? i) 1-4 Km [ ] ii) 5-10 Km [ ] iii) >10 Km
2. What is the time taken to reach the closest market? i) 1-3hrs [ ] ii) 4-5hrs [ ] iii) > 5hrs [ ]
3. Where do you sell the milk? a) Milk collection point [ ] b) Private processors [ ] c) Neighbours [ ] d) Local shops/Kiosks [ ] e) Hospitals [ ]
4. How do you transport your milk to the market? (Tick all in use)
   a) Own Transport [ ] b) Hired transport [ ] c) Public [ ] d) Others (Specify) [ ]
5. What type of facility do you use? (Tick all in use)
   a) Vehicle [ ] b) Bicycle [ ] c) Wheelbarrow [ ] d) Motor Bike [ ] d) Others (specify) [ ]
6. What type of road do you use to the market? a) Marram [ ] b) Tarmac [ ] c) Both [ ]
7. How would you rate the state of the road used? a) Good [ ] b) Very good [ ] c) Average [ ] d) Poor [ ] e) Very poor [ ]
8. Where do you get information on market, including prices? a) Word of mouth [ ] b) Radio [ ]
   b) TV [ ] d) Extension agent [ ] e) Farming magazines [ ] f) Others (specify) [ ]
9. Do you consider the price of goat milk attained to be fair? i) Yes [ ] ii) No [ ]
10. If (No), which buyer would you prefer to sell to? ……..
11. What is the **main** challenge to targeting the preferred buyer? A) High transaction coat [ ] b) Low price [ ] c) Unreliable [ ] d) Lack of information [ ] e) Exploitation potential [ ] f) Other (specify) ……
12. What facility would you need to sell to you need preferred buyer? a) Transport [ ] b) Market information [ ] c) Other (specify) ……..

13. Is there any cooperative/ marketing group where you sell your milk? i) Yes [ ] ii) No [ ]
14. If yes above , please state the specific co-operative/marketing group
    ……
15. What are the services offered by the co-operative/ marketing group? a) Transport [ ] b) Milk collection in bulk [ ] c) Marketing information [ ] d) Providing inputs c) Other (specify) ……..
16. Do co-operative societies/marketing have an effect on the total amount of goat milk (in litres) sold i) Yes [ ] ii) No [ ]
17. If yes, why do you think so? a)) Higher prices [ ] b) bulk collection [ ] c) Reliable payment [ ] d) Other {specify) …….
18. What do you think can be done to help resolve the marketing constraint?

    ……

    ……

F. Household Food Security (Information to help in the assessment of dietary diversity at the household level/ the contribution that dairy goat farming has towards dietary diversity in the past 7 days)

1. Have you consumed the following food groups in the last 7 days?

Food Group	**Frequency**
1. Vegetables including leaves	
2. Fruits	
3. Fish	
4. Meat (beef, goat, poultry)	
5. Eggs	
6. Dairy and dairy products (milk, cheese, yogurt, other dairy)	
7. Sugars (sugar, sweet, other sugar products)	
8. Fats and Oils	
9. Cereals (maize, beans, rice. Sorghum, millet,	

wheat, other)	
10. Wheat products (bread, cake, others)	
11. Root and tubers (cassava, potatoes, sweet potatoes, arrowroot, yams, matoke, and others	
12. Condiments (spices, tea, coffee, salt, other beverages)	

Scale:

1 = at least once

0 = not consumed even once

G. Food Security Assessment

2. What is the main source of food consumed at the household level? a) Home production [ ] b) Purchased [ ] c) Friends/relatives [ ] d) Government support
3. Which of the following do you consider as basic healthy daily food intake?

Diet	**Daily level intake**
Fruit and vegetables, legumes	
Nuts and Whole grains (unprocessed wheat, oat, millet, maize)	
Fat-free foods	
Sugars	
Dairy products	

4. Do you think your household is able to meet the basic daily food intake? i) Yes [ ] ii) No [ ]
5. Did you or other household members skip a meal because there is no adequate money to purchase food over the past 12 months? a) Once a week [ ] b) Once a month [ ] c) Once in 3 months [ ] d) Once in 6 months [ ] e) Never [ ]
6. What is the duration that you or other household members have stayed a whole day without food because of lack of money?

a) Once a week [ ] b) Once a month [ ] c) Once in 3 months [ ] d) Once in 6 months [ ] e) Never [ ]

7. Have you ever eaten less than what you think is enough? a) Once a week [ ] b) Once a month [ ] c) Once in 3 months [ ] d) Once in 6 months [ ] e) Never [ ]

8. Have you ever had to worry on "What if food will run out"? i) Yes [ ] ii) No [ ]
9. If Yes what was the reason? a) Lack of enough money [ ] b) Challenges accessing food c) Other (specify)…….
10. What solutions do you think can help resolve the issue? a) Access to credit [ ] b) Food donation [ ] c) Increased agricultural support by the government [ ] d) Women empowerment [ ] e) Lower food prices [ ] f) Other (specify) ……
11. Have you ever borrowed money for food? i) Yes [ ] ii) No [ ]
12. If Yes in (question 10), did you manage to get it? i) Yes [ ] ii) No [ ]
13. Have you ever had to cut the amount of daily food intake due to lack of enough food? i) Yes [ ] ii) No [ ]
14. Due to Covid 19 pandemic in the country and worldwide, the general food price is expected to continue rising. Do you have any plan to dealing with the situation? i) Yes [ ] ii) No [ ]
15. If Yes, What have you planned a) Increase the number of dairy goats for milk production [ ] b) Increase the number of commercial goats [ ] d) Rear bucks for hiring [ ] e) goat milk value addition [ ] f) Increase crop production [ ] g) Other (specify) ……..

Thank you!

Appendix 4: Research permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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