CONSTRAINTS TO INCREASED MILK PRODUCTIVITY AND COPING MECHANISMS IN SMALLHOLDER FARMS IN BOMET, NAKURU AND NYERI COUNTY MILKSHEDS IN KENYA

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DECLARATION

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

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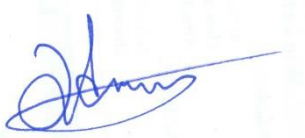
Signature …  Date: 2nd September 2022

DEDICATION

This thesis is proudly dedicated to my dear parents Mr. and Mrs. Wanyiri, my sister Violet and my brother Steve.

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ABBREVIATIONS AND ACRONYMS

AI	Artificial Insemination
ECF	East Coast Fever
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
GFRAS	Global Forum for Rural Advisory Services
GoK	Government of Kenya
KDB	Kenya Dairy Board
KES	Kenya Shilling
KNBS	Kenya National Bureau of Statistics
LSD	Lumpy Skin Disease
MOET	Multiple Ovulation and Embryo Transfer
NAMA-GCF	Nationally Appropriate Mitigation Actions- Green Climate Fund
ODK	Open Data Kit
SPSS	Statistical Package for Social Sciences
USA	United States of America
USAID	United States Agency for International Development

Abstract

The demand for milk and dairy products is rising despite the low milk yield from smallholder dairy animals in Kenya. The aim of this study was to document dairy production system, constraints and coping mechanisms in smallholder farms in three milksheds consisting of New Kenya Cooperative Creameries in Bomet county, Happy Cow Limited in Nakuru county and Mukurweini Wakulima Dairy Cooperative Society Limited in Nyeri county in Kenya. A semi structured questionnaire was administered to 1146 dairy farmers in the three counties. Data collected included livestock inventory, feed resource and feeding systems, mating system, farm milk production and milk network, challenges in dairying and coping strategies. Nyeri had higher milk productivity at 8.3 liters per cow per day followed by Nakuru (5.7) and Bomet (5.4). The limitations to dairying included feed shortage (48.7%), lack of credit (17.4%), poor quality of available genetics (17.0%) and low farmgate milk prices (16.0%). The coping strategies to increasing milk production included increasing number of dairy animals (28.2%), improving animal genetics (25.3%), producing more fodder (21.9%) and purchasing feed (9.4%). The coping strategies adopted to alleviate feed shortage included reducing feed offered to dairy cattle (51.4%), prioritizing feeding of milking cows (33.7%) and selling stock (14.9%). In conclusion, poor dairy cattle performance was attributed to feed shortage and poor farmgate milk price. Coping strategies to increasing milk production included increasing number of dairy animals and improving animal genetics. Coping strategies to alleviate feed shortage included reducing feed offered to dairy cattle and selling stock.

Key words: Smallholder, Dairy, Constraints, Coping, Kenya

CHAPTER ONE

1.1 Background

Agriculture is the main stay of Kenya's economy contributing 26% to the country's gross domestic product (GDP) and another 27% of GDP indirectly through linkages with other sectors (FAO, 2019). Kenya has one of the largest dairy industries in sub-Saharan Africa (Wambugu *et al.*, 2011). Dairy farming, which can be described as a farming practice where milk is produced for home consumption or sale from dairy cattle, in the country contributes 12% to the agricultural GDP, 44% to the livestock GDP and 4.5% to the country's GDP (FAO, 2019; Otieno *et al.*, 2021).

The types of dairy production systems in Kenya have been classified into intensive (stall-feeding only or zero-grazing), semi- intensive (mainly grazing with some stall-feeding and mainly stall-feeding with some grazing) and extensive (free grazing or tethered). Typically, the smallholder dairy farm size ranges between 3-5 acres (1.2-2.0 ha), however, some may exceed (20 acres/ 8ha) or fall below this range (0.5 acres/ 0.2ha), and keep between 1-5 heads of cattle (Mugambi *et al.*, 2015). The commonly kept dairy breeds include; Friesian/Holstein, Jersey, Ayrshire, Guernsey, Sahiwal and their crosses with a daily average yield of about 5-9 litres/cow (Bebe *et al.*, 2003; FAO, 2011; Wanjala and Njehia, 2014; Mugambi *et al*., 2015, Onono and Ochieng, 2018). Dairy farming in Kenya is usually integrated with cash crop farming such as coffee, tea, and food crops, horticulture or with livestock production (ruminants and non - ruminants). Dairying is commonly integrated with maize farming and poultry production (Bebe *et al.*, 2003; Mugambi *et al*., 2015).

Milk production in the country is majorly from exotic and crossbred dairy cattle with an estimated herd population of 3.55 million and an annual milk production of 5.2 billion litres (FAO, 2018; KDB, 2019), and about 80% of this milk is from approximately 1.8 million smallholder

dairy farmers and the rest from medium to large-scale dairy farmers (KDB, 2019). Dairying contributes to livelihoods of 4 million Kenyans through food, income and employment (Mugambi *et al*., 2015). The enterprise provides about 1.25 million employment opportunities (0.75 million jobs directly and 0.5 million jobs indirectly) (KDB, 2019; Njiru, 2020). Dairying serves as a source of nutrition to millions of citizens in the country and Kenya is ranked among the highest milk consumers among the developing countries, with a milk per capita consumption of 110 litres and an annual consumption growth rate of 5.8% (Rademaker, 2016; KDB, 2019). Of the milk produced in Kenya, 24% is from intensive system, 44% and 22% from semi-intensive and extensive dairy production systems respectively (NAMA-GCF, 2017). Smallholder farmers account for 80% of total milk production and 70% of total marketed milk in the country (Mburu *et al.,* 2007).

The current average milk yield of 5-9 litres /cow/day can be considered as low when compared to the genetic potential (KDB, 2019). Low milk production in the country has been a persistent challenge over the past years and has been attributed to poor animal nutrition and feeding, and poor animal husbandry management practices (GoK, 2009; FAO, 2011). Several challenges encompass the dairy sector constraining competitiveness and profitability of dairy farming. These include; low farmgate milk price, seasonal fluctuation in milk production, lack of statistical data on milk market outlets and poor rural infrastructure (Omunyin *et al.,* 2014). Moreover, low technical skills on animal husbandry practices, reduced access to veterinary and extension services, inadequacy of quantitative and high-quality feeds and high cost of inputs negatively affect dairy performance (Methu *et al.,* 2000; Pezo, 2001, Omunyin *et al.,* 2014, Mugambi *et al.,* 2015*;* and Waititu, 2017). Efforts employed in the past to improve dairy production include; extension, good husbandry practices, genetic improvement, fodder

improvement, adoption and use of modern technologies and conducive policies (Mudavadi, 2000; Waithaka *et al*., 2002 and Wanjala and Njehia, 2014).

1.2 Statement of the problem

About 80% of the dairy herd in Kenya is owned by smallholder farmers and they account for 80% of milk production (Odero-Waititu, 2017; Onono and Ochieng, 2018). Many smallholder dairy farmers experience fluctuations in feed availability thus milk production (Njarui, 2011). Studies show that the dairy herd in Kenya is underfed resulting in low milk production (Staal *et al.,* 1998; Msanga *et al.,* 2000; Wanjala and Njehia 2014). The average milk yield per cow per lactation across all dairy production systems in Kenya is lower than the potential milk yield per cow per lactation (Ongadi, 2010). The average milk yield of 5-6.5 litres/cow/day is low (Wanjala and Njehia, 2014), compared to an average potential yield of 12.7 litres/cow/day achieved elsewhere (South Africa) (Wambugu *et al.,* 2011). This study makes an attempt to shed insight on constraints to increased milk production and coping mechanisms in smallholder farms in Bomet, Nakuru and Nyeri milksheds in Kenya and to recommend possible interventions.

1.3 Justification

Despite low milk yields from dairy animals in smallholder farms in Kenya, demand for milk and dairy products is rising and this has been attributed to human population growth, urban migration and increased incomes (Kenya Markets Trust, 2019). Studies show that human population growth, increased incomes, and urbanization result in a 70% rise in demand for livestock products (Rademeaker *et al.,* 2016, Waititu, 2017). To meet the demand, integrated and/-or intensified dairy production systems can be adopted to produce more from less, as these intensified systems use superior breeds. Low milk production has been attributed to; underfeeding, poor dairy management practices and genetics (Hall *et al.*, 2008; FAO, 2011). An increase in dairy

production has been realized through proper feeding, proper breeding and proper disease control management (Ensminger, 2005). Additionally, fodder improvement, adoption and use of advanced dairying technologies, genetic improvement programs and good dairy management practices have resulted in improved animals contributing to remarkable variations in the milk yield and thus proving that limitations to increased milk production lie elsewhere. This study collected and analyzed data on household dairy management practices and identified major limitations to increased milk yield, and coping mechanisms of smallholder farmers in three milksheds in Kenya. The information generated will benefit farmers, policy makers, extension workers and processors by identifying constraints and thus identify interventions to increase smallholder dairy productivity.

1.4 Research objective

1.4.1 Broad objective

To contribute to food and nutritional security and improved livelihood through identification of the main constraints to increased milk production on smallholder farms and coping mechanism s to these constraints in Bomet, Nakuru and Nyeri county milksheds in Kenya.

1.4.2 Specific objectives

1. Determine the main constraints to increased milk production on smallholder dairy farms in Bomet, Nakuru and Nyeri milksheds in Kenya.
2. Determine the coping mechanisms for constraints to increased milk production on smallholder dairy farms in Bomet, Nakuru and Nyeri milksheds in Kenya.

1.5 Research question

1. What are the main constraints to increased milk production on smallholder dairy farms in Bomet, Nakuru and Nyeri milksheds in Kenya?

2. What are the different coping mechanisms for constraints to increased milk production on smallholder dairy farms in Bomet, Nakuru and Nyeri milksheds in Kenya?

CHAPTER TWO

LITERATURE REVIEW

2.1 Smallholder dairy sector in Kenya

Before independence, dairying in Kenya was export-oriented and was practiced in large scale European farms. The Europeans introduced dairy breeds from their countries (Dorward *et al.*, 2000; Kavoi *et al.*, 2009), established dairy input services (Thorpe *et al.*, 2000); and occupied the highlands of Kenya (Central region and the Rift Valley) (Conolly *et al.,* 2000). After independence, policies (e.g., Swynnerton Plan) aimed at including indigenous Kenyans in commercial agriculture such as market-oriented dairying leading to the expansion of the smallholder dairy farms, were introduced (FAO, 2011).

Presently, the smallholder dairy production system in Kenya is classified as either intensive, semi – intensive and extensive. The adoption of a particular dairy production system in an area in Kenya is influenced by human population density, market infrastructure and agro-ecological zone (Staal *et al*., 2003), and characterization is based on the level of intensification and feeding systems (Waithaka *et al.,* 2002).

Smallholder dairy farming in Kenya is mainly practiced in the highlands, which have been described as areas with altitudes equal or greater than 1000 m above sea level and with medium to high ecological potential for dairying (Jaetzold and Schimdt, 1983). The size of majority of smallholder farms in Kenya range between 1.2-2 ha (3-5 acres) (Lukuyu *et al.*, 2009), and dairying is commonly integrated with other livestock (ruminants and non-ruminants) and cash crop farming such as; tea, coffee or horticulture (Bebe, 2003; Lukuyu *et al.*, 2009). In the country, dairying is commonly integrated with poultry production and maize farming and the livestock species kept or

crops grown are usually a function of market opportunities, subsistence needs and agroecological setting (disease prevalence and feed resource base) (Bebe, 2003). Dairy cattle provide manure which is used to replenish nutrients in the soil in cultivated farms while cropping provides animals with fodder (Mutavi and Amwata, 2018).

The dairy industry in Kenya is dominated by smallholder farmers owning about 80% of the herd and accounting for 80% of milk production (Odero-Waititu, 2017; Onono and Ochieng, 2018). Dairying plays a huge socioeconomic role as it provides livelihoods to 1.8 million smallholder dairy farmers (KDB, 2019). Dairying contributes to national food and nutritional security with a per capita milk consumption of 110 litres and an average annual consumption growth rate of 5.8% (Rademaker, 2016; KDB, 2019). The dairy herd is comprised of various breeds such as; Friesians, Ayrshire, Guernsey, Jersey, Sahiwal and their crosses (Dorward *et al.,* 2000; Wanjala and Njehia, 2014; Mugambi *et al.,* 2015; KDB, 2019), and is estimated at 3.55 million with a production estimate of 5.2 billion litres per year (KNBS, 2009; KDB, 2019).

2.2 Factors affecting dairy production

2.2.1 Feed

Availability and Quality

Dairy cattle require nutrients for body maintenance, growth, reproduction and milk production. Availability of dairy cattle feed is a major limiting factor affecting all the different dairy production systems in East Africa (Hall *et al.,* 2008). The feeding strategies adopted by smallholder dairy farmers in Kenya are often opportunistic, unsteady and fluctuate both in quality and in quantity (Methu *et al.,* 2000; Pezo, 2001; Wanjala and Njehia, 2014). Additionally, the feed offered to dairy animals is often not in relation to the expected nutritional requirement therefore limiting performance (Bebe, 2003; Ongadi, 2010).

The type of feed offered to dairy cows can be classified into three categories: roughages, commercial concentrates and additives/special feed and is influenced by markets, technologies available and the feed resource base (Njarui *et al.,* 2014). The common basal feed for dairy cattle in Kenya is Napier grass (*Pennisetum purpureum) (*Lukuyu *et al., 2009)* and its availability has been attributed to land allocation (Muia *et al.,* 2001; Bebe, 2003). Napier is easy to establish and good for soil conservation as it is a soil stabilizer (Mutavi, 2018). It is not suitable for direct grazing as stumping results in poor regeneration and is thus utilized as cut and carry (Orodho, 2006; Mutavi, 2018). Studies indicate that feeding Napier without supplementation yields about 5 litres of milk/cow/day (Waithaka *et al.,* 2002*;* Muraguri *et al.,* 2004; Wanjala and Njehia, 2014). In spite of its high dry matter yield and persistence, Napier grass is considered to be generally low in crude protein and minerals (Lukuyu *et al.,* 2012).

Other types of feeds offered to dairy cattle include banana leaves and pseudo-stems and crop residues such as maize stover (Dorward *et al.,* 2000). Farmers are advised to incorporate forage legumes such as *Leucaena spp., Sesbania spp., Desmodium* and *Calliandra spp.* in their animals' diet because they increase nitrogen supply to the rumen thus increasing digestibility and hence increasing milk production (Smith *et al.,* 1990; Lukuyu *et al.,* 2009). The fodder legumes are used to supplement minerals (calcium and phosphorous) and vitamins (A & D) in animal diets (Kabirizi *et al.,* 2013; Mutavi, 2018). Poor animal nutrition has been linked to low milk productivity (7.5 litres per cow per day) in smallholder farms, besides substandard animal husbandry skills and disease prevalence (Gitau *et al.,* 1994; Mutugi, 2004; Owen *et al.,* 2005; Aleri *et al.,* 2012).

Feed availability and proper agronomic management practices in smallholder dairy farms has led to increased milk production, however, poor quality and low quantity of forage is a major

constraint in the dry seasons (Dorward *et al.,* 2000; USAID/GoK, 2009). Low milk production in the dry season has been attributed to underfeeding (Ageras *et al.,* 2003; Lukuyu *et al.,* 2009). The dry season in Kenya affects feed availability and is usually at peak in the months of February and September, while the months of April, May, June and November are relatively fair with abundance of feed (Bebe, 2003).

Feed conservation

Conservation of surplus animal feed during the wet season (March- July) will guarantee feed availability during the dry season (August- October) (Mutavi, 2018). Animal feed is either conserved as hay or silage and the conservation measures are aimed at achieving high quality feed with minimum nutritional loss (Muriuki, 2003; Mutavi, 2018). Failure to conserve animal feed has been a common constraint in many smallholder dairy farms in Kenya (Dorward *et al.,* 2000; Bebe, 2003; Lukuyu *et al.,* 2009) resulting in feed inadequacy and fluctuation in milk production.

Most smallholder dairy farmers report low milk production and high price of milk during dry seasons due to scarcity and low quality of animal feed (Lukuyu *et al.,* 2009). Crop residues obtained from farm fields after harvesting and are either stored in waterproof sheds or grazed (Mutavi, 2018). It has been noted that the nutritive value of the crop stored residues deteriorates and this has been attributed to poor feed conservation methods (Kabirizi *et al.,* 2013; Mutavi, 2018). Smallholder dairy farmers have expressed the need to be equipped with low input conservation technologies such as box bailing and tube silage so as to conserve animal feed for utilization in the dry season (Methu and Mbuthia, 2005; Lukuyu *et al.,* 2009).

Concentrate feeding

Many smallholder dairy farmers do not take into account their animals' nutritional requirements when feeding (Bebe, 2003; Ongadi, 2010). Most feed 2 Kg of concentrate/cow/day and this low feeding rate results in under nutrition and it usually affects milk production (Johnson, 1984; Lukuyu *et al.,* 2009). A study by Richards *et al.,* 2015 revealed that many (87%) smallholder farmers feed commercial concentrates to their animals. However, the constraint associated with concentrate feeding is improper measurement of feed concentrate rations fed to dairy cattle resulting in underfeeding (1.25 Kg) and low milk production (Richards *et al.,* 2015). Past studies in Kenya have noted an increase (20%) in milk production associated with feeding higher amounts of commercial concentrates (Romney *et al.,* 2000).

Some smallholder dairy farmers' compound home-made concentrates although there is need to train them on proper feed formulation procedures (Mbugua *et al.,* 1998). During ration formulation macro minerals, calcium, magnesium and phosphorous should be taken into account. Mineral deficiency causes low milk production, low fertility, health disorders and poor body condition (Lukuyu *et al.,* 2012). Concentrate feeding should be based on the quality of basal diet which most farmers do not take into account. Smallholder farmers access credit from various sources including Cooperatives, Savings and Credit Cooperatives (Sacco), Agricultural Finance Corporation (AFC) and Commercial banks (Njiru, 2020). There have been bank partnerships with dairy cooperatives where farmers access tailored loans for feed purchase, farm development, increase of stock and/or veterinary service (Wachekeh, 2013).

2.2.2 Diseases

Cattle diseases lower productivity in smallholder dairy farms in Kenya (Omunyin *et al*., 2014; Waititu, 2017). Poor dairy animal husbandry practices predispose dairy cattle to various

problems such as; mastitis from unhygienic milking practice, lameness as a result of standing in slurry, injuries from slippery floor surfaces, and reproduction difficulties from inadequate diets during pregnancy, limiting dairy productivity (King, 1981).

Tick borne diseases affecting the dairy herd in Kenya include East Coast Fever (E.C.F), anaplasmosis, babesiosis and heart water (Omondi *et al.,* 2017; Onono and Ochieng, 2018). Mastitis is a common production disease affecting many dairy herds (Radostits *et al.,* 2007) and the Friesian and Jersey breeds are most (74.3%) susceptible to mastitis as compared to cross breeds (51.8%).

Disease control is mainly achieved through vaccination, regular spraying, treatment of sick animals and deworming (Onono and Ochieng 2018). Control of mastitis in dairy farms has been achieved through teat cleaning and teat dipping and effective treatment of clinical mastitis (Iraguha *et al*., 2015). Animal health services are provided by government veterinarians, animal health assistants and at times the dairy farmers source drugs from local Agricultural and Veterinary input suppliers and sub county veterinary offices and treat their animals (Ondwassy, 1999; Waititu, 2017).

2.2.3 Breeds

The typical dairy breeds in smallholder dairy farms are Friesian and Ayrshire breeds (Dorward *et al.,* 2000; Bebe, 2003; Lukuyu *et al.,* 2009; Mugambi *et al.,* 2015) and breeding management decision among dairy farmers is influenced by; high milk yield, high milk butter-fat content, disease resistance, hardiness, unselective feeding behavior and heavier body weight (Bebe, 2003; Onono and Ochieng, 2018).

Dairy farmers prefer Friesian, Ayrshire and Jersey breeds due to their high milk yield while the Zebu breed and their crosses are preferred due to hardness and ability to resist diseases (Onono and Ochieng, 2018). Studies have shown that the Friesian and Ayrshire breeds have performed poorly under smallholder feeding regimes and this has been attributed to their higher mature body mass and higher nutritional demand (Rege, 1998; Ojango, 2000; Wahkungu, 2000). The Jersey and Guernsey breeds have been identified as alternative options (Rege, 1998; Ojango, 2000; Wahkungu, 2000).

2.2.4 Mating methods

There are various livestock mating systems available to dairy farmers in Kenya such as Artificial insemination (AI), embryo transfer and natural mating. Although the use of improved livestock breeding methods (AI) results in increased milk production, the adoption of better breeding approaches is low among smallholder dairy farmers (ILRI, 2016; Onono and Ochieng, 2018). Studies have indicated low use of AI services (<54%) and the efficiency of AI in smallholder farms is constrained by poor heat detection, unreliability of delivery of service and/or high cost of service (Baltenweck, 2006; Lukuyu *et al.,* 2012). High usage of natural mating in smallholder dairy farms in Kenya has been attributed to high availability and affordability of AI (Lukuyu *et al.,* 2012 and Omondi *et al.,* 2017). Keeping of improved/ grade cattle, feeding of planted fodder (e.g., Napier grass) and commercial concentrates to cattle are indicators of technology uptake in smallholder dairy farms (Baltenweck, 2006). However, inadequate land size and capital to maintain improved animals constrain smallholder farmers (Bebe, 2003; Baltenweck, 2006). Studies indicate that adoption of biotechnology in smallholder dairy farms could improve the production of their cattle (Mutembei *et al.*, 2015; Kios, 2019). An example of such technologies is Multiple Ovulation and Embryo Transfer (MOET), a process involving superovulation of donor

cows using hormones to increase the number of ova ovulated, followed by insemination and flushing of the uterus to recover the embryos (Kios, 2019). MOET can greatly increase the number of offspring that a genetically superior cow can produce compared to natural mating or AI where only a fraction of the reproductive potential of the cow is realized (Mutembei *et al.*,2015; Kios, 2019). However, this process is capital intensive as a single procedure could cost upwards of Kenya Shillings 25,000 (Kios, 2019).

2.2.5 Dairy farm records

Dairy farm records are documentations or files used to keep account of different activities, materials and events regarding farm operations. Cow performance records are necessary for effective management of the herd and improvement of productivity (Ensminger, 2005). They assist in accountability, financial planning decisions, evaluating farm activities and in livestock management decisions (Ensminger, 2005; Yadeta *et al.*, 2020). The farm records kept include; production records, health records, record of agricultural input, financial records, labor and vehicle records (Yadeta *et al.*, 2020). In Kenya, studies have shown a need to create training programs for smallholder farmers on record maintenance practices to ensure dairy cow performance records are preserved and utilized in supporting decision making (Gichohi, 2019). Record keeping can be accomplished by basic manual record keeping (hand written) or elaborate computerized programs (Yadeta *et al.*, 2020).

2.2.6 Technical information and extension

Efficient management of a dairy farm requires availability of new information and training in new technologies. The dairy operator needs to be knowledgeable in animal physiology, basic sciences, animal nutrition and business administration (Ensminger, 2005). Low technical skills

and animal husbandry practices have been identified as a constraint to smallholder dairy production (Waititu, 2017).

The channels used by smallholder dairy farmers to obtain dairy information include; internet and media, other dairy farmers, agricultural shows and exhibitions, farmer training programs, veterinary and extension (Kamau, 2013). Studies have identified a need to provide dairy farmers with knowledge to utilize available resources to improve the quality and quantity of milk (Staal *et al.,* 2003, Opiyo *et al.,* 2011). Extension service if functioning effectively, improve agricultural productivity by providing farmers with information that assists them optimize utilization of limited resources (Jayne *et al.,* 2006). The National Agriculture and Livestock Extension Program (NALEP) is the main government extension program and is implemented by the Ministry of Agriculture and supported by the government of Kenya (NALEP- GoK) and Swedish International Development Agency (NALEP- Sida) (GFRAS, 2022). Its objective is to enhance contribution of agriculture and livestock to development and poverty alleviation by promoting efficient and effective demand driven extension services (Muyanga and Jayne, 2006; GFRAS, 2022). Farmers' groups formed around a common interest have been found to be most efficient in propagating extension knowledge (Muyanga and Jayne, 2006) however, farmers may not be willing to invest their resources to new technologies (Muyanga and Jayne, 2006).

2.2.7 Credit access

Smallholder farmers access credit from cooperatives (41%), Saccos (26%), Agricultural Finance Corporation (AFC) (21%) and commercial banks (12%) (Njiru, 2020). Access to credit affects dairy production and occasionally, smallholder farmers seek credit to facilitate dairy support services or afford dairy inputs such as commercial concentrates (Lukuyu *et al.*, 2009). Limited access to credit has been noted as a constraint to smallholder dairy farming (Njiru, 2020).

Factors affecting credit access include farmer management skills, lack of information or knowledge, collateral availability and interest rates (Kembe *et al* 2008; Njiru, 2020).

Saccos and finance corporations provide access to credit finance for investment by farmers and dairy cooperatives therefore increasing productivity (Wilkes *et al.,* 2018). Credit institutions prefer to loan large amounts of money to few clients than small amount to many clients so as to reduce the transaction costs and farmers have therefore been urged to form dairy cooperatives or groups as they will have better credit access (Kembe *et al.,* 2008). There have been credit sources accessible to smallholder farmers such as bank partnerships where they access tailored loans for farm development, animal feeds, increase of stock and veterinary service (Wachekeh, 2013). There is need to improve competency, management skills and increase financial awareness to trigger credit uptake which will lead to increased milk production (Njiru, 2020).

2.2.8 Factors affecting milk prices

Milk prices in Kenya are affected by milk fluctuations. The season of peak milk production is generally associated with the rainy season of April-June where increased milk supply negatively affects milk prices. Additionally, milk prices are affected by distances as transportation costs are incurred thus lowering farmgate milk prices (Staal et al., 2003).

Marketing of milk through dairy cooperatives channels is linked with proximity to urban centers. Farmers with higher amounts of milk are more likely to sell their milk to dairy processors. Moreover, the adoption of milk marketing through cooperatives is influenced positively by availability of credit. Farmers who want to receive credit from cooperatives are likely to sell their milk through cooperatives to improve their credit rating. Notably, farmers are likely to sell their milk through channels that offer the highest bid either through private milk traders or processors (Mburu et al., 2007).

2.3 Farmers' perception on production constraints and coping mechanisms

Milk production has been increased in the past through several approaches such as; good husbandry practices, fodder improvement, adoption and use of advanced dairying technologies, genetic improvement programs, and conducive farming policies (Mudavadi, 2000; Waithaka *et al*., 2002; Ensminger, 2005; Wanjala and Njehia, 2014). Though dairy intensification could increase milk yield, it is constrained by; requirement of capital to sustain production using external resources, reduced land size, poor soil fertility and reduced extension visits (Nicholson *et al.*, 2001; Bebe, 2003). Other limitations included; unavailability of dairy markets, low farmgate milk price, poor animal husbandry skills, unsustainable use of natural resources, poor rural infrastructure, inadequate use of appropriate dairy technologies, high cost and unavailability of dairy inputs and support services (Muia *et al.*, 2001; Onono and Ochieng, 2018).

Low farmgate milk price has been a major constraint to dairying; however, the government through Kenya Dairy Board has introduced a minimum price of KES 33/- (from previously KES 19/- in 2020) per liter payable to farmers on delivering milk to processors which will lead to increased production.

Dairy cattle feeding is a major limiting factor that cuts across all dairy production systems (Hall *et al.* 2008). Feeding costs account for 60 -70% of the total cost of production in Africa and other developing countries (Madubuike, 1993; Lukuyu *et al.,* 2009). Feed inadequacy and high cost of feed constrain dairy production (Ayantunde *et al.,* 2005; Lukuyu *et al.,* 2009). The shrinking feed resource base affects dairy production and is attributed to reduced land sizes (0.2-0.4ha per household) and high human population density (Bebe, 2003). Smallholder farms are dominated by cash crops such as tea, coffee and horticultural crops at the expense of fodder crops, which are mainly purchased off-farm (Syomiti *et al.,* 2015).

Smallholder farmers adopt various strategies to help alleviate feed supply aimed at improving dairy performance under different production systems (Njarui, 2011). The coping strategies included; fodder conservation, selling stock, establishing improved fodder/ pasture, long distance walking in search for fodder/ pasture and livestock feed supplementation (Syomiti *et al.*, 2015). Additional strategies consist of feeding of crop residues (dry maize stovers, bean haulms, sorghum and wheat straws), reducing feed offered to dairy cattle, purchasing animal feeds (hay, maize stovers, grass or silage and concentrates), cultivation on roadsides, forest and public land, and hiring labor to gather feed (Mwangi and Wambugu, 2000; Lukuyu *et al*., 2009).

Moreover, smallholder dairy farmers utilize unconventional feeds including tree leaves, sugarcane tops, brewers waste and kitchen waste as animal feed (Mwangi and Wambugu, 2000; Lukuyu *et al*., 2009). However, some of the coping approaches have limitations as the animal feed sourced off-farm pose risk of disease transfer (especially tick-borne diseases) and usually is of low-quality resulting in low milk production (Nansen *et al.,* 1990; Njarui *et al.,* 2014). The costs associated with these coping strategies such as; feed purchase, labor and transportation costs may raise the cost of milk production (Lukuyu *et al.,* 2009; Njarui *et al.,* 2014). To overcome production constraints, smallholder dairy farmers have been encouraged to widen the feed resource base by introducing high quality and high yielding forages or purpose bred forages and pastures, increase acreage under planted fodder, adopt feed conservation techniques and improve skills on management of natural pastures (Lukuyu *et al.,* 2009).

CHAPTER THREE

METHODOLOGY

3.1 Study design and study areas

The study was quantitative in nature with household data collected using semi-structured questionnaires. Project team members from the University of Nairobi in the Africa-Milk project visited different dairy processors in three dairy production areas, identified milk collection systems, established sampling frames of farmers delivering milk to dairy processors, and determined the sample size of the household survey. Figure 1 is a map of Kenya showing the study areas (counties). The three study sites were selected as they were milk sheds to target dairy processors in the project areas; Happy Cow Limited (Nakuru), Mukurweini Wakulima Dairy Cooperative Society Limited (Nyeri) and New Kenya Cooperative Creameries (NKCC) (Bomet).

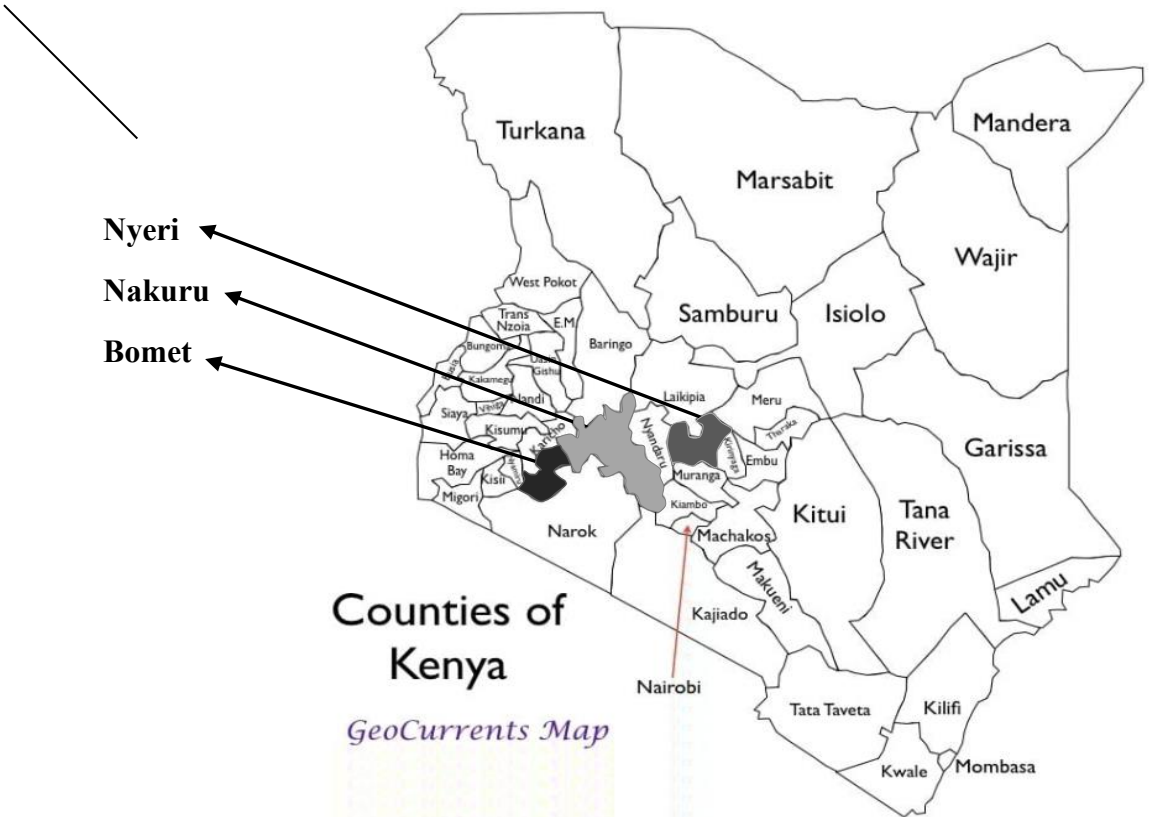


Figure 1. Map of Kenya showing the study areas *(Source: GeoCurrents Map, 2020*)

3.1.1 Bomet

Bomet county is one of the 47 counties in Kenya and is located in the former Rift Valley Province approximately 174 kilometers west of Nairobi city. It has a population size of 875,689 inhabitants and a population density of 440/Km^2 (KNBS, 2019). The county is located at latitude -0.785561 and longitude 35.339138. The altitude is 1962 m above sea level and the total area is 1630 Km^2. The average annual temperature is 17.5^{0}C and the average annual rainfall is 1247 mm (KNBS, 2015).

3.1.2 Nakuru

Nakuru county is located in the former Rift Valley Province and is approximately 160 kilometers north west of Nairobi. The county is located at latitude -0.303099 and longitude 36.080025. It has a population of 2,162,202 inhabitants (KNBS, 2019) and a total area of 7509.5 Km^2. The county lies about 1850 meters above sea level. The average annual temperature is 17.5^0 C and the average annual rainfall is 895 mm (KNBS, 2015).

3.1.3 Nyeri

Nyeri county is located in the central region of the country. It has a population size of 759,164 inhabitants (KNBS, 2019) and a land area of 2,361 Km^2. It located at latitude -0.42013 and longitude 36.94759. It is 150 kilometers north of Nairobi. The county lies about 1750 meters above sea level. The average annual temperature is 16.1^{0}C and the average annual rainfall is 1497 mm (KNBS, 2015).

3.2 Sampling method

Sampling of milk suppliers in the study areas

A multistage sampling technique was used where in the first stage; purposive sampling was used to target dairy farmers delivering milk to the processors. In the second stage, systematic sampling approach was used to determine a desired sample size from the study areas. Samples were drawn from two groups; farmers delivering their milk directly to processors (milk suppliers) and farmers delivering to middle-men (traders/milk agents - contracted by processors to collect milk and deliver to them) (non-suppliers) and both groups were selected systematically to ensure that the sample size selected was a representation of the whole population. After identifying a milk collection system (sub-location), a list of dairy farmers supplying milk through the various milk collection systems was obtained from the cooperative societies, self-help groups, milk agents/brokers/traders and dairy processors. The respondents for the survey were selected using systematic random sampling approach. A total of 1146 households were sampled.

Table 1. Sampling of milk suppliers in Bomet, Nyeri and Nakuru milksheds

Bomet		
No.	**Milk collection system**	**Sampled channel**
1.	Linda Cooperatives (Lobotiet Cooperative *S*ociety)- collects milk from farmers and delivers it to NKCC	Chebonyo
2.	Olbutyo Cooperative Society	Segemik
3.	Farmers delivering their milk directly to NKCC Sotik factory (Industry)	Chepilat
4.	Nyasiongo Coolers (Mara Cooperative Society)	Demu
5.	Traders collecting milk from farmers and delivering it to NKCC: i) Trader 1 ii) Trader 2	Mabwaita Rongena
Nyeri		
No.	**Milk collection system**	**Sampled channel**
1.	Milk traders supplying milk to Mukurweini Wakulima Dairy Cooperative Society Limited	Iriani
2.	Farmers delivering their milk directly to Mukurweini Wakulima Dairy Cooperative Society Limited	Gaturia
3.	Cooperative society collecting milk from farmers and delivering it to Mukurweini Wakulima Dairy Cooperative Society Limited	Gakindu
4.	Mukurweini Wakulima Dairy Cooperative Society Limited sourcing milk from other cooperatives	Murichu
5.	External contracted suppliers (Self-Help Group)	Karigoini
6.	Processor supplying milk to Mukurweini Wakulima Dairy Cooperative Society Limited	Chinga
7.	Direct delivery of milk by farmers at established collection centres	Mweru
Nakuru		
No.	**Milk collection system**	**Sampled channel**
1.	Milk supply agent (Milk trader) - sources milk from farmers and delivers it to Happy Cow Ltd	Trader 3
2.	Farmers delivering their milk directly to Happy Cow Ltd	Key Informant Interviewed (not sampled for household survey)
3.	Happy Cow Ltd collects milk from other cooperative societies	Olenguruone Cooperative Society and Njoro Cooperative Society
4.	Happy Cow Ltd source milk from other cooperative society	Olkalou Cooperative Society
5.	Happy Cow Ltd source milk from individual farmers who deliver milk through established collection centres at Subuku	Subuku milk collection centre

***Traders - middlemen contracted to collect milk and deliver to dairy processors*

3.3 Data collection and analysis

A questionnaire was administered and data collected using an ODK platform. A pretest of the questionnaire was done prior to data collection, and a revision of the questionnaire was made to ensure that it was effective in capturing the required data. A total of 1146 households were sampled across three milksheds; 410 households under Wakulima Dairy Cooperative Society Limited in Mukurweini, Nyeri, 383 under Happy Cow in Njoro, Nakuru and 353 under New Kenya Cooperative Creameries in Sotik, Bomet. Face to face interviews were conducted by trained enumerators who either interviewed household heads or their spouses.

Among the information collected included; socio-demographic attributes, livestock inventory, feed resource and feeding systems, mating system, farm milk production and milk network, major challenges in dairying and coping strategies (Appendix 1). The data was entered in the Statistical Package for Social Sciences (SPSS 22) software and cleaned before analysis and presented using descriptive statistics (means, measures and frequencies), correlation and other relevant statistics.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Sociodemographic attributes of farmers

The socioeconomic characteristics of farmers in the three milksheds are shown in Table 2. Male farmers dominated in the three counties with 72.6%, 64.6% and 60.5% in Bomet, Nyeri and Nakuru respectively. This can be explained by the fact that in many household farming contexts, males are the main decision makers (Rota *et al.,* 2010; Syomiti *et al.,* 2015). The age distribution of farmers differed between the milksheds where 64%, 46% and 31% of farmers in Bomet, Nakuru and Nyeri milksheds respectively were aged between 20-35 years and 14.4% 13.3% and 4.5% in Nyeri, Nakuru and Bomet milksheds respectively were above 56 years of age. Studies have shown that age could be used as a proxy for farming experience where older farmers may have more experience in dairying as opposed to younger farmers (Kahwai *et al.,* 2018). However, younger farmers tend to be more risk loving which enhances their appreciation of new technologies and innovations which could potentially solve their problems (Kahwai *et al.,* 2018; Mutavi, 2018). There were more young farmers in Bomet and Nakuru compared with Nyeri and this can be attributed to limited landholdings in Nyeri as opposed to Bomet and Nakuru, an indication that the younger generation is seeking for alternative sources of livelihood other than farming. Low participation of youth in dairying has been identified as a farming constraint (KDB, 2019) and has been linked to white collar job preference, negative attitude toward agriculture due to low returns, lack of land and limited access to credit (Njiru, 2020).

Table 2. Social attributes of farmers from the three milksheds in the study areas

Attribute				
Milkshed	**Overall (%)**	**Nyeri (%)**	**Nakuru (%)**	**Bomet (%)**
N	1146	410	383	353
Age of the respondents				
20- 35 years	47.0	31.0	46.0	64.0
36- 55 years	42.3	54.6	40.7	31.4
Above 56 years	10.7	14.4	13.3	4.5
Gender				
Male	65.9	64.6	60.5	72.6
Female	34.1	35.4	39.5	27.4
Marital status				
Single	3.9	5.1	2.2	4.3
Married/living together	79.0	73.7	81.1	82.3
Divorced/separated	1.1	2.4	0.7	0
Widower	16	18.8	16.0	13.4
Education level				
No formal education	7.1	2.9	12.8	5.8
Elementary	39.5	36.5	38.9	44.4
Primary school	35.3	41.2	31.8	33.2
High school	13.6	16.5	10.9	12.6
University/ college	4.5	2.9	5.6	4.0
Household size				
2	23.3	42.1	18.9	7.0
3	17.7	22.0	18.2	13
4	15.9	13.9	16.6	17.3
5	15.2	12.9	14.6	18.1
6	10.6	4.9	12.1	14.4
7	7.7	2.9	7.2	13.0
>8	9.6	1.3	12.4	15.2

There were differences in the level of education of the farmers across the three milksheds. A higher number of farmers in Nyeri (41.2%) had attained primary school education, compared with 33.2% and 31.8% in Bomet and Nakuru respectively. Notably, very few farmers had attained university/college education; 5.6%, 4% and 2.9% in Nakuru, Bomet and Nyeri milksheds respectively. Studies have attributed low smallholder milk production to low adoption of technical

skills and poor animal husbandry practices (Waititu, 2017). The level of education has been linked to improved dairy production as farmers with higher education level are more capable of synthesizing new information and thus making better informed decisions (Ntshangase *et al.,* 2018) and are more likely to adopt innovations to improve productivity (Mutavi, 2016). Additionally, farmers with a higher level of education are more likely to provide their cattle with higher quality feeds (Richards *et al.,* 2015).

There was a difference in the number household members across the three milksheds where 42.1%, 18.9% and 7.0% of the households in Nyeri, Nakuru and Bomet respectively comprised of 2 members while 15.2%, 12.3% and 1.3% in Bomet, Nakuru and Nyeri respectively comprised of more than 8 members. Kenya National Bureau of Statistics (KNBS), (2019) reported Bomet to have a higher household size (4.7) than Nakuru (3.5) and Nyeri (3.0). Studies in Kenya have shown that households with more than 5 members consume most of the milk produced rather than selling (Richard *et al.,* 2015). In this study, more households in Bomet (20%) utilized more milk (>7.5 litres/day) for home consumption as opposed to Nakuru (11.7%) and Nyeri (7%). Nyeri had smaller household size and this can be explained by the fact that it had lesser landholdings compared with Bomet and Nakuru. Past studies in Kenya have attributed larger household size to larger acreage (Otomu, 2000). Larger households are likely to have more family labor available for dairy production therefore lowering the cost of production.

4.2 Land ownership and crop enterprises

4.2.1 Land ownership

The mode of land acquisition and proof of ownership in the study areas is shown in Table 3. Across the three milksheds, 69.2% of the farmers acquired land as an inheritance while 30.8% purchased. Additionally, majority (52.2%) of the farmers had an official proof of ownership (title

deed) for their land. More farmers in Nyeri (53.8%) purchased their land as compared with Bomet (24.6%) and Nakuru (14.0%) and are therefore more likely to maximize its utilization thus more milk production. Nakuru mainly obtained their land as an inheritance (86%) compared with Nyeri (46.2%) and Bomet (75.4%) This was partly explained by the fact that dairy farmers in Nakuru and Bomet are relatively young (20-35 years), and therefore may have acquired their land through inheritance. Nyeri farmers were relatively older and may have acquired their land through purchase since older people would be expected to have more financial resources which they can use to buy land compared to younger people. Majority of the farmers (>71.5%) did not rent in land for farming across the milksheds. Land ownership is a vital factor as it guarantees continuity and provides a place for shelter (Otomu, 2000). Stable land tenure system or ownership backed by proper documentation such as Title deed or lease contract can safeguard investment in dairying such as intensive system or fodder production therefore guaranteeing better returns.

Table 3. Mode of land acquisition and proof of ownership in the study areas

Milkshed	**Overall (%)**	**Nyeri (%)**	**Nakuru (%)**	**Bomet (%)**
N	1146	410	383	353
Mode of farm acquisition				
Heritage	69.2	46.2	86.0	75.4
Purchase	30.8	53.8	14.0	24.6
Proof of ownership				
Yes	52.2	60.0	54.7	41.8
No	47.8	40.0	45.3	58.2
Land leasing				
No leased land	76.5	78.3	71.5	79.9
0.01-0.25 acres	3.1	4.9	2.1	2.0
0.3-0.9 acres	6.9	9.0	3.7	7.9
1-2 acres	10.3	7.1	15.9	7.9
2.1-5 acres	2.1	0.7	3.7	2.0
Above 5 acres	1.1	0	3.1	0.3

4.2.2 Farm size

Table 4 shows the land sizes owned by the respondents within the study areas. More (71.4%) of farmers in Nyeri owned between 0.1-3 acres compared with Bomet (60%) and Nakuru (56.7%) whereas more farmers in Bomet (24.7%) and Nakuru (22.7%) had more than 5 acres of land compared with Nyeri (13.3%). Size of landholdings impacts the type of production system adopted. In Nyeri, dairy cows were zero grazed whereas open grazing was mainly practiced in Bomet where farmers owned more acreage. Studies have shown that the average acreage of smallholder dairy farms in Kenya range between 3-5 acres in size (Mugambi *et al.,* 2015; Migose *et al.,* 2018; Otieno *et al.,* 2021). Limited land availability would lead to reduced feed resource base thus constraining the smallholder farmer resulting in fluctuations in feed availability and low milk production (Muia, 2001; Bebe, 2003). In the extensive system, an animal requires 1-2 acres of improved pasture per year in areas receiving over 900 mm of rainfall annually (Lukuyu *et al.,* 2012).

Table 4. Sizes (acres) of selected farms in the study areas

Milkshed	**Overall (%)**	**Nyeri (%)**	**Nakuru (%)**	**Bomet (%)**
N	1146	410	383	353
Farm size (acres)				
0.1- 3 acres	62.7	71.4	56.7	60.0
3.01-5 acres	18.5	15.3	20.7	19.6
5.01-10 acres	12.5	8.8	15.0	13.6
10.1-20 acres	4.3	2.5	6.2	4.1
Above 20 acres	3.5	2.0	1.5	7.0

4.2.3 Crops and fodder

Food crops and crop residues

The types of food crops grown within selected farms and types of crop residues utilized as livestock feed in the study areas are shown in Figure 2 and 3 respectively. Overall, maize farming was most (65.8%) common across the three milksheds, followed by beans (23.9%) and Irish potato (6.4%). Maize farming has been identified as commonly integrated with smallholder dairying in Kenya (Bebe *et al.,* 2003; Mugambi *et al.,* 2015). In integrated smallholdings cropping provides animals with fodder from nitrogen binding legumes, farm weeds and crop residues such as maize stover while animals provide manure used to replenish lost nutrients in cultivated area (Amwata *et al.,* 2018).

The types of crop residues and their utilization as animal feed in the study areas are shown in Figure 3. Maize stover was the main (70.1%) crop residue utilized as livestock feed in the study areas followed by bean haulms (22%). Past studies have listed maize stovers, banana leaves and pseudo-stems, pigeon peas residue, cowpea residue and bean haulms as the crop residues commonly utilized as animal feed in smallholder farms (Dorward *et al.,* 2000; Njarui *et al.,* 2011). Banana leaves and pseudo stems have been identified as poor livestock feed due to its high moisture content and low nutritive value (Mugambi *et al.,* 2015).

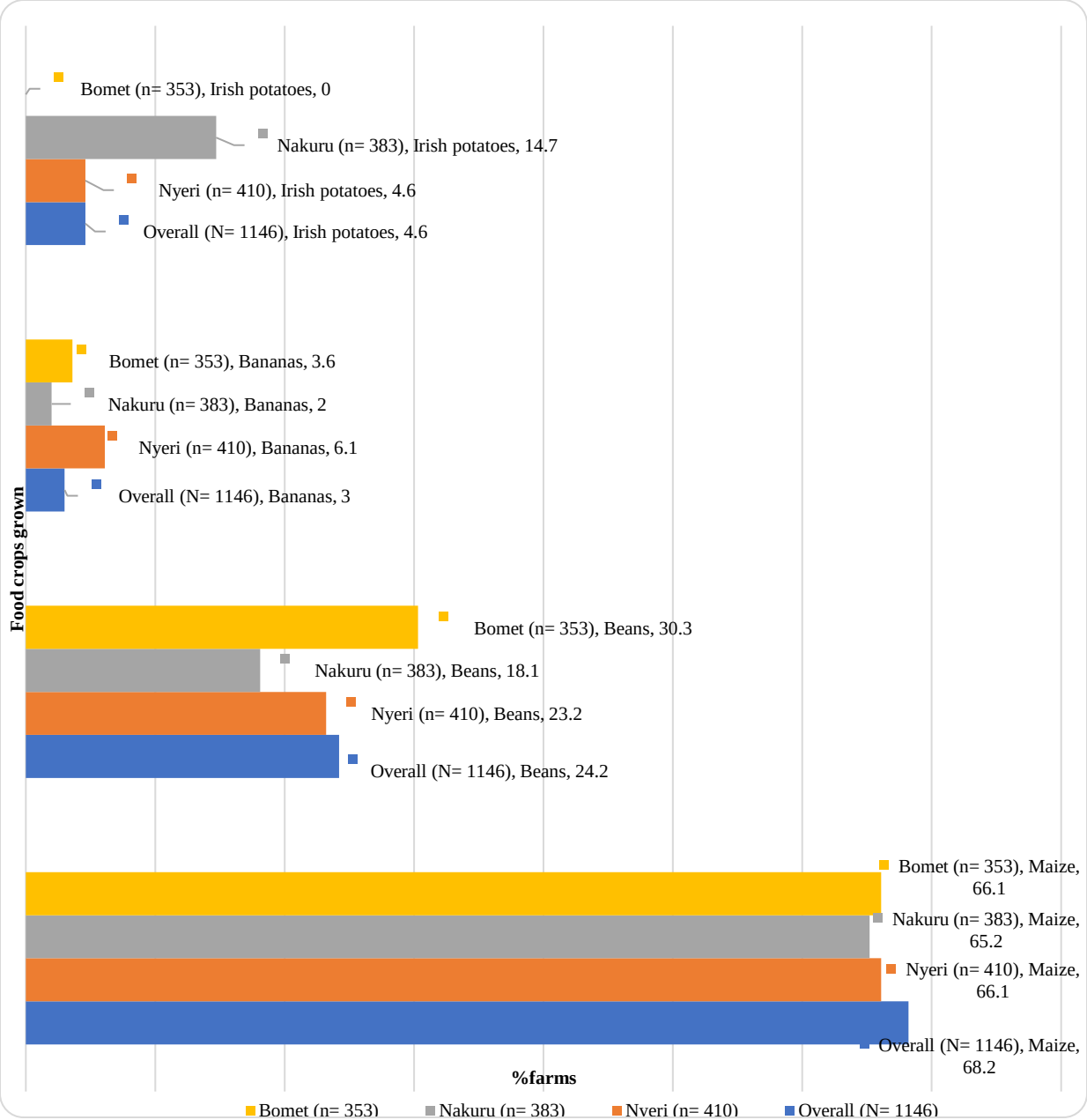


Figure 2. Types of food crops grown within selected farms in the study areas

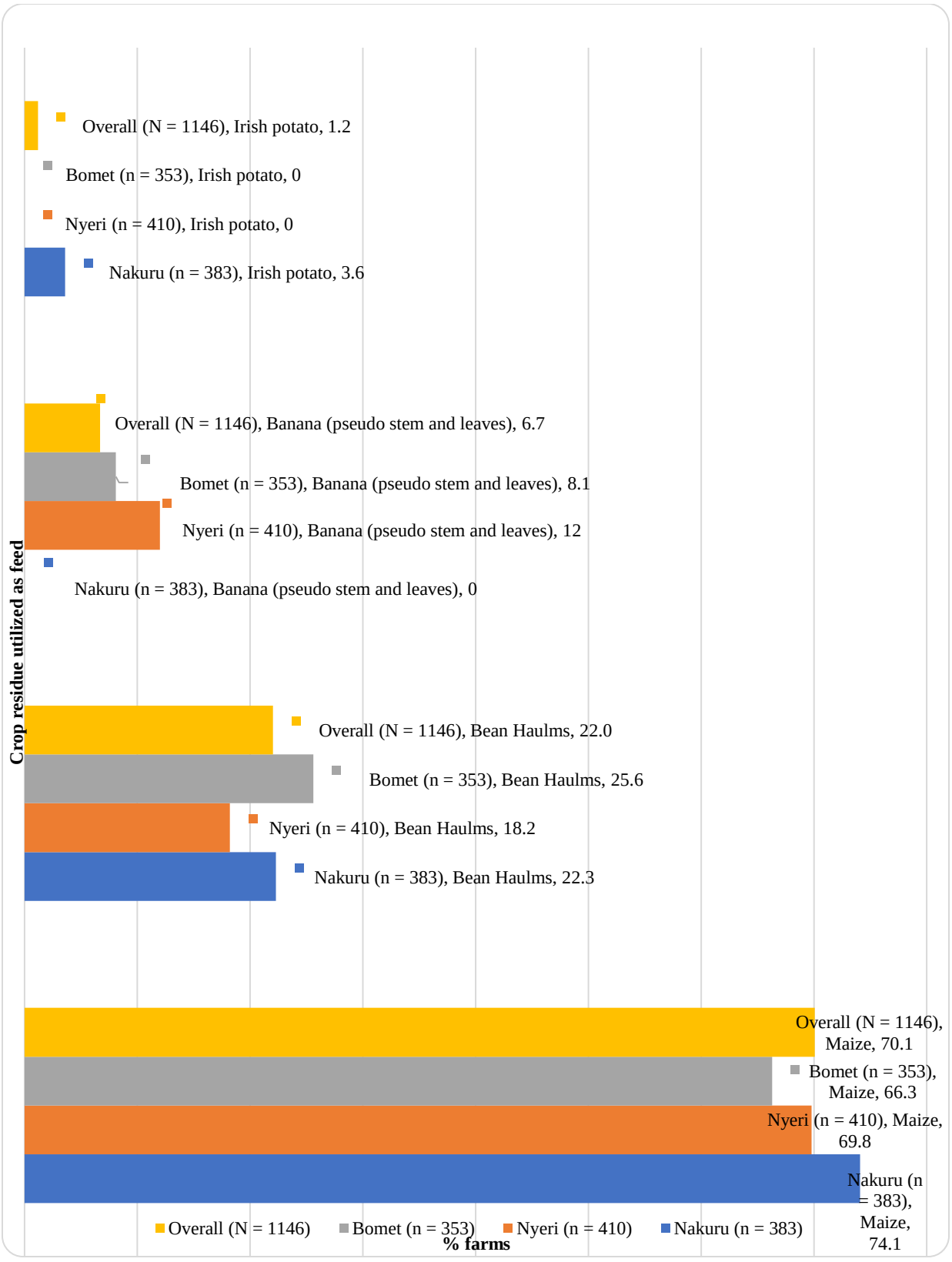


Figure 3. Types of crop residue utilized as livestock feed in the study areas

Cash crops

The types of cash crops grown in the study areas are shown in Figure 4. Coffee and tea were the main cash crops grown in the smallholder farms across the three milksheds. Mostly coffee (50.2%) and tea (16.6%) were grown in Nyeri compared to Nakuru (no coffee) and Bomet (11.6% - tea) milksheds. This was attributed to Nyeri being in an agroecological zone which favors coffee farming. Coffee requires specific temperature (20^0C–27^0C), rainfall (1500–2000 mm) and altitude conditions (1400 m–2000 m) and the acidic soils in Nyeri, right amount of sunlight and rainfall provide excellent conditions for coffee plants (Condliffe *et al.,* 2008). Past studies in Kenya have noted that coffee and tea are the main cash crops integrated with smallholder dairying (Bebe, 2003; Lukuyu *et al.,* 2009). Growing of cash crops like tea and coffee in smallholder dairy farms competes for arable land with fodder crops such as Napier. Smallholder dairy farmers plant cash crops such as tea, coffee and horticultural crops in their landholdings at the expense of fodder crops which are mainly purchased off farm impacting negatively on dairy production (Syomiti *et al.,* 2015). Fewer farmers in Nakuru and Bomet grew coffee and tea, an indication that they relied more on milk production for cash compared with Nyeri. There is a likelihood of more land being available for pasture and fodder growing in Nakuru (no coffee/tea) compared to Nyeri and Bomet where tea and coffee are major crops. Also, a large percentage of the farms surveyed in Nyeri did not grow cash crops and this was attributed to smaller landholdings in the county. Maina *et al., (*2015) reported that the constraints facing tea farming in Nyeri (Mathira and Othaya) included small landholdings, low prices and pests and diseases. Studies have reported various factors affecting cash crop farming in Kenya including farm size, access to credit and household size (Kamau *et al.,* 2017).

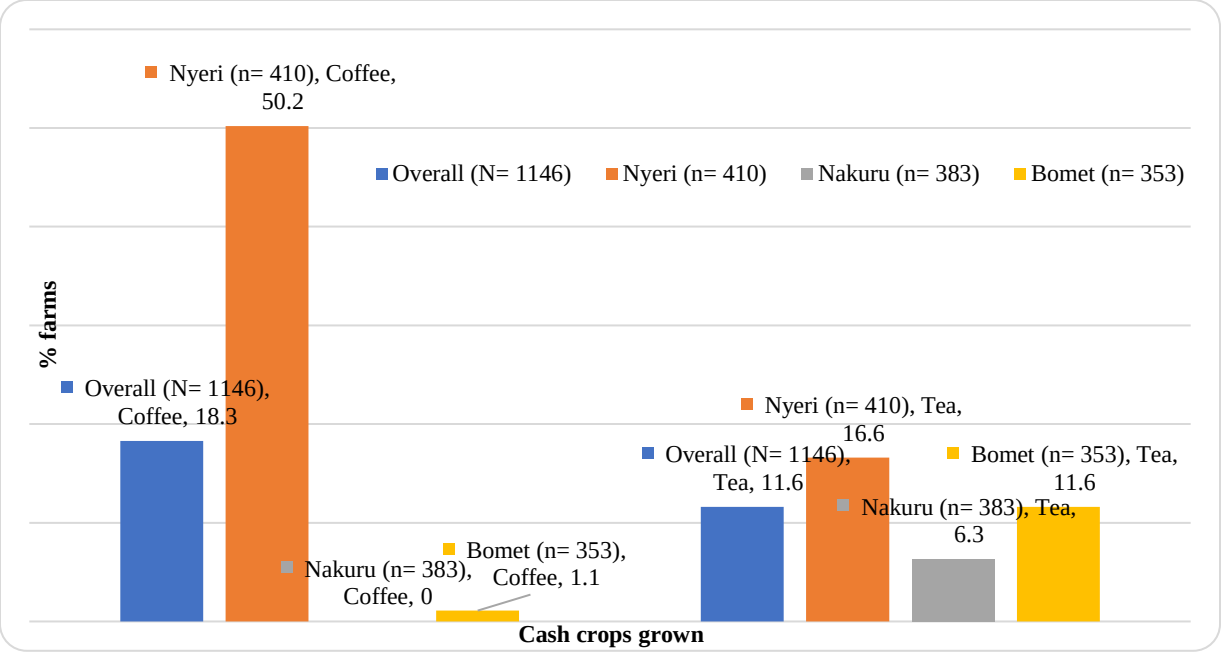


Figure 4. Types of cash crops grown in the study areas

Fodder crops

The types of fodder crops grown in the study areas are shown in Figure 5. Napier grass was the most common (69%) fodder crop grown in the three milksheds. Other fodder crops grown included *Brachiaria* (5.4%), oats (3.7%), lucerne (1.1%) and *Desmodium* (0.6%). Past studies in East Africa have reported that feeding Napier alone yields about 7 Kg of milk; Napier-Legume (*Desmodium*) yields 9 Kg-12 Kg; Rhode's grass yields 5 Kg-7 Kg; Oats yield approximately 10 Kg and Grass-Legume yields 7 Kg-10 Kg (Lukuyu *et al.*, 2012). More farmers in Nyeri (90.2%) grew Napier grass compared with Bomet (69.4%) and Nakuru (47.3%) and this was attributed to the intensive system adopted in Nyeri (80.7%) compared with 16.2% and 2.2% in Nakuru and Bomet respectively. Past studies in Kenya have noted that Napier grass is mainly utilized as cut and carry/stall fed but not suitable for direct grazing as stumping leads to poor regeneration (Orodho, 2006; Mutavi, 2018). While Napier grass is widely grown and utilized as fodder by many

smallholder dairy farmers, it is nevertheless generally low in crude protein and minerals and therefore requires supplementation with legumes (Kariuki, 1998; Lukuyu *et al.,* 2012).

In this study, only a few farmers had incorporated forage legumes in their farms. There is need to increase awareness among smallholder dairy farmers to incorporate forage legumes such as *Desmodium,* lucerne, *Stylosanthes guianesis* and fodder trees such as *Calliandra* thus increasing milk production (Lukuyu *et al.,* 2012). Forage legumes increase nitrogen supply to the rumen thus improving digestibility and increasing milk production (Smith *et al.,* 1990; Lukuyu *et al.,* 2009). They supplement minerals such as calcium and phosphorous and vitamins (A & D) in animal diets (Kabirizi *et al.,* 2013; Mutavi, 2018). Notably, the feed resource base is constrained by high population density and reduced land sizes affecting smallholder dairying (Zemmelink *et al.,* 1999; Bebe, 2003).

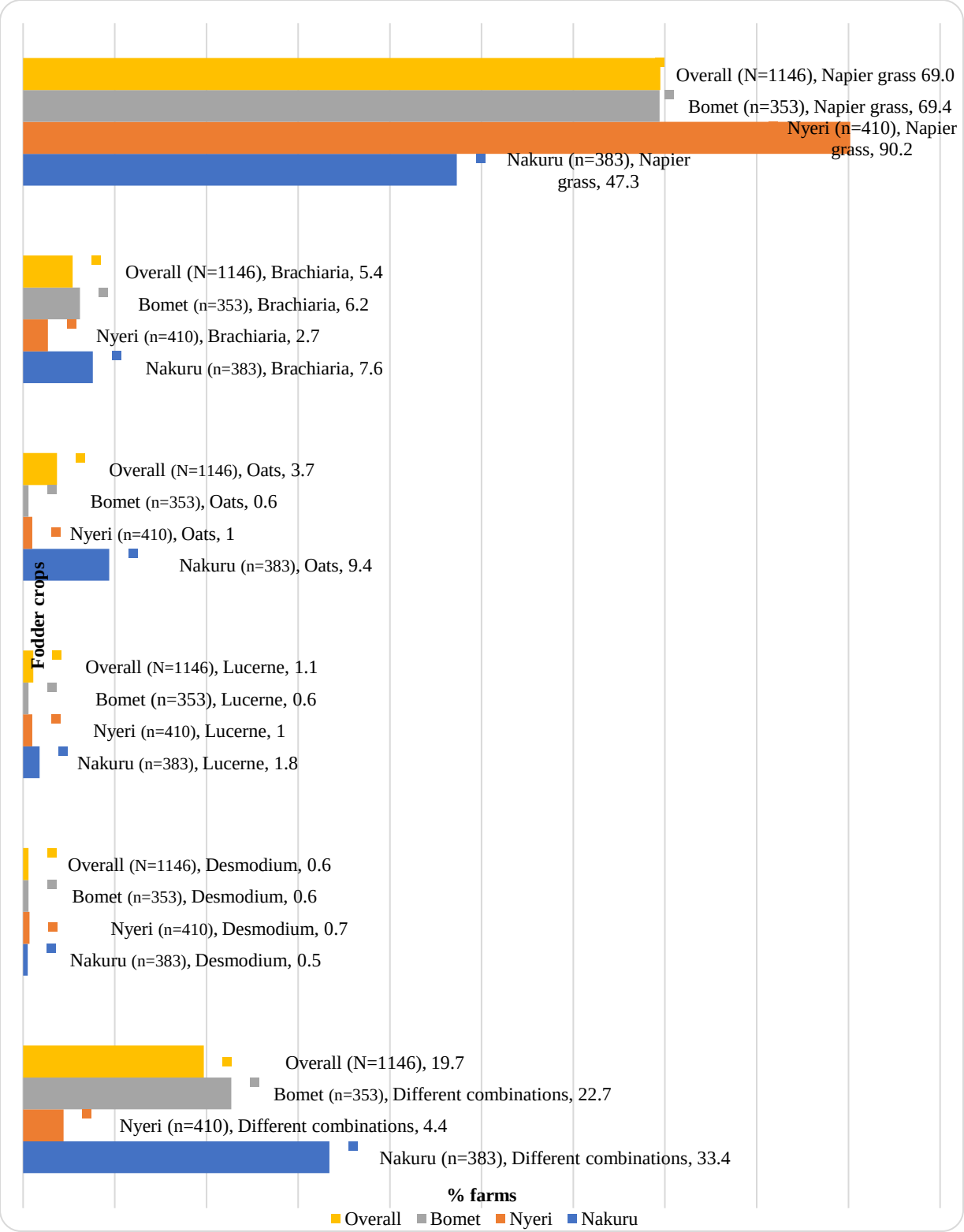


Figure 5. Types of fodder crops grown in the study areas

4.3 Dairy herd composition and performance

4.3.1 Herd composition

The types of dairy cattle breeds reared in the study areas are shown in Figure 6. The common dairy breeds in the study areas included; Holstein-Friesian, Ayrshire, Guernsey and Sahiwal breeds. The Holstein-Friesian breed was more common in Nyeri (84.4 %) compared with Nakuru (58%) and Bomet (53.9%) and this can be attributed to the type of production system mainly adopted in Nyeri (intensive system) with farmers preferring breeds with high milk capacity. Also, in the Nyeri milkshed, the farmgate prices of milk were higher and thus an encouragement for keeping animals with high capacity for milk.

The Ayrshire breed was more prevalent in Bomet (45%) and Nakuru (41.5%) compared with Nyeri (14.4%) where the commonly adopted production system in both Bomet (97.9%) and Nakuru (83.8%) was mixed grazing (mainly grazing with some stall feeding/ mainly stall feeding with some grazing). The Guernsey and Sahiwal breeds were less common (0.9%) across the three milksheds. Studies have reported similar findings in smallholder farms in Kenya characterizing the dairy herd to comprise of Friesian (82%) and Ayrshire (8%) breeds (Ajak, 2020), and, the Ayrshire breed being more common in western Kenya (22%) (Wanjala and Njehia, 2014). Past studies in Kenya have identified Friesian, Ayrshire, Jersey, Guernsey and their crosses as the common dairy cattle breeds in many smallholder farms (Dorward *et al.,* 2000; Aleri *et al.,* 2012; Wanjala and Njehia, 2014; Mugambi *et al.,* 2015). Overall, the Holstein-Friesian was preferred due to its high milk production and selling value while the Ayrshire was preferred for high resistance to disease, moderate to high milk yield and less feed requirement compared to Friesian. Past studies have reported that high milk production is the preferable trait in the Friesian breed

while high milk fat content and lower feed requirement in the Ayrshire breed are the preferred traits (Lukuyu *et al.*, 2009; Onono and Ochieng, 2018).

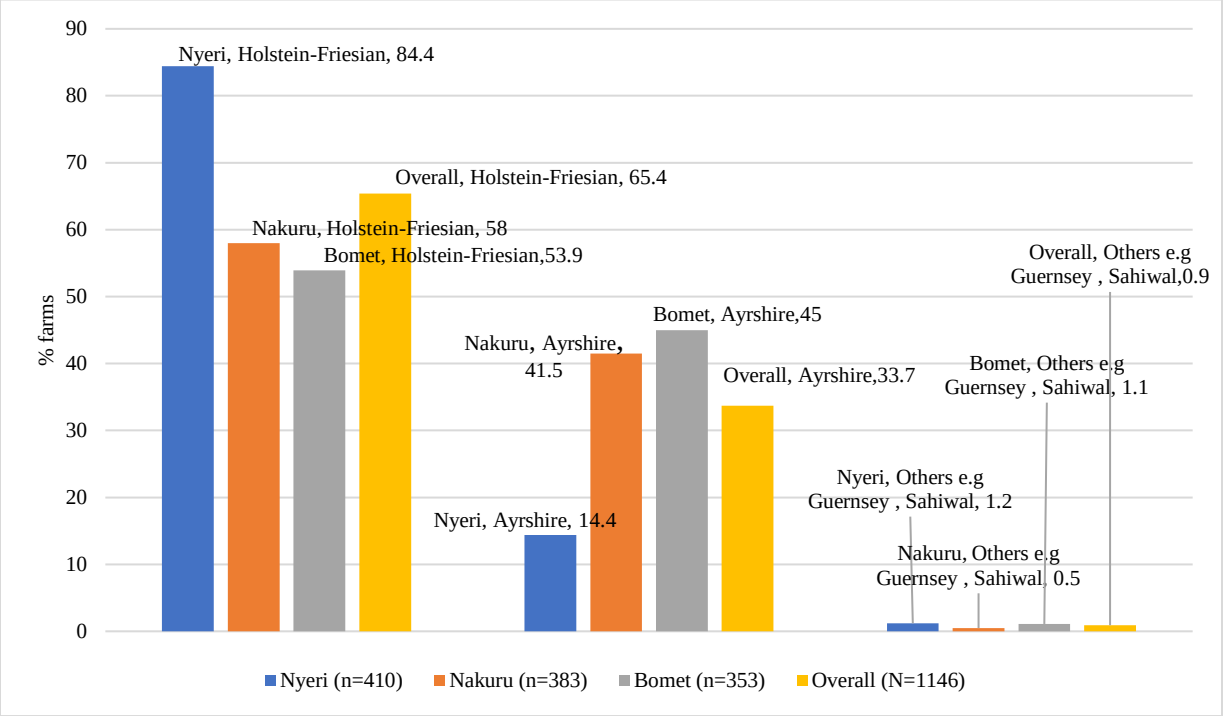


Figure 6. Commonly kept dairy cow breeds in the study areas

4.3.2 Milking herd, milk production and household milk consumption

Milking herd and milk production

The average herd size of the milking cows and the average milk production/cow/day in the study areas are shown in Table 5. Milk yield data was recall data from the preceding year (2018), and did not take into account the lactation period. The larger herd size in Bomet (3.2) and Nakuru (3.0) compared with Nyeri (2.5) can be attributed to larger landholdings in the two milksheds. In an earlier study, Otieno *et al.*, (2021) reported that the average dairy herd comprised of 3 milking cows in smallholder dairy farms in Nakuru. Dairy intensification can increase milk production, however, reduced land sizes, capital to sustain production, reduced extension services and low soil fertility constrain intensification (Nicholson *et al.*, 2001; Bebe, 2003). Several factors affect the

herd size in Kenya including high cost of inputs, feeding, low animal husbandry technical skills and diseases (Mugambi *et al.,* 2015; Waititu, 2017; Onono and Ochieng, 2018).

Of the three milksheds, Bomet (5.4l/c/d) had lower milk production compared to Nyeri (8.3l/c/d) and Nakuru (5.7l/c/d). This was attributed to the adopted production system (extensive), type of dairy cattle breed kept, lower farmgate milk price and lesser usage of commercial concentrate feed in Bomet compared with Nyeri and Nakuru milksheds. The average milk production per cow in the study areas (6.5 litres/ day) is low compared to 7 - 9 litres/cow/day average in Kenya (KDB, 2019). The extensive system practiced in Bomet is less capital intensive and less laborious. However, it requires more land space and cows waste a lot of energy by walking while grazing. On the other hand, intensive system is laborious, capital intensive, cows yield more as they do not waste energy walking in search of pasture and also avoids diseases associated with grazing (Lukuyu *et al.*, 2012).

Low milk productivity in Kenya has been associated with feed inadequacy, lack of credit, low technical skills on husbandry practices and reduced access to extension services (Omunyin *et al.,* 2014; Mugambi *et al.,* 2015; Waititu, 2017). Feed inadequacy (48.7%), tickborne diseases (41.8%), lack of credit (17.4%) and low farmgate milk price (16.0%) were identified as the main dairying constraints in this study.

Table 5. Average herd size and average daily milk production/cow in the study areas

Milkshed	**Overall**	**Nakuru**	**Nyeri**	**Bomet**
N	1146	383	410	353
Average milking cows herd size				
Mean	2.9	3.0	2.5	3.2
SEM	0.2	0.2	0.1	0.2
Average daily milk production/cow in litres **in 2018**				
Litres/cow/day	6.5	5.7	8.3	5.4
SEM	0.5	0.4	0.5	0.5

Household milk consumption

The average daily household milk consumption in the study areas is shown in Figure 7. Majority (41.2%) of the households across the three milksheds consumed a daily average of 2-5 litres of milk. More households in Nyeri consumed higher amounts (>5 litres) compared with Bomet and Nakuru and this was attributed to higher milk productivity in Nyeri compared to the other two milksheds. Additionally, higher milk consumption in Bomet was attributed to larger household size compared to the other two milksheds. A Pearson Correlation examined the relationship between household size and household milk consumption. The mean for the household size was 4.2 members (SD = 2.13) and the mean for household milk consumption was 5.3 litres (SD =1.55). The association between household size and household milk consumption was positive, weak and statistically significant (r (1146) = .15, p = .00). Past studies have noted that smallholder dairy households with more members tend to consume more milk rather than selling (Richard *et al.*, 2015).

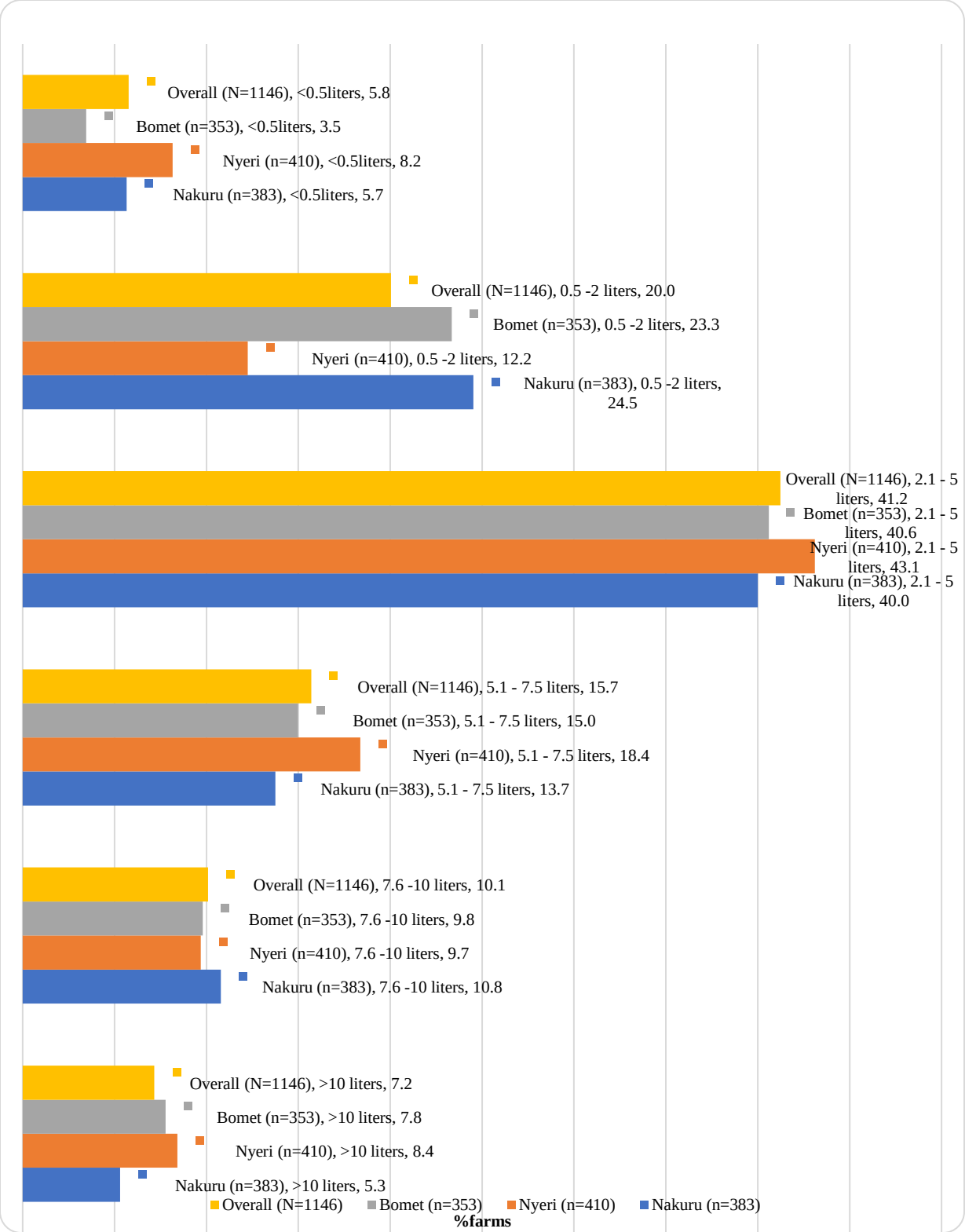


Figure 7. Average daily household milk consumption in litres in the study areas

Milk buyers and farmgate milk price

The milk buyers and farmgate milk price in the study areas is shown in Table 6. Overall, across the three milksheds, milk was marketed through individual customers and middlemen (46.8%) than processors (40.8%). More farmers in Nakuru (56.5%) and Bomet (52.3%) sold their milk to individual customers and middlemen compared with Nyeri (31.7%). This can be explained by the fact that individual buyers/middlemen offered slightly higher milk rates (at the time of study) in Nakuru (KES 23.3/-) and Bomet (KES 19.3/) compared with the processors'/cooperatives' (KES 19.4/- and KES 17.2/- respectively). Low farmgate milk prices have been identified as dairying constraints (KDB, 2019).

Table 6. Milk buyers (%) and farmgate milk price (KES/l) in the study areas

Milkshed	**Overall**	**Nakuru**	**Nyeri**	**Bomet**
N	1146	383	410	353
Farm milk buyers (%)				
Processor	40.8	33.6	54.9	33.8
Individual customers and middlemen	46.8	56.5	31.7	52.3
Processor and individual customers & middlemen	8.9	7.4	10.1	9.1
All the above	3.6	2.6	3.5	4.7
Average milk price (KES/l) offered by Cooperative/Processor*				
Mean price/liter	19.3	19.4	21.3	17.2
SEM	0.17	0.16	0.19	0.15
Average milk price (KES/l) by Individual customers & middlemen				
Mean price/liter	21.6	23.3	22.2	19.3
SEM	0.29	0.29	0.29	0.28

**1 KES=0.008$*

4.4 Integration of dairy with other livestock

The type of livestock integration with dairy farming in the study areas is shown in Figure 8. Various livestock species were integrated with dairy in the study areas mainly including; poultry, sheep and goat production. Poultry farming was most (36.0%) common followed by sheep

& poultry (19.8%) and goats & poultry (11.3%). Notably 16.4% of farmers across the three milksheds did not integrate dairy with other livestock. Integration of dairying and poultry production has been reported among Kenyan smallholder farmers (Bebe *et al.,* 2003). Past studies in Kenya have reported that ownership of indigenous chicken by farmers is a food security issue where they supply protein in form of eggs and meat and generate income from quick sales (Nduthu *et al.,* 2015). Adoption of mixed farming systems maximizes on resources such as land and capital (Mutavi and Amwata, 2018). Dry poultry waste/excreta from caged birds has CP 25-28% (dry basis) and poultry litter mainly from broiler operations can be utilized as livestock feed (Lukuyu *et al.,* 2012). Poultry waste can be used as a source of non-protein nitrogen (NPN) for ruminant livestock such as dairy cattle. Though this may be widely practiced in peri-urban areas, in the current study areas across the three milksheds, only 2 farmers in Nyeri fed poultry liter to their cows.

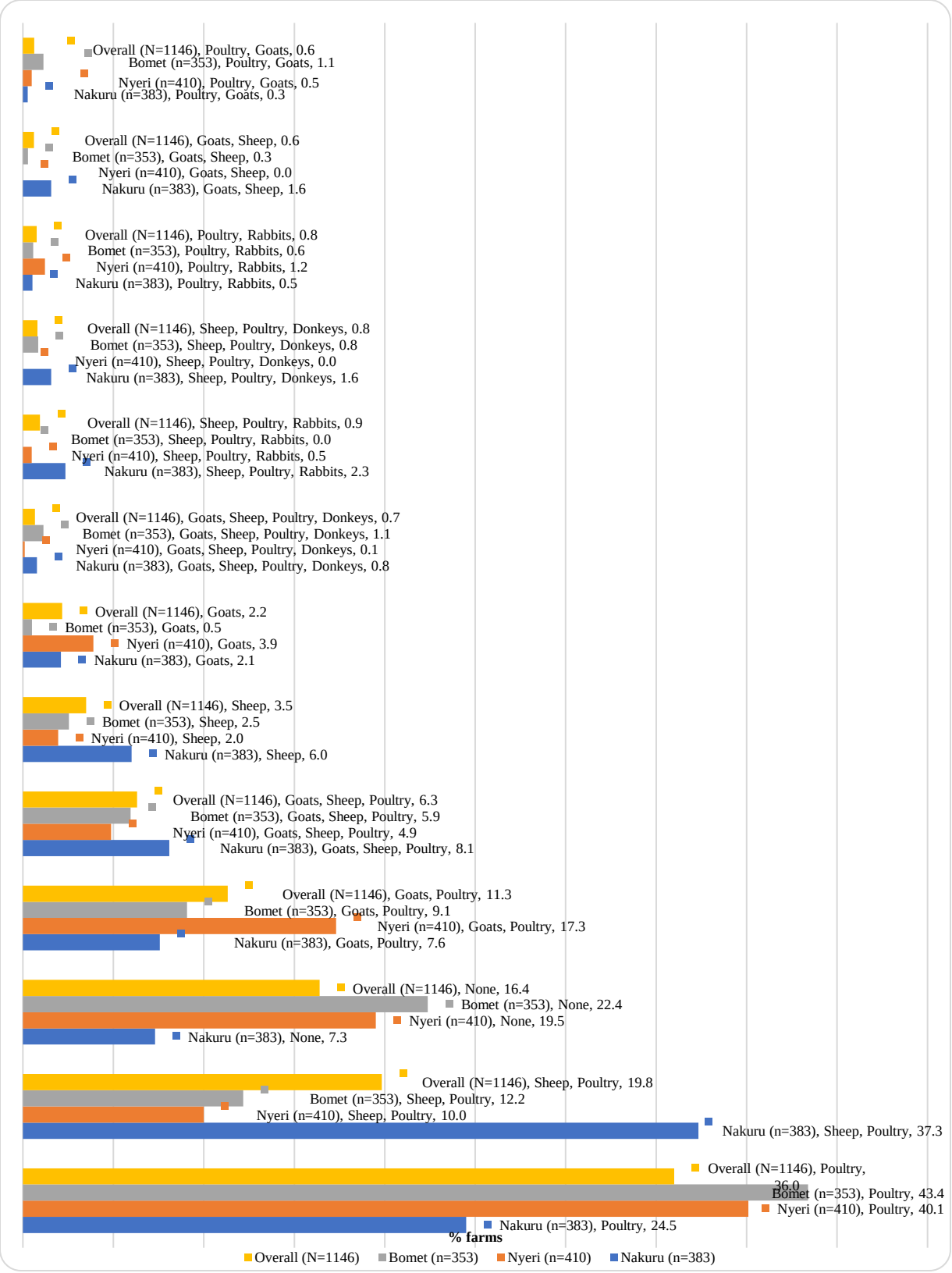


Figure 8. Integration of dairy farming with other livestock species in the study areas

4.5 Management practices

4.5.1 Animal feeding and stocking density

The production systems during the dry and rainy season in the study areas are shown in Table 7. The production systems across the three milksheds did not vary between seasons. Intensive system was practiced by 80.7%, 16.2% and 2.2% of the farmers in Nyeri, Nakuru and Bomet milksheds respectively while semi-intensive system was practiced by 26%, 10% and 8.6% of farmers in Nakuru, Bomet and Nyeri milksheds respectively and extensive system was practiced by 61.2%, 31.9%, and 2.2% of farmers in Bomet, Nakuru and Nyeri milksheds respectively. This can be explained by the fact that Nyeri had lesser landholdings compared with Nakuru and Bomet milksheds where grazing was more pronounced. Past studies have reported similar findings showing that the commonly adopted smallholder feeding system in Nyeri is the intensive system (74%) (Ajak, 2020), and the semi-intensive system is commonly adopted in Western Kenya (32%) (Wanjala and Njehia, 2014). Bomet and Nakuru had higher stocking density compared to Nyeri and this was attributed to larger landholdings in Bomet and Nakuru compared with Nyeri.

4.5.2 Grazing and other types of feed offered to dairy cows

Grazing area

The ownership of area available for grazing during the rainy and dry season in the study areas is shown in Figure 9 and Figure 10. Across the three milksheds, grazing was done on owned land (77.9%) or on state land (roadside, forests, community land and open grasslands) (19.3%). Of the farmers in Bomet, 78.2% and 55.5% in Nakuru grazed their animals on owned land during both the rainy and dry season. Wanjala and Njehia, (2014) reported similar findings in Western Kenya where many smallholder farmers grazed their animals on their own land. Notably, there was minimal grazing in Nyeri and this was attributed to the type of production system adopted

where animals were mainly stallfed. Despite being less laborious and less capital intensive, the extensive system requires more land allocation to grazing and is low yielding as cows' waste energy through walking while grazing (Lukuyu *et al.,* 2012).

Table 7. Dairy production systems in the study areas

Production systems				
Milkshed	**Overall**	**Nakuru**	**Nyeri**	**Bomet**
N	1146	383	410	353
Production system during the dry season (%)				
Extensive system	31.7	31.9	2.2	61.2
Mainly grazing with some stall feeding	30.0	44.6	12.0	33.4
Mainly stall feeding with some grazing	5.3	7.3	5.1	3.1
Intensive system	33.0	16.2	80.7	2.3
Production system during the rainy season (%)				
Extensive system	31.7	31.9	2.2	61.2
Mainly grazing with some stall feeding	30.0	45.2	11.7	33.1
Mainly stall feeding with some grazing	5.2	6.8	5.4	3.7
Intensive system	33.1	16.2	80.7	2.0
Stocking density	1.8	1.9	1.6	2.0

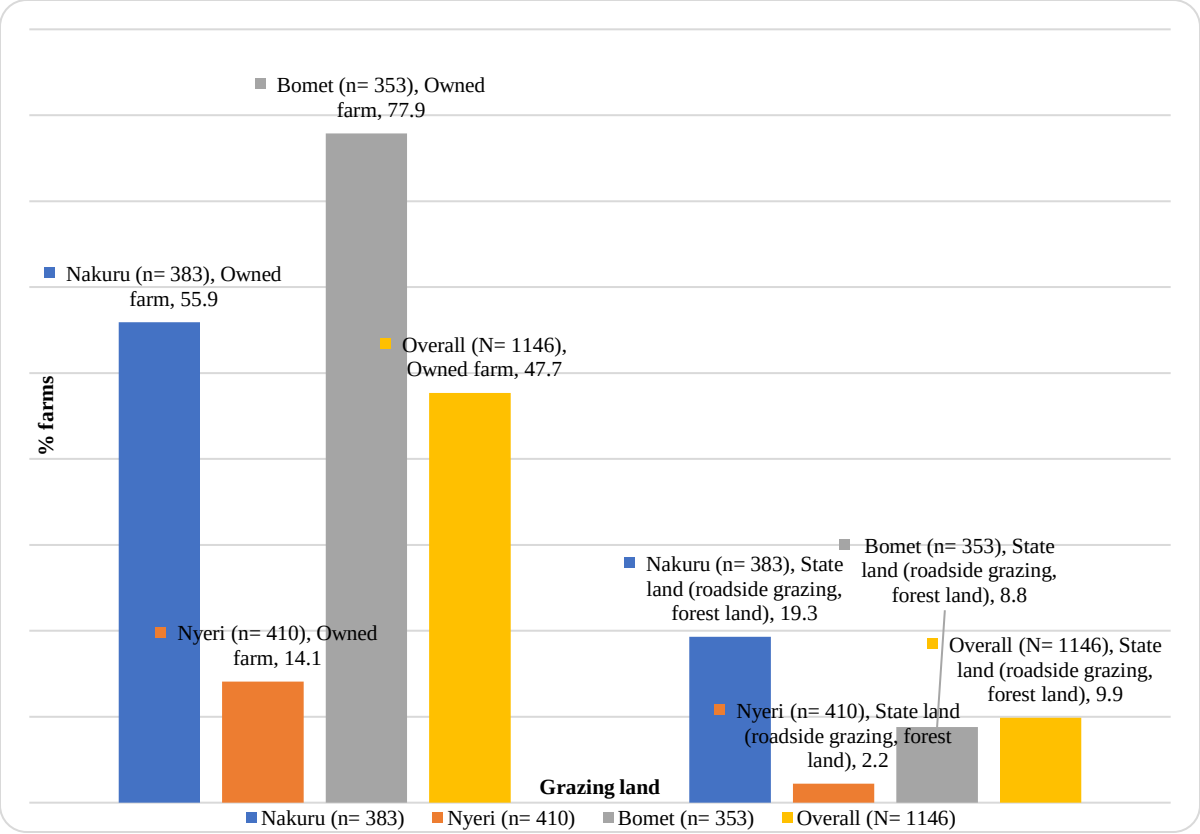


Figure 9. Availability of grazing land during the rainy season in the study areas

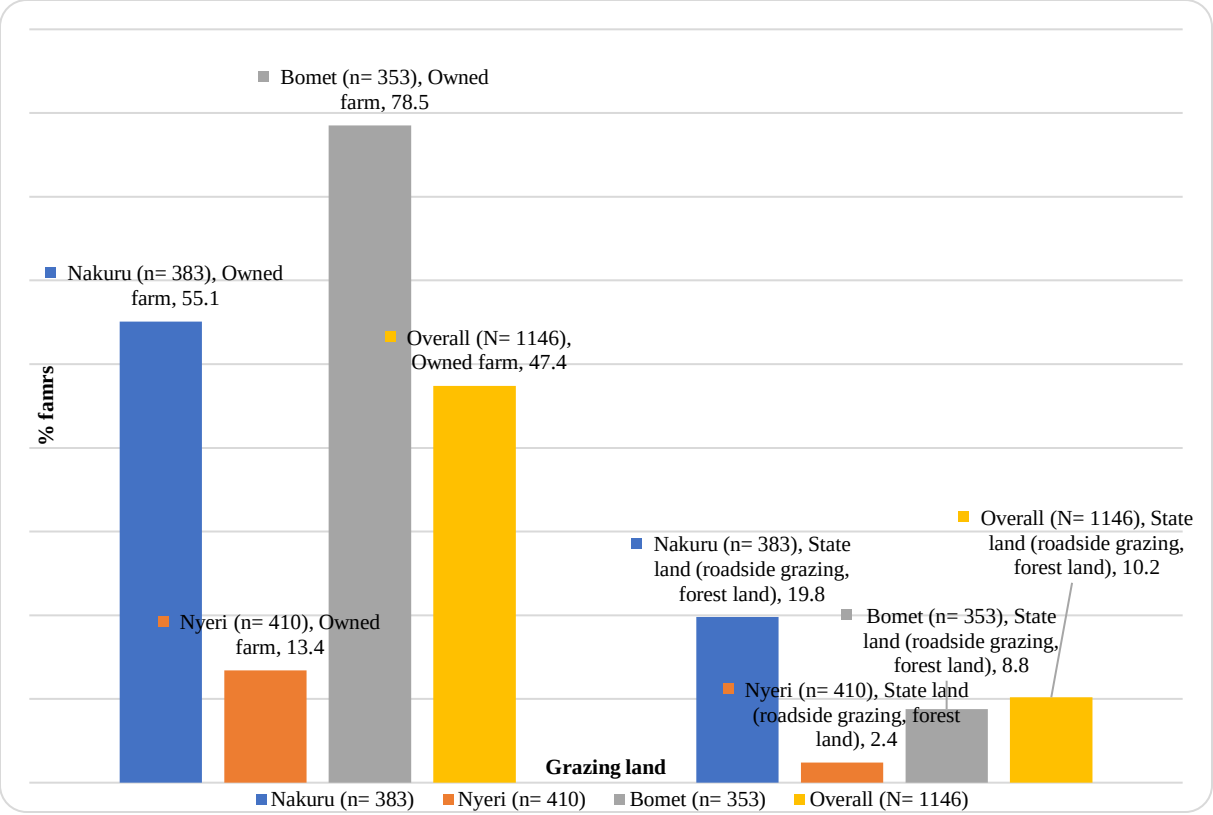


Figure 10. Availability of grazing land during the dry season in the study areas

Other types of feeds

The feed resource offered to dairy cattle during the rainy and dry season in the study areas is shown in Table 8. Roughages (Napier grass, maize stover, farm weeds, cut grass) were the most common (76.8%) feed offered to dairy cattle during both the rainy and the dry season. The availability of roughages declined during the dry season and more silage and hay (Rhodes) were offered to dairy cows during the dry season than during the rainy season across the three milksheds. This can be explained by the fact that maize fodder conserved as silage were utilized during the dry season while hay was mainly purchased in the event of feed shortage during the dry season. Several studies have reported that the common type of feed in smallholder dairy farms in Kenya included; Napier grass, maize stovers and farm weeds (Dorward *et al.*, 2000; Bebe, *et al.*, 2003; Lukuyu *et al.*, 2009; Waititu, 2017; Mutavi and Amwata, 2018). Feed inadequacy during the dry

season had been identified as a dairying constraint. The quality of Napier offered to dairy cattle by farmers is low as it is usually overgrown (>2m) with large proportion of dry leaves accounting for low milk production (Njarui, 2011; Mugambi *et al.,* 2015). Past studies in East Africa have reported that feeding Napier alone yields about 7 Kg of milk and Napier-Legume e.g., *Desmodium* yields 9-12 Kg of milk (Lukuyu *et al.,* 2012). However, only few farmers had incorporated forage legumes in their farms in the study.

Table 8. Feed resources during different seasons in the study areas

Milkshed		**Nakuru (%)**	**Nyeri (%)**	**Bomet (%)**	**Overall (%)**
N		383	410	353	1146
Types of feed offered to dairy cattle in the rainy season					
Roughages	Roughages (e.g., Napier, maize stover, weeds)	89.6	82.6	89.6	87.3
Hay	Hay (Rhodes)	6.3	8.4	5.3	6.7
Silages	Grass silage	3.1	6.1	4.0	4.4
	Maize silage	1.0	2.9	1.1	1.7
Types of feed offered to dairy cattle in the dry season					
Roughages	Roughages (e.g., Napier, maize stover, weeds)	70.6	61.3	66.9	66.3
Hay (Rhodes)	Hay (Rhodes)	21.2	23.2	22.9	22.4
Silages	Grass silage	6.6	10.4	8.7	8.6
	Maize silage	1.6	5.1	1.5	2.7

4.5.3 Types of commercial supplements

The types of commercial supplements (incorporating both mixed and individual ingredients) and supplements offered to dairy cattle in the study areas are shown in Figure 11. These included hay, commercial concentrates and minerals. In the three milksheds, 78.4%, 61.3% and 51.4% of farmers in Bomet, Nakuru and Nyeri respectively purchased minerals while 42.1%, 37.0% and 18.6% of farmers in Nyeri, Nakuru and Bomet respectively purchased concentrate feed. Farmers from Bomet milkshed purchased more minerals (78.4%) and less commercial

concentrates (18.6%) and this can be explained by the low farmgate milk price constraining farmers in Bomet compared with Nyeri and Nakuru milksheds which were higher. Moreover, more (6.5%) farmers in Nyeri purchased hay compared with Nakuru (1.7%) and Bomet (1.4%). This was attributed to smaller landholdings in Nyeri as compared to Nakuru and Bomet. Past studies in Kenya have reported that many smallholder farmers offer roughages, commercial concentrates and minerals to their animals (Ajak, 2020). Additionally, high usage of minerals and commercial concentrates has been attributed to their positive effect on milk production (Romney *et al.*, 2000; Lukuyu *et al.*, 2009).

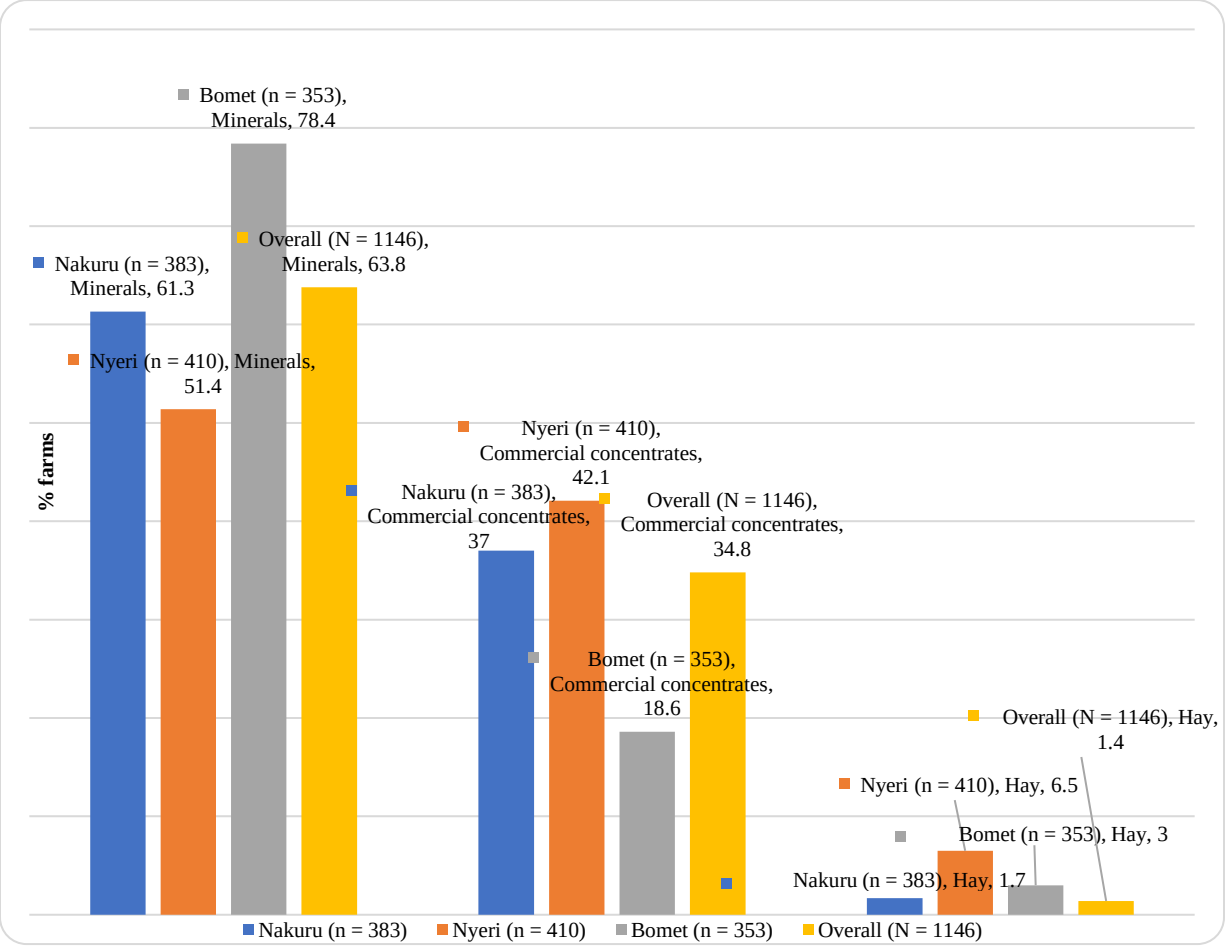
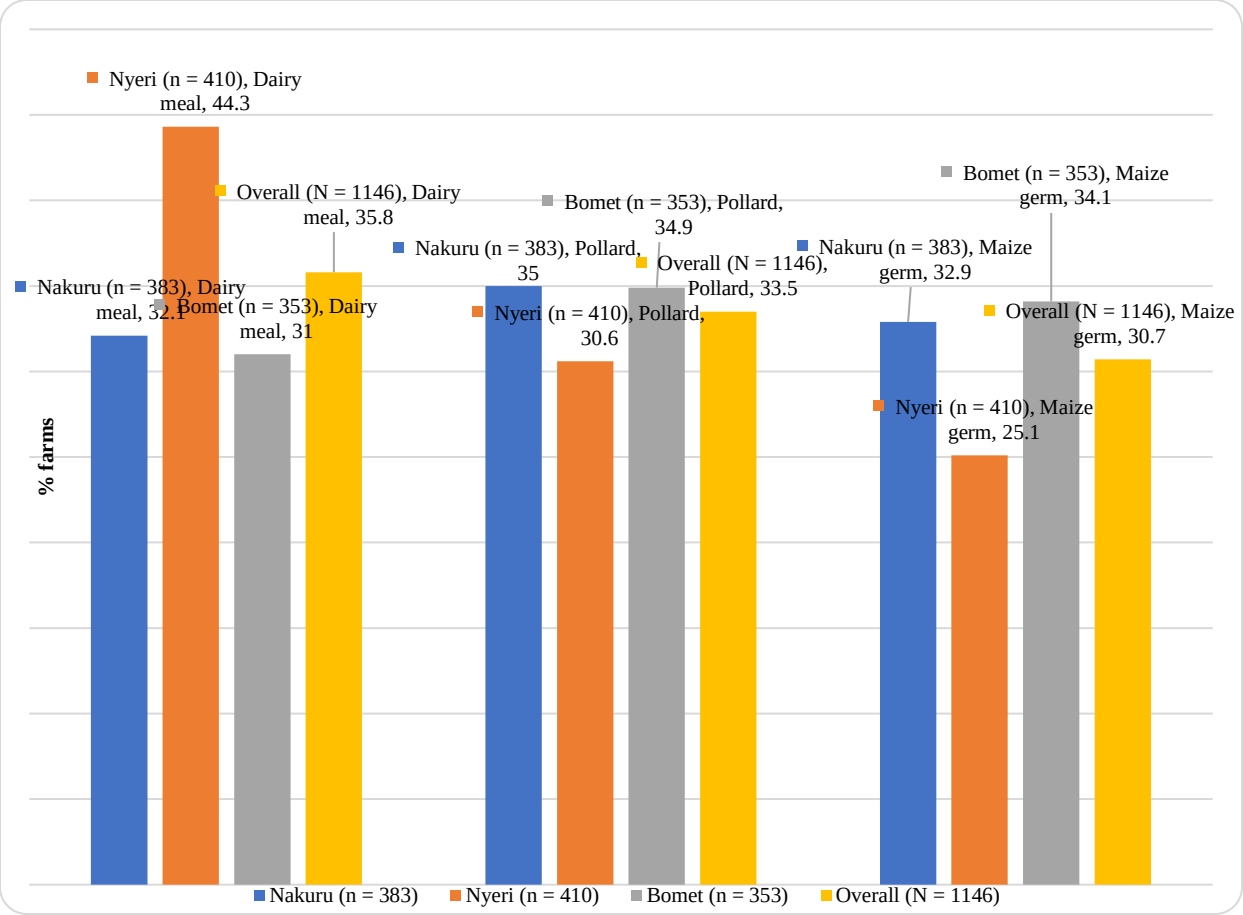


Figure 11. Types of animal supplements purchased by dairy farmers in the study areas

Types of commercial concentrates

The types of commercial concentrates purchased by farmers in the study areas are shown in Figure 12. Across the three milksheds, the most commonly purchased commercial concentrates included dairy meal (35.8%), wheat pollard (33.5%) and maize germ (30.7%). More dairy meal (commercial compounded concentrate) was purchased in Nyeri (44.3%) compared with Nakuru (32.1%) and Bomet (31.0%). Farmers in Nyeri and Nakuru received higher farmgate milk prices which acted as an incentive to increase yield by buying more commercial concentrates. Also, more farmers in Nyeri (44.3%) purchased "dairy meal'® (which is a compounded balanced mixture of ingredients) than wheat pollard (30.6%) and maize germ (25.1%) resulting in higher milk production compared with the other milksheds. Dairy meal, maize germ and maize bran have been identified as the main commercial concentrates purchased by smallholder farmers (Wanjala and Njehia, 2014). Dairy meal has been identified as a principal commercial supplement offered to smallholder cattle. It has however been reported that the amount of concentrate fed is not based on milk yield but the number of times the animals are milked (Njarui *et al.,* 2011).



**Dairy meal - commercial compounded concentrate*

Figure 12. Types of commercial feeds purchased by farmers in the study areas

Homemade concentrate dairy rations

The number of farmers mixing 'homemade' concentrates in the study areas are shown in Table 9. This involved purchasing individual ingredients and mixing them at home using a mixing ratio provided by livestock service providers. Overall, very few farmers (5.8%) across the three milksheds mixed 'homemade' concentrates which can mostly be attributed to lack of knowhow lack of facilities to mix the various ingredients and to an extent lack of capital to purchase in bulk. Mixing of 'homemade' concentrates could lower the cost of milk production and improve quality and past studies in Kenya have identified a need to train farmers and increase awareness on

concentrate feed formulation so as to develop high quality feed (Mbugua, 1998). One of the main complaints from farmers about commercial compounded concentrates is the low quality and high price (Ajak, 2020). Home mixing would address the two issues provided the ingredients are of good quality and are sourced at a competitive price. Due to credit accessibility by farmers through bank-dairy cooperatives partnerships (Wachekeh, 2013; Njiru, 2020) farmers can source for raw materials. The ration formulated must be nutritionally adequate and be consumed in adequate amounts to provide for the level of production desired at reasonable cost (Lukuyu *et al.,* 2012).

Table 9. Farmers mixing 'homemade' concentrates in the study areas

Milkshed	**Overall (%)**	**Nyeri (%)**	**Nakuru (%)**	**Bomet (%)**
N	1146	410	383	353
Farms mixing homemade concentrates				
No	94.2	92.7	93.2	96.9
Yes	5.8	7.3	6.8	3.1

4.5.4 Milk production trend

The average daily milk production per cow for the 12 months across the three milksheds during the study period is shown in Figure 13. Of the three milksheds, Nyeri had a relatively higher productivity (8.3l/c/d) as compared to Nakuru (5.7l/c/d) and Bomet (5.4l/c/d). This can be attributed to the dairy breeds kept in Nyeri (Holstein-Friesian) which are more productive compared with the Ayrshire breeds which were more prevalent in Nakuru and Bomet. Wanjala and Njehia (2014) attributed low milk yields in Western Kenya to underfeeding, type of animal breed and low-quality feed. The mean milk production across the three milksheds during the study period was relatively higher between March-June (6.8l/c/d) and lower between September-November (6.2l/c/d). Past studies in Kenya have reported that smallholder farmers experience fluctuation in feed availability and in milk production (Njarui, 2011). Relatively adequate livestock

feed has been reported among smallholder dairy farmers during the wet season (June- August) following the long rains (March- May) with many (72%) experiencing feed shortage during the dry season (August – October) resulting in low productivity (Njarui, 2011). Dry season feeding has been listed as a dairying constraint in smallholder farms in Kenya and maize stover has been identified as the main principal crop residue utilized as livestock feed during the dry season (August- October). Additionally, maize stover has low nutritive value (2.5 – 6.5% CP) and is highly fibrous and not sufficient to provide adequate nutrients required for optimal animal production (Mureithi, 2006; Njarui, 2011).

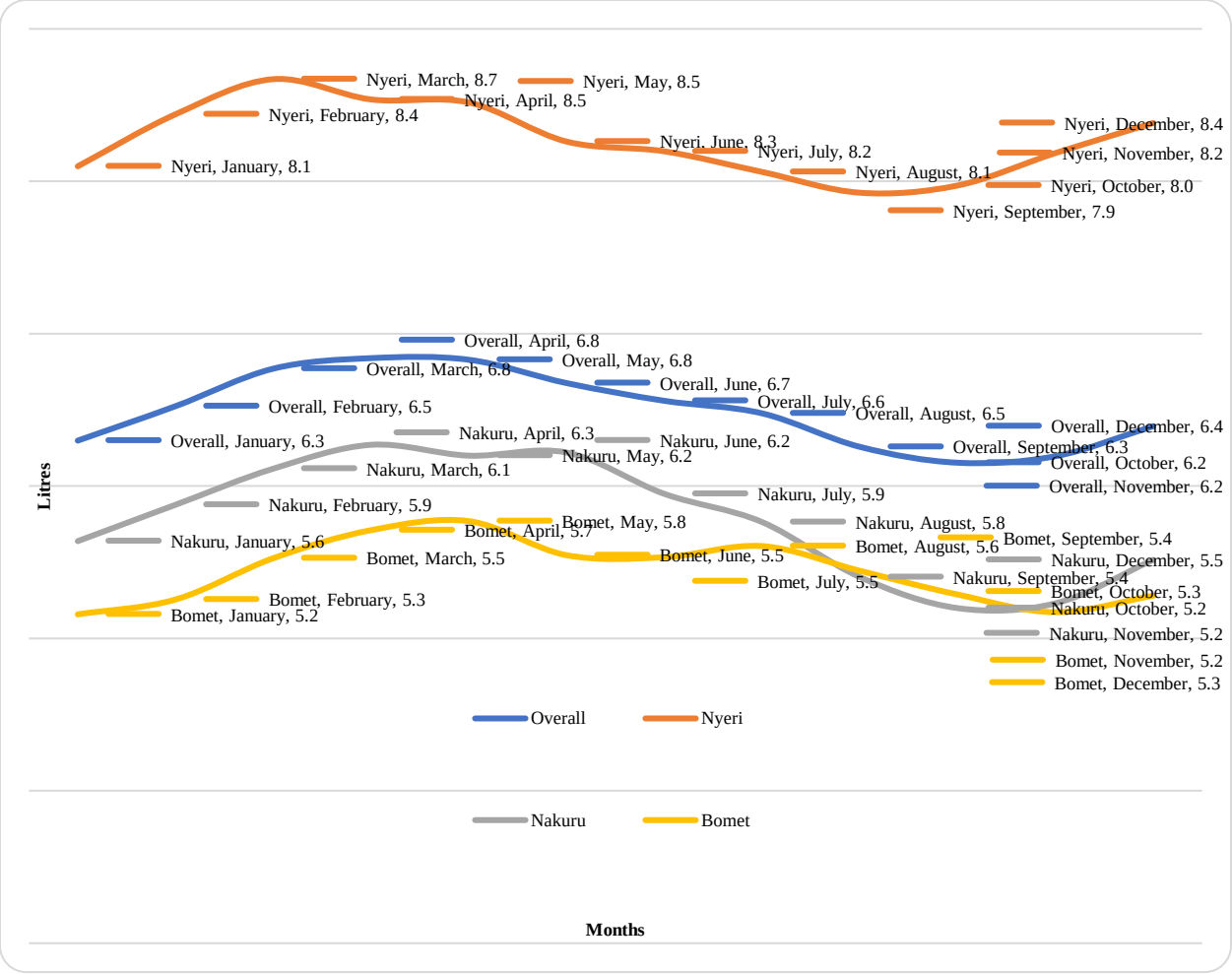


Figure 13. Average daily milk production per cow for the 12 months in the study areas in 2018

4.5.5 Feed conservation

The percentage of farmers conserving feed and types of feeds conserved in the study areas is shown in Table 10. Majority (51.7%) of farmers across the three milksheds did not conserve any type of feed. Among the farmers who conserved animal feed, maize stover (47.1%) was the commonly conserved while 9.4% conserved silage. This can be explained by the fact that maize was popularly grown by many farmers across the three milksheds and many utilized the crop residue as livestock feed. More farmers in Nakuru (62.3%) and Bomet (41.6%) conserved maize

stover compared with Nyeri (17.3%) and this was attributed to the fact that only a few (23.4%) farmers in Nyeri practiced feed conservation. The conservation methods across the study areas included stacking stovers in store/ under shade (29.8%) and silage making (5.3%). Syomiti *et al.*, (2015) in a study to determine factors influencing economic efficiency of milk production among smallholder farmers identified feed shortage as a major livestock keeping constraint in 61% of dairy farms in Nyeri and attributed this to low adoption of feed conservation. Njarui *et al*., (2011) reported 72% of smallholder farmers experience feed shortage during the dry season (Sep- Oct) resulting in cows receiving inadequate feed resulting in low milk production. Conservation of surplus feed during the rainy season reduces feed wastage and guarantees feed availability for utilization in periods of scarcity (Lukuyu *et al.,* 2009; Mutavi, 2018).

Constraints to feed conservation

The constraints to feed conservation in the study areas are shown in Figure 14. In Nyeri, 45.1%, 29.5% in Bomet and 9.7% in Nakuru, the main constraint was lack of enough feed to conserve while 15.4%, 12.2% and 6.5% of farmers in Nyeri, Bomet and Nakuru cited lack of feed storage space. Lack of feed storage space in Nyeri could be attributed to smaller land holdings compared with the other two milksheds. The cost of conservation was only a minor constraint across the three milksheds with only 5.4% overall. Njarui *et al.,* (2015) suggested where cost of conservation was high, use of simple and cost-effective methods should be encouraged to maximize conservation of surplus feed resource experienced during the wet seasons. Past studies in Kenya have reported that silage making requires expertise and thus expressing need to train farmers (Mutavi, 2018).

Table 10. Farmers conserving feed (%), type conserved and method for conservation in the study areas.

Milkshed	Overall (%)	Nyeri (%)	Nakuru (%)	Bomet (%)
N	1146	410	383	353
Feed conservation				
No	51.7	76.6	21.9	56.7
Yes	48.3	23.4	78.1	43.3
Types of feeds conserved				
Maize stover	47.1	23.9	73.5	43.9
Silage (Maize)	9.4	12.3	7.5	8.5
None N/A	43.5	63.8	19.0	47.6
Conservation methods				
Stacking in store	17.1	3.2	30.3	17.8
Traditional stacking under shade	12.7	5.4	20.1	12.7
Left standing in fields	4.0	2.7	2.1	7.1
Above ground silage	2.9	1.2	6.8	0.8
Tube silage	1.3	3.2	0.3	0.3
Pit silage	1.1	1.2	1.8	0.3
None	60.9	83.1	38.6	61.0

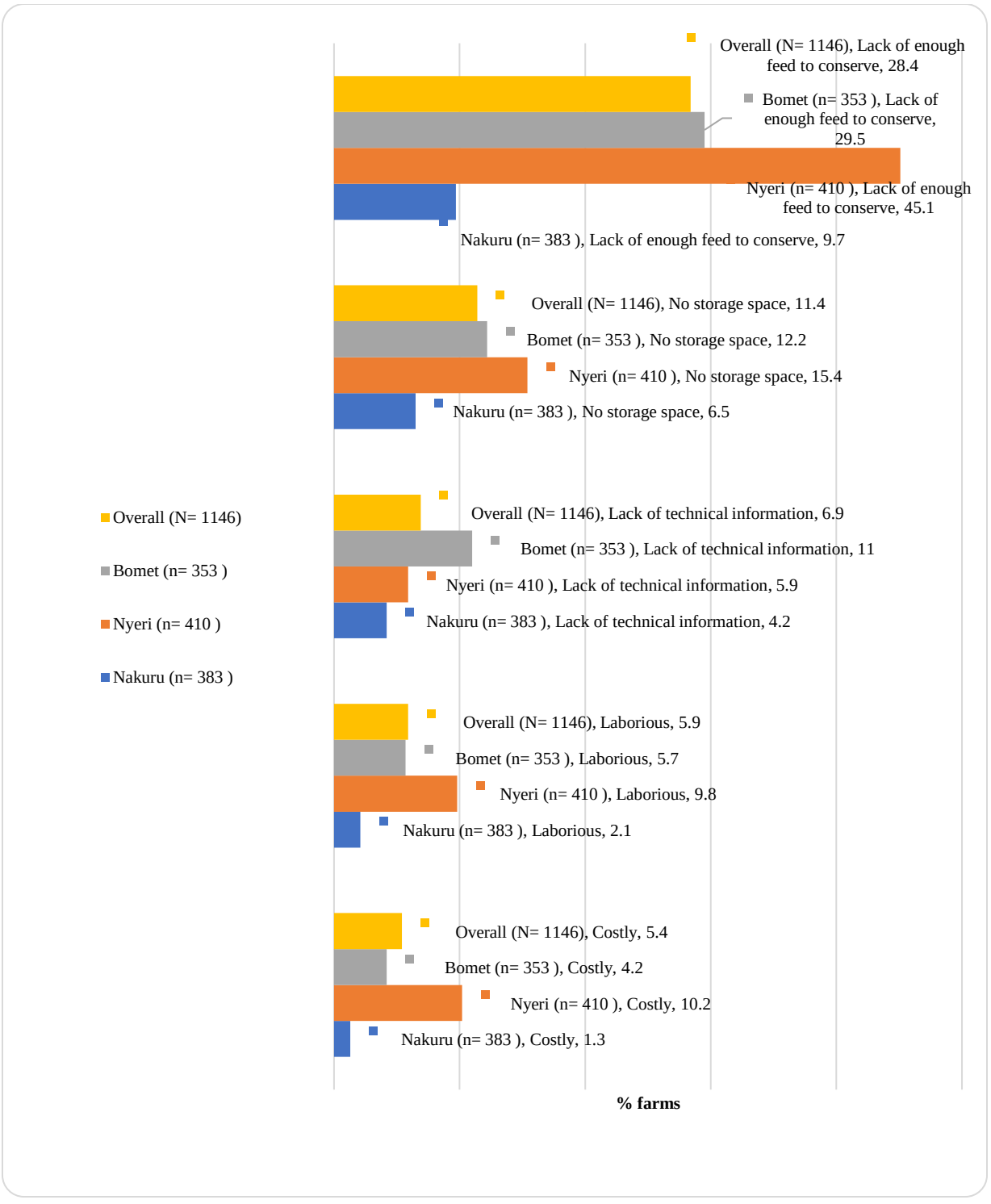


Figure 14. Constraints to feed conservation in the study areas

4.6 Source of water

Table 11 shows water availability to cattle and source of water in the study areas during the rainy and dry seasons. Overall, 88.8% of farmers across the three milksheds had water available for their cattle throughout the day with Nyeri having the most access (93.2%). Overall, the main source of water during the rainy and dry season was piped water 68.8% but this was more pronounced in Nyeri where 76.9% of farmers had access from this source. Harvested rain water was a main source in Nakuru (43.9%) and Nyeri (32.4%) milksheds during the rainy season while the rivers mainly served as source of water in Bomet (32.9%) and Nakuru (22.7%) during the dry season. Water accounts for 59% of the weight of a mature cow and every 100 Kg of milk contains up to 87 Kg of water. Water intake is influenced by moisture content of feed, amount of dry matter consumed, milk yield, environmental temperature and salt intake (Lukuyu *et al.,* 2012). Water constraints across the three milkshed were minimal (0.7% of the farms).

Table 11. Access and source of water for dairy cattle in the study areas

Milkshed	Overall (%)	Nakuru (%)	Nyeri (%)	Bomet (%)
N	1146	383	410	353
Dairy herd access to water throughout the day				
Yes	88.8	86.2	93.2	87.0
No	11.2	13.8	6.8	13.0
Water source during dry season				
Household tap water	35.7	20.6	79.3	7.1
River	19.8	22.7	3.9	32.9
Dam/ storage	15.0	8.6	2.2	34.3
Harvested rainwater	11.0	12.5	14.6	5.9
Borehole	8.1	19.1	2.7	2.5
Stream	6.2	2.1	5.6	11.0
Water source during rainy season				
Household tap water	33.1	17.8	74.4	7.1
Harvested rainwater	32.7	43.9	32.4	21.8
Wells	13.0	23.0	2.4	13.6
Dam/ storage	13.0	6.0	1.7	31.2
River	12.7	15.4	1.2	21.5
Borehole	7.0	15.4	2.2	3.4

4.7 Milking management

Milking management practices among the farmers across the three milk sheds are shown in Table 12. In all the milksheds, over 99% of the farmers practiced hand milking with only 1.7% in Nyeri, 0.3% and 0.4% in Nakuru and Bomet respectively practicing machine milking. Low usage of machine milking can be attributed to the small number of milking cows and high cost of the equipment. The type of buckets used by the farmers across the three counties differed where 67.6%, 57.4% and 50.5% in Nyeri, Bomet and Nakuru counties respectively used aluminum while 49.5% and 42.6% in Nyeri and Bomet counties respectively used plastic.

In Nyeri and Nakuru counties, 99.5% and 97.7% of the farmers washed the teats with warm water before milking where 82.4% and 81.1% of the farmers in Nyeri and Nakuru respectively used pre-milking products. Only 6.5% of the overall farmers used a disinfectant post-milking

product. Teat cleaning and teat dipping have been reported to control mastitis in dairy farms (Iraguha *et al*., 2015). The findings of this study are consistent with Aleri *et al.,* (2012) who observed that many smallholder farmers use hand milking (77%), warm water (96.3%), cloth/towel (66%) and milking jelly (66%). Overall, across the three milksheds, incidences of mastitis were low (8.3%).

Table 12. Milking management practices in the study areas

Milkshed	Overall (%)	Nyeri (%)	Nakuru (%)	Bomet (%)
N	1146	410	383	353
Method of milking				
Hand milking	99.2	98.3	99.7	99.6
Machine milking	0.8	1.7	0.3	0.4
Type of milking can				
Aluminum	58.5	67.6	50.5	57.4
Plastic	41.5	32.4	49.5	42.6
Washing of teats with warm water before milking				
Yes	96.4	99.5	97.7	92.1
No	3.6	0.5	2.3	7.9
Use of Pre-milking products				
Yes	79.0	82.4	81.1	73.6
No	21.0	17.6	18.9	26.4
Type of pre-milking of product				
With disinfectant	15.5	18.3	13.4	14.8
Without disinfectant	43.2	41.0	52.1	36.5
Both	20.4	23.2	15.6	22.4
Use of post milking products				
Yes	28.2	43.1	25.5	15.9
No	71.8	56.9	74.5	84.1
Type of post milking product				
With disinfectant	6.5	11.1	6.2	3.2
Without disinfectant	12.6	20.5	12.7	4.7
Both	13.9	27.3	6.2	7.9

4.8 Animal diseases

The common animal diseases and conditions reported in the study areas are shown in Table 13. Bomet (54.3%) and Nakuru (49%) had higher incidences of tickborne diseases compared with Nyeri (22.1%). This can be attributed to the type of production system adopted in Nakuru and Bomet where animals were grazed (greater exposure to ticks) compared with Nyeri where animals were stallfed. Notably, a mean of 33.1% of the farmers reported no incidences of diseases in their farms during the study period and this could be attributed to the use of different combinations of disease control measures. Overall, only 8.3% of farmers reported incidences of mastitis in their farms which can be explained by the hygiene measures (Table 12) in the farms. Control of mastitis in smallholder farms can been achieved by proper hygiene practices, teat cleaning and teat dipping and effective treatment of clinical mastitis (Iraguha et al., 2015). Past studies have identified diseases affecting smallholder dairy farms to include; mastitis and tick-borne infections (East Coast Fever (ECF), Anaplasmosis, babesiosis, heart water and trypanosomiasis) (Gitau *et al.,* 1997 and Omondi *et al.,* 2017).

Table 13. Animal diseases and conditions reported in the study areas

Milkshed	**Overall (%)**	**Nyeri (%)**	**Nakuru (%)**	**Bomet (%)**
N	1146	410	383	353
Animal diseases and conditions				
Tickborne diseases (East Coast Fever (ECF) & Anaplasmosis)	41.8	22.1	49.0	54.3
Notifiable diseases (Lumpy Skin Disease (LSD) & Foot and Mouth Disease (FMD))	6.1	4.4	5.5	8.2
Mastitis	8.3	16.2	4.5	4.3
Milk fever	2.0	2.0	2.4	1.7
Intestinal worms	8.7	13.8	8.4	4.0
None	33.2	41.5	30.4	27.6

4.9 Disease control

The types of measures used for disease control in the study areas are shown in Table 14. The measures that were applied within milksheds included deworming, vaccination, tick control and their combinations. There were more farms practicing tick control in Nakuru (14.4%) and in Bomet (5.9%) compared with Nyeri (2.4%). This was attributed to the type of production systems adopted in Nakuru (semi-intensive system) and Bomet (extensive system) with higher risk of exposure to ticks compared to Nyeri (intensive system). Farmers practicing stall feeding do not see a danger of ticks thus minimal acaricide application. Nyokabi *et al.,* (2021) reported that disease control measures used in smallerholder farms in Laikipia, Nakuru and Nyandarua counties included using warm water to wash udder/hands, vaccination, deworming and teat dipping.

Table 14. Disease control measures undertaken in the study areas

Milkshed	**Nakuru (%)**	**Nyeri (%)**	**Bomet (%)**	**Overall (%)**
N	383	410	353	1146
Disease control measures				
Deworming + Tick control +Vaccination	37.3	30.0	42.2	36.5
Deworming only	16.2	38.0	23.2	25.8
Deworming and Tick control	27.7	16.8	21.8	22.1
Tick control only	14.4	2.4	5.9	7.6
Vaccination only	0.8	6.3	4.5	3.9
Deworming and Vaccination	3.7	5.9	0.3	3.3
Vaccination and Tick control	0.0	0.5	2.0	0.8

4.10 Mating systems and cost

The mating systems practiced by farmers in the study areas are shown in Figure 15. AI was practiced by 92.8% in Nyeri, 54% in Nakuru and 27.8% in Bomet. High adoption of AI in Nyeri can be linked to stall-feeding with farmers keeping superior dairy animals. Besides the higher milk yields compared to Nakuru and Bomet milksheds, more high yielding breeds (Holstein

Friesian) were kept in Nyeri and this could be attributed to the high adoption of AI in Nyeri. Majority (68.3%) of farmers in Bomet used natural mating. Past studies have reported high (68%) use of natural mating in western Kenya and was attributed to high availability and affordability (Lukuyu *et al.*, 2012 and Omondi *et al.*, 2017). Ajak, (2020) reported similar findings in Nyeri, with many (94.5%) farmers using AI to inseminate their animals.

The charges of bull/AI per service are shown in Table 15. Of farmers in Nyeri, 28.8% paid KES 1000 per AI service while 62.9% in Bomet accessed natural services free of charge. The high frequency of natural mating in Bomet was attributed to the fact that most farmers accessed bulls from neighbors, and the service was free. Past studies in Kenya have reported that high cost of AI service and unavailability of service has led smallholder farmers to use bulls of unknown genetic merit hence slowing genetic progress (FAO, 2011; Mutavi *et al*., 2016; Waititu, 2017).

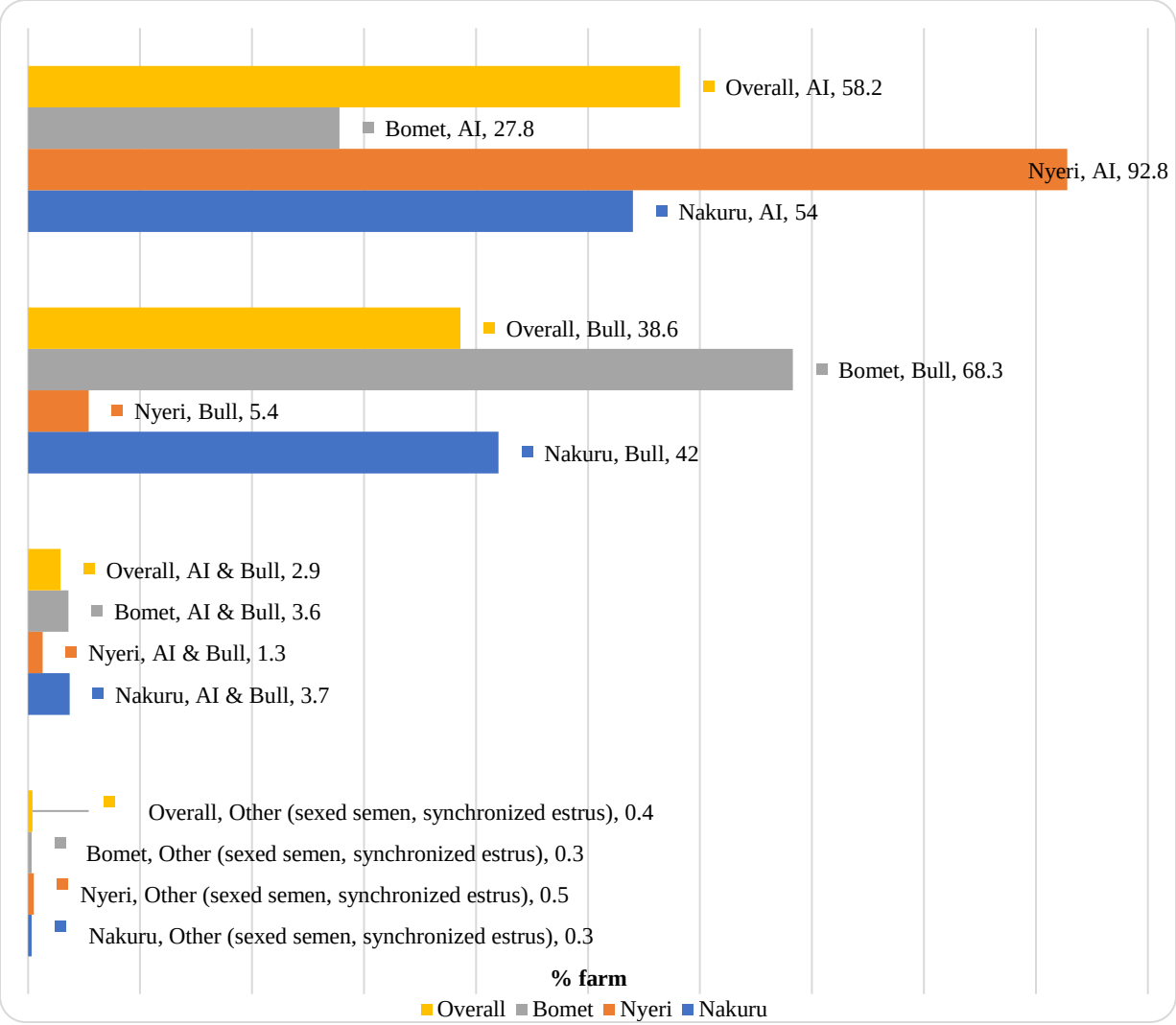


Figure 15. Mating systems used in the study areas

The sources of AI services in the study areas are shown in Table 15. Of the three milksheds, 92.3%, 86.0%, and 81.6% of farmers in Bomet, Nakuru, and Nyeri respectively, obtained AI services from private practitioners while 18.4%, 14.0%, and 7.7% in Nyeri, Nakuru, and Bomet respectively from government officers. Ajak, 2020 reported similar findings in smallholder dairy farms in Nyeri where farmers obtained AI services from private practitioners (71%), government officers (19%) and cooperative societies (2.5%). Low budgetary allocation for the agricultural sector in Kenya is a major constraint limiting production (KDB, 2019).

Table 15. Charges per bull/AI per service (KES) in the study areas

Milkshed	Nakuru (%)	Nyeri (%)	Bomet (%)	Overall (%)
N	383	410	353	1146
AI charges per service (KES)*				
1000	23.2	28.8	8.2	20.6
1200	13.8	19.5	6.2	13.5
1500	9.7	14.9	5.7	10.3
2000	1.3	7.6	1.4	3.6
Bull charges per service (KES)				
Free	34.7	2.7	62.9	31.9
200	0.3	0	3.1	1.0
500	5.0	1.7	2.5	3.1
Artificial insemination service providers in the study areas				
Private practitioners	86.0	81.6	92.3	86.6
Government officers	14.0	18.4	7.7	13.4

**1 KES=0.008$*

The reasons for choosing AI service compared with natural service in the study areas are shown in Figure 16. Across the three milksheds, farmers chose AI because of breed variety (35.1%), availability (31.3%) and affordability (19.7%). Increased uptake of modern breeding methods such as AI has been linked to accessibility of service, affordability and success rate of conception (Mugambi *et al.*, 2015).

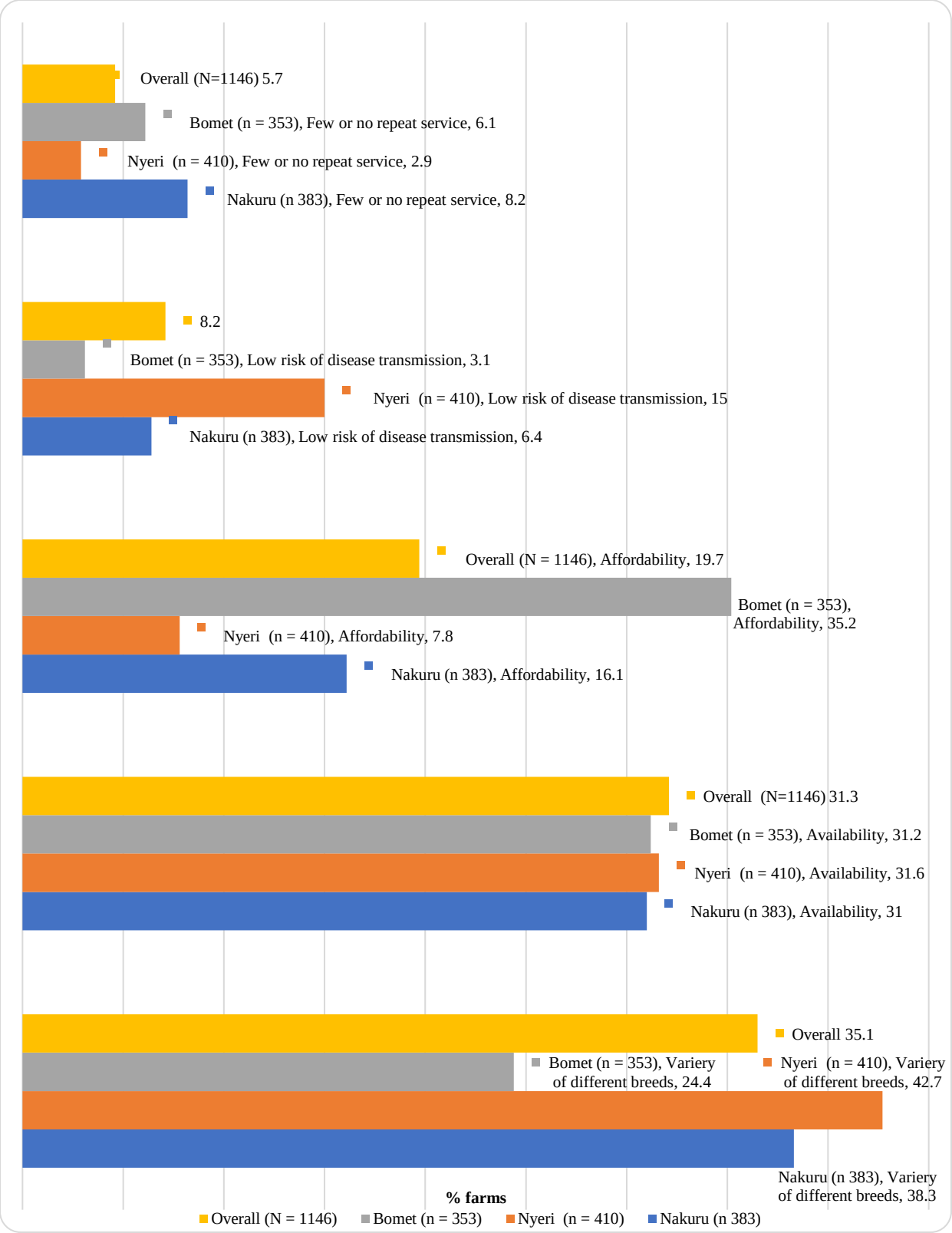


Figure 16. Reason for choosing AI in the study areas

4.11 Calf management

Calf management practices in the study areas are shown in Table 16. Overall, across the study areas, more than 96.6% of the farms did not weigh the calf at birth. This indicated that farmers used age as the weaning criteria other than weaning weight which has been reported to be a good indicator of proper management (Lukuyu *et al.,* 2012; Ajak, 2020). Mostly (>91%) calves were fed with milk only during the first month and 8.5% were fed on milk, milk replacer and calf starter. Low usage of calf starter and milk replacer in the study areas was attributed to cost. Studies have reported that as the calf rumen develops, calves are usually fed on liquid feeds and low fiber solid feeds as the rumen cannot digest complex fibrous feeds. However, most of these calf feed products such as milk replacer/calf starter are expensive (Lukuyu *et al.,* 2012).

The main method of calf feeding in Nyeri (91.5%) was bucket feeding while they were suckled in Bomet (92.8%) and Nakuru (52.5%). This can be attributed to the type of production system adopted in Nyeri (intensive system) compared with the semi-intensive system adopted in Nakuru and Bomet (extensive system). Studies have reported similar findings in smallholder farms in Nyeri where calves are mainly bucket-fed (93%) and only 7% are suckled (Ajak, 2020). Suckling is the natural way for a calf to feed and has been identified as the most hygienic way as the calf obtains milk directly from the mother, clean and at body temperature (Lukuyu *et al.*, 2012).

Across the three milksheds, the average quantity of milk fed to calves daily was 4.3l during the first week to the first month and 3.6l between the first and the third month. Nyeri farmers fed (5.4l) higher amounts of milk compared with Nakuru (4.2l) and Bomet (2.3l) and this was attributed to higher milk production in Nyeri and also calves in Nyeri are AI and maybe perceived to be more valuable. Calf weaning on average (62%) was done at three months across the three milksheds and 55.3% of farmers across the three milksheds had calf houses. Studies have reported

that calves in smallholder farms were fed 2- 4 litres of milk per day and weaning is done at three months (60%) (Ajak, 2020). Other studies in Kenya have reported that calves are commonly weaned when they are between 2-3 months old, weigh 75 Kg, and are consuming 1 Kg of concentrate per day (Mwangi, 2012).

The factors that were considered when weaning in smallholder farms in Kenya consisted of age of calf, ability to consume large quantity of forage, weight and sex of calf (Ajak, 2020). Calf diseases were the major constraint affecting calves in the study areas (52.3%) with higher incidences reported by farmers in Nakuru (62.1%) and Bomet (56.4%) compared with Nyeri (38.3%). This was attributed to the type of production system adopted in Nakuru and Bomet (extensive farming) with higher incidences of diseases associated with grazing (Lukuyu *et al.*, 2012). Calves in Nyeri had minimal problems and can be attributed to the superior care due to the production system adopted (more milk fed and more housed).

Calf feeding should be aimed at reducing mortality while maintaining a daily growth rate of at least 400 g and weaning is done at 3 months at approximately 80 Kg body weight (Lukuyu *et al.*, 2012). Good calf housing should be used to curb risk of infections, allow fresh air flow and protection from sunlight/rain. Calf feeding and management is the foundation of well-developed heifers and insemination is done when body weight of 350 Kg is attained (14-16 months) (Mwangi, 2012).

Table 16. Calf management practices in the study areas

Milkshed	Nakuru (%)	Nyeri (%)	Bomet (%)	Overall (%)
N	383	410	353	1146
Calf weighing at birth				
No	96.6	98.0	99.2	97.9
Yes	3.4	2.0	0.8	2.1
Type of feed fed to calves during month 1				
Milk only	91.6	91.2	91.8	91.5
Milk, milk replacer and calf starter	8.4	8.8	8.2	8.5
Calf feeding method				
Suckling	52.5	8.5	92.8	51.3
Bucket feeding	47.5	91.5	7.2	48.7
Average milk quantity (litres**) fed to calves during week 1 - month 1**				
Mean (litres)/day	4.6	5.6	2.7	4.3
Average milk quantity (litres**) fed to calves during month 1 – month 3**				
Mean (litres)/day	3.7	5.1	1.9	3.6
Calf weaning (months)				
2 months	14.1	11.7	9.2	11.6
3 months	51.4	73.1	61.3	62.0
4 months	13.1	11.5	19.0	14.5
6 months	7.0	0.7	4.1	3.9
Above 6 months	14.4	3.0	6.5	8.0
House for calves				
Yes	61.6	75.4	28.9	55.3
No	38.4	24.6	71.1	44.7
Problems facing calves				
Calf diseases (e.g., Pneumonia, diarrhea)	62.1	38.3	56.4	52.3
Inadequate feeding	6.5	8.8	4.2	6.5
Poor housing	6.2	8.0	11.0	6.4
None	25.2	44.9	26.4	32.2

4.12 Cow performance records

The number of farms that kept performance records and types of records kept in the study areas are shown are Table 17. Overall, across the three milksheds more than 70.2% of the farms did not keep any type of cow performance records. The records kept across the three milksheds included pedigree & veterinary records (11%) and pedigree and production records (9.8%). Farm

records enhance farm performance (Ensminger, 2005). Past studies in Kenya have reported low level of farm record keeping among many farmers and was attributed to subsistence nature of farming, lack of time and lack of awareness of usefulness of records (Yadeta *et al*., 2020). Additionally, studies have expressed need to develop training programs for smallholder farmers on keeping and utilization of cow performance records in supporting dairying decision making (Gichohi, 2019). Record keeping is a vital practice as it facilitates accountability process, proper management and decision making (Yadeta *et al.*, 2020).

Table 17. Types of performance records kept (%) by farmers in the study areas

Milkshed	Overall (%)	Nyeri (%)	Nakuru (%)	Bomet (%)
N	1146	410	383	353
Dairy farm records				
Did not keep records	73.6	70.2	75.2	75.4
Pedigree and veterinary records	11.0	12.5	7.2	13.2
Pedigree and production records	9.8	8.6	12.9	8.0
Pedigree records	4.4	8.0	3.9	1.4
Sales and purchases	1.2	0.7	0.8	2.0

4.13 Access, source and type of dairy information

Access, source and type of technical information on dairying by farmers in the study areas during the study period are shown in Table 18. Overall, 64.5% of the farmers across the three milksheds had access to some type of information. The most common types of information accessed by farmers included; feeding (20.7%), cattle management (16.3%) and milking and milk marketing (12.5%). Farmers obtained dairying information from field days/seminars (8.9%), and media/radio & TV (8.5%) and from other dairy farmers (7.3%). Studies have identified reduced access to veterinary and extension services and low animal husbandry technical skills as major constraints to smallholder dairying (Methu *et al.*, 2000; Pezo, 2001; Mugambi *et al*., 2015*;* Omunyin *et al.*, 2014; Waititu, 2017). Smallholder farmers may obtain this knowledge from

various sources such as; extension, internet, media, shows and field days so as to increase milk production and maximize returns (Staal *et al*., 2003; Opiyo *et al.,* 2011) however, they may not be willing to invest their resources to new technologies (Jayne *et al.,* 2006).

Table 18. Access, source and type of dairying information to farmers in the study areas

Milkshed	**Overall (%)**	**Nakuru (%)**	**Nyeri (%)**	**Bomet (%)**
N	1146	383	410	353
Access to dairying information				
Yes	64.5	66.6	53.7	73.1
No	35.5	33.4	46.3	26.9
Type of information accessed				
None	41.0	44.3	19.5	59.3
Feeding	20.7	19.1	27.8	15.3
Milking management and marketing	12.5	14.1	15.4	7.6
Cattle management	16.3	12.8	23.7	12.5
Feeding and cattle management	5.3	6.0	6.8	3.1
Feeding, cattle management and milk management	2.8	1.3	5.8	1.1
Cattle management and milk management & marketing	1.4	2.1	1.0	1.1
Source of dairy information				
Other farmers	7.3	8.9	10.5	2.4
Field days, demos, barazas, seminars	8.9	8.1	10.7	7.9
Media (Radio, Print, TV & internet)	8.5	6.8	11.6	7.0
Cooperative societies	5.1	5.2	7.1	3.1
Religious organization	3.3	2.6	4.4	2.8
Government	2.5	1.8	2.0	3.7
Government and private entrepreneurs	1.8	3.1	1.2	1.1
Farmer groups and cooperative societies	1.5	1.1	3.4	0
Government and cooperatives	0.8	1.0	1.5	0
None	60.3	61.4	47.6	72.0

4.14 Constraints to increased milk production

The perceived limiting constraints across the three milksheds are shown in Table 19. Overall, across the study areas, the main perceived constraints to increased milk production included feed inadequacy (48.7%), lack of credit (17.4%), poor quality of available genetics

(17.0%) and low milk price (16.0%). Higher frequency of feed inadequacy in Nyeri milkshed (52.8%) was attributed to small landholdings and low adoption of feed conservation technologies. More farmers in Nakuru (19.6%) and Bomet (17.1%) were limited by poor quality of available genetics compared with Nyeri (14.4%). This was attributed to the fact that Nyeri had higher adopters of AI (intensive system) and thus had more superior dairy animals compared to Nakuru and Bomet. Studies in Kenya have identified inadequate feed, limited landholdings, lack of credit, poor genetics and diseases and parasites as key constraints to smallholder dairying (Baltenweck, 2006; Mutavi, 2018; Njiru, 2020). Ajak, (2020) reported that the major constraints to smallholder dairying in Nyeri included feed shortage, low farmgate milk prices, high cost of feed and low-quality feed.

Table 19. Perceived constraints to production in the study areas

Milkshed	Overall (%)	Nakuru (%)	Nyeri (%)	Bomet (%)
N	**1146**	**383**	**410**	**353**
Major constraints to increasing milk production				
Feed inadequacy	48.7	45.6	52.8	47.9
Lack of credit	17.4	14.9	19.0	18.3
Poor quality of available genetics	17.0	19.6	14.4	17.1
Low farmgate milk price	16.0	19.1	13.1	15.8
Limited water access	0.8	0.8	0.7	0.8

4.15 Coping mechanisms for constraints to increased milk production

The suggested coping mechanism for constraints to increased milk production and suggested coping mechanisms to alleviate feed shortage in the study areas are shown in Table 20. The coping strategies to increasing milk production varied between the milksheds and included upgrading genetics of the dairy cows and increasing feed availability. Increasing the number of dairy cows was also an option for some farmers. More farmers in Nakuru (31.1%) and 28.7% in Bomet perceived upgrading the genetics of their cows as a coping mechanism compared with

Nyeri (16.1%). This can be explained by the fact that Nyeri had more superior breeds compared with Nakuru and Bomet. Past studies in Kenya have shown that upgrading cow genetics, purchasing feed and better feeding practices are among the methods used by smallholder farmers to increase milk production (Syomiti et al., 2015).

Overall, across the study areas, the coping strategies adopted by farmers to alleviate feed shortage included reducing feed offered to dairy cattle (51.4%), priority feeding of milking cows (33.7%) and selling stock (14.9%). Past studies have reported the main coping mechanisms to smallholder dairying constraints in Kenya included producing more fodder, purchasing feed, offering less feed to dairy cattle and following advice from livestock service providers. Other coping strategies included selling stock and utilization of unconventional feeds such as banana roots and pseudo stems and kitchen waste (Syomiti *et al*., 2012; Ajak, 2020).

Smallholder dairy farmers experience fluctuations in feed availability thus milk production (Njarui, 2011). Hall *et al*., (2008) reported that feeding is a major limiting factor cutting across all different dairy production systems in East Africa. Low milk production in smallholder farms in Kenya has been attributed to underfeeding (Lukuyu *et al*., 2009). Farmers have been encouraged to introduce high quality and high yielding forages or purpose bred forages and pastures so as to widen the feed resource base and to adopt feed conservation technologies (Lukuyu *et al.,* 2009).

Table 20. Coping mechanisms for constraints in the study areas

Milkshed	Overall (%)	Nakuru (%)	Nyeri (%)	Bomet (%)
N	**1146**	**383**	**410**	**353**
Coping strategies to increasing milk production				
Increase number of dairy cows	28.2	21.2	37.2	26.2
Improve genetics of animals	25.3	31.1	16.1	28.7
Increase feed production	21.9	24.0	18.0	23.4
Purchase feed	9.4	9.7	12.2	6.3
Better management and feeding practices	9.4	8.4	10.7	9.2
Follow extension advice	5.9	5.8	5.8	6.0
Coping strategies to alleviate feed shortage				
Reducing feed offered to dairy cattle	51.4	48.7	50.5	55.0
Priority feeding of milking cows	33.7	37.1	34.0	30.1
Selling stock	14.9	14.3	15.4	15.1

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The objective of the study was to assess constraints to increased milk production and document coping mechanisms adopted by smallholder farmers in Bomet, Nakuru and Nyeri milksheds in Kenya.

1. The main constraints to increased milk production in small holder dairy farms identified in the study areas included feed inadequacy, poor quality of available genetics, lack of credit and low farmgate milk prices.
2. The major coping strategies to increasing milk production in the study areas included increasing the number of dairy cows, improving cow genetics, producing more feed and purchasing feed. The coping strategies adopted by farmers in the event of feed shortage in the study areas included reducing feed offered to dairy cattle and feeding of unconventional feedstuff, priority feeding of milking cows and selling stock.

5.2 RECOMMENDATIONS

1. Farmers should be trained to adopt simple and cost-effective skills on feed conservation through approaches such as tube silage and box bailing to minimize fluctuations in feed availability.
2. Revitalization of extensions services and heightened farmer training will lead to increased awareness and increased uptake of technologies and innovations therefore increasing milk production.

3. Better farmgate milk prices by processors will encourage dairy farmers to invest in breeding and feeds leading to increased milk production.

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APPENDIX 1: QUESTIONNAIRE

This questionnaire is on the assessment of constraints to milk production in smallholder farms in Bomet, Nakuru and Nyeri counties, Kenya.

1. Questionnaire number…… Date……
2. Name of enumerator…… contact……

SECTION 1: Demographic attributes and their effects on smallholder dairy farming

Details on the farm location and identification of the farmer

3. Name of County /sub-county/Ward/Location……
4. Name of farmer……
5. Contact of the farmer……
6. Gender of farmer
   a) Male ☐ b) Female ☐
7. Marital status
   a) Married ☐ b) Single ☐ c) Divorced ☐ d) Widow(er) ☐
8. Telephone number of respondents……
9. Education level of the farmer
   a) Primary level and below ☐ b) Secondary ☐ C) Post-secondary ☐
10. For how long has the farmer practiced dairy farming?
    a) 1-5 years ☐ b) 5-10 years ☐ c) 10-15years ☐ d) >15 years ☐
11. Household size……
12. Age of the farmer……
13. Do you have land for food and cash crop production? a) Yes ☐ b) No ☐
14. What is the amount of land under fodder production?
    a) Under 1-acre ☐ b) 1-2 acres ☐ c) 2-4 acres ☐ d) 4-6 acres ☐

e) Above 6 acres ☐

15. What is the size of the land in acres? ……

16. What is your total acrerage?.....

17. Does your household have the following animals? (Indicate number)

a) ☐ Goat…… e) ☐ chicken…….

b) ☐ Sheep…… f) ☐ Rabbits…….

c) ☐ Donkeys…… g) ☐ Pigs……

d) ☐ Others…….

SECTION 2: Herd structure and dairy production system

18. Type of production system

a) Semi-intensive ☐ b) intensive ☐ c) Other(specify) ☐ …….

19. Type of dairy cattle breeds in the farm

a) Friesian ☐ b) Jersey ☐ c) Ayrshire ☐ d) Guernsey ☐

e) crosses ☐ f) Others(specify) ☐

20. Herd structure

	Herd composition	Number
1	Non- pregnant Lactating cows	
2	Pregnant and Lactating Cows	
3	Dry cows	
4	Heifers	
5	Heifer calves	
6	Bull calves	
7	Bulls	
8	Steers	
	Total cattle	

21. Who takes the responsibility of feeding the dairy animals?

a) Adult owner male ☐ b) Adult owner female ☐ c) Children ☐

d) worker ☐ e) All ☐

SECTION 3: Calf Management and feeding

22. Do you weigh calves at birth? a) Yes ☐ b) No ☐

23. If yes, how and what is the average birth weight?.....

24. What method of calf feeding do you use?

    a) Suckling ☐ b) Bucket feeding ☐ c) Other ☐ ……

25. When does calf feeding start?

    a) 0-6hours ☐ b) 6-12 hours ☐ c) 12-24 hours ☐ d) past 24 hours ☐

26. How many litres are fed to the calf per day?

    a) 1-2 litres ☐ b) 2-4 litres ☐ c) Other (specify) ☐

27. Do you monitor calf growth? a) Yes ☐ b) No ☐

28. If yes, explain how?

    ……

    ……

29. Which of the following are fed to the calf from one week to one month?

    a) Milk only ☐ d) Milk replacer and forages ☐

    b) Forages ☐ e) Calf starter ☐

    c) Milk and forages ☐ f) Other (specify) ☐

30. What quantity of the above mentioned is fed to the calf form one week to one month?

    a) Milk only……. d) Milk replacer and forages…….

    b) Forages…… e) Calf starter……

    c) Milk and forages……. f) Other (specify)…….

31. Which of the following are fed from (1) one month to 3 months?

    a) Milk only ☐ d) Milk and forages ☐

    b) Calf starter ☐ e) Milk replacer and forages ☐

c) Forages ☐ f) Others (specify) ☐

32. What quantitiy of the above mentioned feeds is fed to the calf betwwen one month and 3 months ?

a) Milk only……. d) Milk and forages……

b) Calf starter……. e) Milk replacer and forages…….

c) Forages…….. f) Others (specify)…….

33. At what age do you wean the calf?

a) Less than 3 months ☐ d) >9 months ☐

b) 3 months ☐ e) other ☐

c) Less than 6 months ☐

34. What criteria is used for weaning at the time mentioned above?

……

……

35. What is the objective for rearing the calf in your farm?

……

……

……

36. What are the problems facing the calves?

a) Diseases ☐ c) Other ☐

b) Inadequate feeding ☐ d) poor housing ☐

37. Have you in the past one year lost a calf? a) Yes ☐ b) No ☐

38. If yes, form what?.....

39. What are the common calf diseases?

……

……

……

40. What are the measures taken to control diseases?

……

……

……

41. Is there a house for the calf? a) Yes ☐ b) No ☐

42. If yes, which is type of floor/wall?

    a) Concrete ☐ c) Other ☐

    b) Non-concrete ☐

43. Which bedding material is used?

    a) Wood shavings ☐ b) calf mattress ☐ c) Other(specify) ☐

44. What type of roof do you use?……

45. Where do you get information about calf feeding and management?

    a) Radio/TV ☐ c) Extension services ☐

    b) Print Media ☐ d) Other (specify) ☐

SECTION 4: Heifer management

46. Feeding of heifers

    a) Pasture only ☐ d) Forages and concentrate ☐

    b) Pasture and concentrate ☐ e) Others(specify) ☐

    c) Forages ☐

47. What are the common problems facing heifers?

……

……

……

48. How do you control the problems mentioned above?

……

……

……

49. At what age do you serve the heifers?

a) 15-18 months ☐ c) >20 months ☐

b) 18-20 months ☐ d) Other (specify) ☐

50. Which method do you use to serve the heifers?

a) Artificial insemination ☐ b) Natural service ☐

51. Age at first calving of heifer(s) in months?.....

52. Do you monitor heifer growth? a) Yes ☐ b) No ☐

53. If yes, how?

……

……

……

54. Do you sell heifers? a) Yes ☐ b) No ☐

55. If so, how do you select the ones to retain?

……

……

……

56. Where do you get information about heifer management?

a) Farm visits ☐ c) Print media ☐

b) Extension services ☐ d) Radio/TV ☐

57. What is your main objective in rearing heifers?

……

……

……

SECTION 5: Feeds and Feeding

58. What feed resources do you give to the cows?

    a) Roughage and concentrates ☐ c) Roughage and salt lick ☐

    b) Roughages alone ☐ d) Other(specify) ☐

59. Where do you source fodder/feeds for your animal/s?

    a) Own production ☐ c) Natural pastures ☐

    b) Purchased ☐ d) Other(specify) ☐

60. If own produced, what are the feed resources you produce?

    ……

    ……

    ……

61. Do you conserve feeds? a) Yes ☐ b) No ☐

62. How do you conserve feeds?

    ……

    ……

    ……

63. What type of fodder do you conserve?

    ……

    ……

    ……

64. Do you formulate feeds? a) Yes ☐ b) No ☐

65. How do you formulate the feeds?

    ……

……

……

……

66. How much feed do you feed the animal/s per day?

……

67. Why do you feed the above specified amount?

……

……

……

68. What is the cost of the feeds purchased for your animals per month?

……

69. Do you do a feed budget for your animals? a) Yes ☐ b) No ☐

70. If yes, how do you budget for the feeds?

……

……

……

1. What are the major feed constraints you encounter?

……

……

……

2. How do you overcome the challenges above?

……

……

……

3. Do you weigh feeds for your cattle? a) Yes ☐ b) No ☐

4. What is the amount fed to the animals daily in Kg s?

Feed	Early lactating	Mid lactating	Late pregnancy
Roughage			
Concentrate			
Mineral lick (Salt lick)			

5. How much do you spend on the dairy concentrate per month (KES)?.....

6. How much do you spend on the mineral lick per month (KES)?.....

7. How much feed do you need for you animal/s per day?.....

8. Where do you get information about feeds and feed management?

   a. Farm visits ☐ c) Print media ☐

   b. Extension services ☐ d) Radio/TV ☐

SECTION 6: Dairy cattle performance

9. What is the calving interval of your dairy cow(s) in months?.....

10. How do you stimulate milk let down?

    a. Use of calf ☐ b) Massaging ☐ c) Other ☐

11. Type of milking

    a. Machine ☐ b) Hand ☐ c) Both ☐

12. How frequently do you milk the cow(s) in a day?

    a. Once ☐ b) Twice ☐ c) Thrice ☐ d) Other ☐

13. How many litres of milk does you produce per cow per day?

    a. 1-2 litres ☐ d) 10-15 litres ☐

b. 2-5 litres ☐ e) 15-20 litres ☐

c. 5-10 litres ☐ f) above 20 litres (specify) ☐

14. What is the total amount of milk produced in litres per day?

……

15. What amount of milk in litres is consumed by the household members?

……

16. What is the selling price of a liter of milk on your farm?

a. 30-40 KES ☐ b) 40-50 KES ☐ c) Above 50 KES ☐

17. What quantity of milk in litres is sold per day?

……

18. Where do you sell the milk?

a. Neighbors ☐ d) Processors ☐

b. Local shops and hotels ☐ e) Dairy cooperatives ☐

c. Middlemen ☐

19. What are the challenges you encounter in dairy farming?

……

……

……

……

20. How do you overcome the above challenges?

……

……

……

……

21. What are the benefits of dairy farming?

……

……

……

……

……

Section 7: Housing

22. Is there a house for your cattle?
    a. Yes ☐ b) No ☐
23. Type of floor?
    a. Concrete ☐ b) non- concrete ☐ c) Other(specify) ☐
24. Type of bedding?
    a. Cow mattress ☐ b) No bedding ☐ c) Other (specify) ☐
25. Type of walls?
    a. Concrete ☐ b) non- concrete ☐ c) Other(specify) ☐
26. Type of roof? ……

SECTION 8: Management practices

27. What type of mating do you use in your farm?
    a. Artificial insemination ☐ c) Both ☐
    b. Natural mating ☐
28. If artificial insemination, who provides the service?
    a. Government ☐ b) private institutions ☐ c) Cooperatives ☐
29. Time of calving to first heat of your cow(s) in months?

    ……
30. What are the common dairy cattle diseases in your farm?

    ……

    ……

    ……..

……..

……..

31. What are the disease control measures put in place for the above mentioned?

……..

……..

……..

……..

32. Do you keep records in your farm? a) Yes ☐ b) No ☐

33. If yes, what type of records do you keep?

……..

……..

……..

34. How do you store data in your farm?

……..

……..