EVALUATION OF DAIRY CATTLE PERFORMANCE IN SMALLHOLDER FARMS IN NYERI COUNTY, KENYA

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This thesis is my original work and has not been presented in any University for the award of a degree.

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DEDICATION

I dedicate this thesis to my dear wife, Mary Atong Gai Aleng and my children for their patience and moral support during the study. To my mother Alek Chol Dhiak and late father, for having brought me up with ethical values and unlimited guidance. It is also dedicated to the entire family of Ajak Diang for their love and encouragement that resulted in this great achievement and to Almighty God for his love, care and protection during my studies.

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LIST OF ABBREVIATIONS/ACRONYMS

AFC	Age at First Calving
AFS	Age at First Service
CI	Calving Interval
CGN	County Government of Nyeri
EADDP	East Africa Dairy Development Program
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations, Statistics Division
GDP	Gross Domestic Product
GOK	Government of Kenya
IFAD	International Fund for Agricultural Development
KDB	Kenya Dairy Board
KNBS	Kenya National Bureau of Statistics
SDP	Smallholder Dairy Project
MoALDM	Ministry of Agriculture, Livestock Development and Marketing
MoALF	Ministry of Agriculture, Livestock and Fisheries
MoLD	Ministry of Livestock Development
MoSPND	Ministry of State for Planning and National Development
NAFIS	National Farmers Information Services
USAID	United States Agency for International Development

ABSTRACT

Dairy Production provides approximately 4.5% of the Kenyan National Gross Domestic Product (GDP), contributes to job creation along the value chain and food security in Kenya. However, individual cow milk yield is still low under the smallholder dairy production system which contributes 80% of milk production despite concerted efforts to improve productivity in the last few decades. The purpose of this study was to evaluate the productivity in smallholder dairy farms in Nyeri County with the specific objectives to assess feed resources and feeding systems, management of young and growing stock, reproductive and productive performance. The study sites were Mathira East and Othaya Sub Counties where 200 farmers were purposively selected from each. A semi structured questionnaire was administered to collect data on feed resources, feeding systems, calf feeding, age at first service (AFS), age at first calving (AFC), calving interval (CI), milk yield (MY) and lactation length (LL). Feed samples consisting of both forages and concentrates were collected for quality analysis. Data was analysed using Statistical Package for Social Sciences (SPSS), version 21.0. The calves were fed first colostrum at various times: 0-6 hours (97.7%), 6-12 hours (1.8%) and >24 hours (0.5%). The calves were bucket fed (93.0%), suckled (5.8%) and both buckets fed and suckled (1.2%). The average amount of milk fed to calves was 5.2±1.51 litres/day. Majority of dairy farmers (59.6%) weaned their calves at 3 months. Common calf problems were; diseases (52.4%), inadequate feed (7.8%) and poor housing (2.5%). The dominant feeding system was stall feeding (74.2%). The common forages were Napier grass, Bracharia grass and Maize fodder (32.6%); Napier grass, weeds and crop residues (28.6%); Napier grass (20.3%); Napier grass, Maize fodder and legumes (Desmodium) (10.5%) and Napier grass and sweet potato vines (8.0%). Conserved feeds were also fed as silage (20.8%), hay (20.0%), both hay and silage (3.8%) while 55.4% of the farmers did not use conserved feeds. The commonly fed concentrates were commercial dairy meal, homemade dairy concentrate, maize germ and soya meal. The amount of concentrates fed per day during early lactation were; 2-4 kg (47.6%), 4-6 kg (22.1%) and 1-2 kg (15.3%). The mean of AFC, CI, MY and LL were 28.5±2.84 months, 15.2±5.11 months, 10.7±5.85 litres/cow/day and 10.0±4.90 months, respectively. The main challenges in dairy cattle production were feed shortages (30.6%), low farm gate milk prices 28.3%) and high cost of feeds (17.8%). It was concluded that reproductive and productive performance were poor due to feed shortages.

Key Words: Dairy cattle, Milk yield, Feeding, Reproductive performance

CHAPTER ONE: INTRODUCTION

1.1. Background

The global dairy industry is an exceptional supporter of the economies of developed and developing countries (Herrero *et al.*, 2013). Between the two economies, there exists many differences in production systems and their efficiencies. Dairy production within the developed nations is for the most part by large scale businesses characterized by high take-up of innovation and big capital cost whereas within the developing nations it is to a great extent by smallholder farmers with minimal management and specialized skills, constrained by little capital and data (Muriithi *et al*., 2014).

This has resulted in incongruities in production levels in developing and developed economies. Studies have reported mean production of 3,500, 7,100 and 9,000 litres/cow/year for Argentina, Germany and USA respectively (EADDP, 2008). Others have respective average production levels of 5,750, 3,700, 956 and 3,868 litres/cow/year are reported for Australia, China, India and New Zealand (FAO, 2010). Within the European Union member nations, total production of milk is controlled through quotas assigned per country and thus production is pre-determined (FAO, 2010). Livestock production provides a major contribution to national economies worldwide (FAO, 2018). According to FAO (2018), the value of livestock production in 2014 in developed and developing countries accounted for 40 and 20 percent of total agricultural output respectively.

Kenya is among the biggest milk producers in Africa and highest in all the East African nations (Muriithi *et al*., 2014). South Africa has the foremost effective production system in Africa with production levels of 2,500 compared to 800 in Uganda, 1,000 in Tanzania and 1,983 litres/cow/year in Kenya (FAO, (2010); ACET, 2015; Kageni *et al*., 2019). All these nations have a production system comparable to the one in Kenya, which is low cost since it is based on rain fed pasture production (GOK, 2010).

Dairy Production is a principal farming activity that provides approximately 4.5% of the Kenya National GDP, 12% of Agricultural GDP and contributes to the livelihood of 1.5 million smallholder dairy farmers (KDB, 2016). It provides employment by creating 750,000 direct jobs and 500,000 indirect jobs in addition to supporting other service industries such as animal feed processing, breeding and animal healthcare among others (KDB, 2016). According to Odero-Waitituh, (2017), dairy cattle population was estimated at 4.3 million while annual per capita dairy consumption was 80 to 100 kg (KDB, 2016) compared to less than 30 kg in most of the countries in Central and East Africa (Kasirye, 2015). The mean milk yield per cow according to MoLD (2010), had stagnated at only 6 kg/day for a period of more than thirty years.

By having one of the advanced dairy sub-sectors, Kenya produces approximately 5.2 billion litres of fresh milk per year mainly from cattle. Dairy production has proved to be a very important means of income generation and as a source of food for an estimated 1.5 million small scale farmer households who reportedly produce 80% of the total national milk output (KDB, 2016).

1.2. Problem Statement

Milk Production for most parts of the country is in smallholder dairy herds (Owen *et al*., 2005; Musalia *et al*., 2007; Lukuyu *et al*., 2011), characterized by low productivity resulting in reduced profitability. In a study done in Kirinyaga county, only 25% of the dairy animals produced more than 8 litres/day while 60% produced between 1-4 litres, and 15% produced 4-8 litres of milk per day (Njonge, 2017).

The low productivity has been attributed to feed shortage, diseases and parasites, poor dairy farming practices, and poor access to extension and veterinary services (Ayantunde *et al,* 2005; Njarui *et al*., 2011; Onono *et al*, 2013). More than 70% of small-scale dairy producers indicated t accessibility of feeds as the main constraint in dairy cattle raising (Njonge, 2017). Although these constraints have been documented, new technologies and changing land sizes and use in several parts of the country requires that we continuously re-evaluate them.

1.3. Justification

Dairy production is key to the Kenyan economy as it is a means of income generation and food source for an approximated 1.5 million smallholder farmer households who contribute about 80% of the national milk output. However, land sizes are changing; leading to intensification thus new challenges are emerging. Data on current milk yields and constraints to milk production should be continuously collected to identify new challenges. Higher incomes, increased urban migration and inclinations by the working classes to consume more foods of animal origin has increased the demand for milk and ensures a future for dairy farming (Delgado *et al*., 1999; Jayne *et al*., 2003).

This study collected information from small scale dairy farmers in 2 sites, where intensification has been documented. The data collected included: feed resources; feeding systems; calf, heifer and cow management practices; and productive and reproductive performance with a view to identifying challenges and suggest ways to optimize productivity.

1.4. Broad Objective

To evaluate productivity in smallholder dairy farms in Nyeri County.

1.5. Specific Objectives

1. To assess feed resources and feeding systems in smallholder dairy farms in Nyeri County.
2. To evaluate management practices of young and growing stock in smallholder dairy farms in Nyeri County.
3. To determine reproductive and productive performance of dairy cattle in smallholder dairy farms in Nyeri County.

1.6. Research Questions

1. What are the feed resources and feeding systems in smallholder dairy farms in Nyeri County?
2. What are different management practices of young and growing stocks in smallholder dairy farms in Nyeri County?
3. What is the level of reproductive and productive performance in smallholder dairy farms in Nyeri County?

CHAPTER TWO: LITERATURE REVIEW

2.1. Dairy Industry in Kenya

Kenya is one of the largest producers of dairy products in Africa and its livestock population consists of a dairy herd of about 3.5 million exotic cattle, 14.1 million indigenous cattle,27.7 million goats and 2.97 million camels according to 2009 census (MoALF, 2013). In Kenya, cattle account for approximately 88% of milk produced while the rest comes from camels and goats (MoALF, 2013).

Dairy production is a principal farming activity that provides approximately 4.5% of the Kenya National GDP, 12% of Agricultural GDP and contributes to the livelihood of 1.5 million smallholder dairy farmers (KDB, 2016). It provides employment by creating 750,000 direct jobs and 500,000 indirect jobs in addition to supporting other service industries such as animal feed processing, breeding and animal healthcare among others (KDB, 2016).
The country has the highest per capita milk consumption in Africa (of approximately 100 kg) compared to an average of 25 kg per capita for Sub-Saharan Africa. However, this remains below the global annual per capita milk consumption requirement of about 220 kg per capita (MoALF, 2013).

In Kenya, dairy farming has been categorized into smallholder and large scale with the smallholder production contributing 80 to 90% of the whole dairy subsector (KDB, 2014; KNBS, 2017). The milk yield per cow according to MoLD, (2010) had remained at only 6 kg/day for a period of more than thirty years whereas South African average is 19 kg/day (KDB, 2016).

The low productivity was due to insufficient quantities and poor-quality feeds and poor breeding services, ineffective animal husbandry, poor extension and advisory services, ineffective disease control and veterinary services (MoALF, 2013). Limited access to product markets also leads to low incentive to maximize dairy production (MoALF, 2013).

2.2. Smallholder Dairy Production System

The human population density and agro-ecological zones determines the dairy production system practiced in a certain area (Staal *et al*., 2003). In the Kenyan highlands where population densities are high, small scale dairy farming system is practiced where forages and crop residues are stall fed to dairy cattle (Njarui *et al*., 2016). Njarui *et al*., (2016). Also reported that more than three out of four family units in these areas are associated with dairy farming and 73% practised integrated crop-dairy farming. In these high potential areas, the dairy farming systems practiced by households include; intensive, semi-intensive and extensive in the proportion of 44%, 33% and 23% respectively (Bebe *et al*., 2003). Nevertheless, Mbugua *et al*., (1998) reported that where semi-intensive system is practiced, cows are taken for grazing and zero-grazed based on the existing season in areas with moderate population densities.

2.2.1. Intensive or Stall feeding

After independence, according to Muriuki, (2003), most of the large productive farms owned by white pioneers were purchased and subdivided into small parcels leading to development of smallholder dairy production. With a few acres, smallholder dairy production system is practiced with exotic and crossbred cattle ranging from 1 to 5 in number (Muriuki, 2003). Small scale dairy farming is mostly integrated with maize-oriented production system where 71% of the producers keep average of 1 to 3 dairy animals (Bebe *et al*., 2003; Mugambi *et* *al*., 2015). Higher milk yield of 3,150 kgs/cow/lactation was reported (Mbugua *et al.,* 1998) compared to 1,510 kgs/cow/lactation under Semi-intensive system (Karanja, 2002). Together with dairying, some farmers grow cash crops like tea, coffee, or pyrethrum (Bebe *et al*., 2003; Mugambi *et al*., 2015).

According to Mugambi *et al*. (2015), most of dairy animals are Friesian or Ayrshire or their crossbreeds. The utilization of the manure for food and cash crops is an essential element of this system, leading to increased crop production on the small pieces of land (Ndambi *et al.,* (2019). The benefits of integrated smallholder system include: integration as manure is utilized on crops, cut and carry minimizes hooves compaction of the soil and conserves feed resources (De haan *et al*., 1997).

Lukuyu *et al*., (2011), reported that feed resources in Central and Northern Rift Valley Provinces included pastures (Kikuyu, Star, Couch and Wire grasses) and forages such as Napier grass, Maize fodder, Fodder trees (Leucaena spp., Sesbania spp. or Calliandra spp.) and Legume (Lucerne and Desmodium).The most frequently cultivated fodder used for dairy cattle is Napier grass, especially in the central Kenya highlands (FAO, 2011). It is a main forage for dairy cattle in intensive and semi intensive systems and grown by more than 70% of small-scale dairy farmers in Kenya (Orodho 2006; Mulaa *et al*., 2013). Napier grass produces enormous amounts of biomass and tolerates frequent cuttings and represents between 40 to 80% of the fodder for small-scale dairy farms ((Nyambati *et al*., 2011; Staal *et al*., 1998). In Kenya and Uganda, Napier grass reaches harvest at 3-4 months after planting and continuously harvested at interval of 6-8 weeks for 3-5 years depending on management, soil fertility and soil moisture. With good management practices, Napier grass can produce 40MT/ha/year in areas of high rainfall (1200 mm to 2400 mm of rainfall) and 1 acre of

Napier grass planted by the Tumbukiza (mico-catchments) method can produce enough feed for 2 to 3 dairy cows per year (Kabirizi *et al*., 2015).

2.2.2. Semi-intensive system

Semi-intensive system of dairy production is practiced in moderate to high potential regions with minimal use of concentrates and zero grazing (Muia *et al*., 2011). The characteristics of this system are grazing during daytime and zero grazing at night, with supplementation of animals at milking time where crossbreeds are preferred (Muia *et al*., 2011). The average milk production in this system was reported to be 1,510 kgs/cow/lactation which is lower than under the stall-feeding system (Karanja, 2002; Odero-Waitituh, 2017).

Lukuyu *et al*., (2011), reported feed resources in Central and Northern Rift Valley Provinces where semi-intensive feeding is practiced included pastures (Kikuyu, Star, Couch and Wire grasses) and forages such as Napier grass, Maize fodder, Fodder trees (Leucaena spp., Sesbania spp. or Calliandra spp.) and Legume (Lucerne and Desmodium). In semi intensive system, animals are slightly confined and are able to graze freely or under paddocking and put in fences or houses in the evening, where feed supplements are given (Thornton *et al.*, 2019)

2.3. Feed Resources and Feeding Systems

The main feeding regime in the smallholder dairy system is zero-grazing or semi-zero grazing which relies upon the cut and carry method (Muia *et al*., 2011). Approximately 40% of family units practicing small-scale farming feed their dairy animals on improved forages which are supplemented with concentrates (Muia *et al*., 2011). Planted fodder such as Napier grass is fed to dairy cattle together with maize stovers, weeds, grass and crop wastes (Njarui *et al*., 2011) and are supplemented at times with concentrate feeds such as grain milling by-products or mixed commercial dairy feeds (Mbugua *et al*., 1998; Njarui *et al*., 2011).

A significant part of forage in this production system was collected from community land or bought (Njarui *et al*., 2011). Around 95% of dairy producers kept postharvest residues for their animals but the conservation techniques were inconsistent with the sustainability of quality (Njarui *et al*., 2011). Approximately 93% of the small-scale producers faced seasonal variations of feed availability and hence milk yield (Njarui *et al*., 2011).

From the studies in Northern Rift area of Kenya, Napier grass was reported to be the dominant forage grown by 28, 15, 18 and 24% of the farmers in Siongiroi, Metkei, Kabiyet, and Kaptumo respectively (Lukuyu *et al*., 2011). Other types of feeds differed across farms and areas based on season and farm productivity. Kashongwe *et al*. (2017) studied feeding practices in Nakuru County, Kenya in peri-urban and rural small-scale dairy farms. They reported that the peri-urban dairy farmers fed Napier grass (68.4%) along with concentrate supplements (100%), oat forages (42.9%) and crop wastes (28.6%). Rural farmers fed their animals on pasture (87.7%) with Napier grass (89.4%) and concentrates (93.9%) as supplements (Kashongwe *et al*. 2017).

Feed quality, especially the NDF content, is an important determinant of the digestibility, the intake and indirectly the performance of animals on the feed (McDonald *et al*., 2011). Napier grass harvested during the wet season has 74.2% NDF and 72% DM digestibility (Orodho, 2006). The nutrient content of Napier grass was reported as 20% DM, 8-10% CP, 70% NDF, and 45% ADF (Mukisira and Khasiani, 1989). Based on Singh and Oosting report (1992), forages with NDF values of less than 45% are classified as high quality, those ranging from

45% to 65% as medium and those with more than 65% as poor quality. Thus, using the criteria, Napier grass, whose NDF content was reported at 74.2 and 70% by Orodho, (2006) and Mukisira and Khasiani, (1989) respectively, would be classified as poor quality feed. , As with most grasses, the NDF and ADF for Napier grass increases with harvest interval, while digestibility decreases (Van Soest 1994).

2.3.1. Feed Conservation

Feed conservation is practiced to some extent among smallholder dairy producers in Kenya, yet the forage quality stays poor because of insufficient information in feed conservation systems and access to forage storing facilities (Lukuyu *et al*., 2011). More than 60 % of the dairy farmers in Nakuru County experience feed shortage in the dry season (Kashongwe *et al*., 2017). However, in semi-arid area of Machakos County, Njarui *et al*., (2011) reported that 97.5 % of the study group preserved feed; hay (94.9 %) and silage (5.1 %). Among the sampled farmers, 92.9 % experienced regular feed supply throughout the year (Njarui *et al*., 2011). In mid-altitude region, central highlands and north western highlands, over 90% of farmers grow Napier grass compared with 14.5% in coastal lowlands (Njarui *et al*., 2016). Despite the number of livestock farmers growing Napier grass, it was insufficient for marketing and conservation (Musalia *et al*, 2016). The priority was given to crop cultivation due to limited land and approximately 80% of the farmers in Nkondi, Igambang'ombe and Tharaka Central divisions conserved maize stalks and other crop residues for their livestock (Musalia *et al*., 2016).

2.3.2. Dairy concentrates

The concentrates are feeds used as supplements to maximize milk production and growth in calves. They are essential in correcting some deficiencies in fodder and low feed intake

(Kimunya, 2014). The commonly used concentrates are dairy meals (with some ingredients such as maize germ, pollard and bran). The prices of the feed concentrates fluctuate due to availability and transport cost (Kimunya, 2014).

According to Kimunya, (2014), a 70 Kg bag of dairy meal on average costs US$ 14.74; a 70 Kg bag of pollard US$ 12.90 whereas a 70 Kg bag of maize germ US$ 8.29. Farmers prefer dairy meal concentrate because it contains more nutrients compared to other concentrates. The concentrates were fed to dairy cattle depending on the amount of milk produced by each cow. Concentrates are rich source of nutrients (energy and protein) and offer higher nutrients than an equal weight of roughages (Lukuyu *et al*., 2012). Feeding one kg of concentrates was expected to increase milk production by 1.5 kg of milk (SNV, 2017). The concentrates should constitute 40% of the dry matter intake of the dairy cow (Biwott *et al*, 1998; Kimunya, 2014). However, most farmers feed their cattle below the requirement, citing high cost of feed concentrates (Biwott *et al*, 1998).

2.4. Breeds and Breeding Systems

After Kenya's independence in 1963, dairy production system quickly moved from large scale to smallholder systems (MoALDM, 1998). The move to smallholder dairy production was accompanied by an increase in the number of high-grade dairy cows of Friesian breed. In a contemporary characterization investigation of small-scale dairy systems in the Kenyan Central Highlands, Staal *et al*., (1998) reported proportions of 3.8% zebus, 53.6% dairy crossbreeds and 42.6% exotic dairy breeds. The breeds on the sampled farms were Friesian (51%), Ayrshire (23%), Guernsey (13%) and others being Jersey and native zebus. A more recent study in the same area by Bebe *et al*., (2003) reported 43% of sampled dairy farmers kept Friesian, 19% kept Ayrshire, 16% kept Guernsey and Jersey while 22% kept Bos indicus cows (East African Zebu, Boran, Sahiwal). Dairy producers keeping Friesians and Ayrshires were more commercially oriented while those keeping Bos indicus, Guernsey and Jersey breeds had a higher need for milk production for the family consumption (Bebe *et al*., 2003).

Artificial insemination is the predominant breeding method in dairy producing areas. In Mirangine (Nyandarua County), 72.3% of the respondents used AI, while 27.7% used natural mating (Gitau, 2013). According to Karanja (2002), good genetics is one way of improving milk production. The present average cost of AI using local semen is US$ 15 whereas that of imported semen US$ 40 (Mutavi *et al* 2016). According to Karanja (2002), imported semen is estimated to have a market share of 22 %. However, Muia *et al* (2011) reported improved AI usage at 44% in smallholder farms. This has also decreased genetic progress of the dairy cattle because of inbreeding and poor coordinated breeding (Odero-Waitituh, (2017).

2.5. Management Practices

The common management practices in a dairy farm include: calf management, heifer management and cow management.

2.5.1. Calf Management

Calf management starts with steaming up (start feeding some concentrates) of the cow about 3 weeks before the expected calving date (SNV, 2017). Additional concentrate should be fed to the heifer in the milking parlour to accustom it if possible and allow the rumen bacteria to get adapted to high levels of concentrate (Lukuyu *et al*., 2012). It gives more nutrients for the animal and the growing foetus (Lukuyu *et al*., 2012). According to Lukuyu *et al*., (2012), steaming up also allows the dairy animal to put on extra weight to promote optimum milk production as the lactation period starts. It helps the cow to make a good start of the lactation and produce a strong calf (SNV, 2017).

The purpose of calf feeding should be to minimize the mortality rate while maintaining a growth rate of at least 400 g/day (Lukuyu *et al*., 2012). According to Lukuyu *et al*., (2012), calves should be fed to wean at 12 weeks (3 months) at approximately 80 kg body weight for bigger breeds (Friesians Ayrshire).

The calf is the foundation stock of the future dairy herd which demonstrates the importance of good calf management. Selection of replacements for culled cows can only be effective if good replacement heifers are available in the farm stock. A good management programme will result in improving calf mortality, age at first service, age at first calving and calving interval (Lukuyu *et al.,* 2012).

Good calf rearing involves ensuring adequate intake of high-quality colostrum within the first day of life and feeding management to encourage early rumen development (Goopy and Gakige, 2016). A calf should be fed at least 10% of their body weight of colostrum as a common rule, in its first 24 hours of life, preferably half of this within 6-12 hours of birth (SNV, 2017). A calf is removed from the dam as soon as possible after birth (within 15 min) and fed colostrum via suckling, bucket or stomach tube (Goopy and Gakige, 2016). The average expected birth weight for large dairy breeds (Friesian and Ayrshire) reported in Kenya is 42.5 kg (Wichtel and VanLeeuwen, 2012) and weaning weight of 80 kg (Lukuyu *et al*., 2012).

The dairy calves' management before weaning over the last 30 years has concentrated on reduced mortality, early weaning and rumen development (Soberon *et al*., 2012). In North

America, dairy neonates are mainly fed milk at 8 to 10% of Body Weight (BW)/day or comparable amounts of milk replacer (Sweeney *et al*., 2010).
According to Mulei *et al*., (1995) study at Kabete area, 46.8% of the total calf deaths took place within the first 2 months.

Mortality statistics mainly, range from 6.5- 30.7% in pre-weaned calves (Tesfaye, 2019). Various researchers have also examined numerous determinant factors in calf morbidity and mortality within the country. Usually, calf hood diseases and disease associated symptoms like calf diarrhoea and calf pneumonia were the significant causes of calf morbidity and mortality. Furthermore, calf hood diseases, host factors or calf factors (age, sex, vigour or dam factors (health and nutrition, parity, birth type), poor management and environmental factors ((like calving, colostrum feeding time and amount, poor housing, herd size, production system) were reported as the causes of calf morbidity and mortality (Tesfaye, 2019).

The goal of the calf nutrition program in dairy cattle would be to double the birth weight of calves by weaning age through maximized milk replacer and starter intake (Soberon *et al*., 2012). According to Muraya, (2019) study in Meru County, ADG of calves was 0.443±0.375 kg with a median of 0.360 kg. For calves under 15 months of age, mean ADG was 0.482±0.441 kg, whereas the heifers over 15 months had a mean ADG of 0.364 ±0.151 Kg (Muraya, 2019).

Weaning is the withdrawal of milk or milk replacer when the calf becomes completely dependent on other feeds (Lukuyu *et al.*, 2012). Usually, most dairy calves are weaned based on age, 12 - 16 weeks being the most common. Early weaning is possible when more milk is fed and calves provided with pre-starter and starter concentrate diets early in life. To minimize stress, weaning of calves should be done intermittently (Lukuyu *et al.,* 2012). In a study conducted in Meru, average pre-weaning daily weight gain of calves was 0.50±0.45 kg/day and mean body weight of 85.2±32.8 kg at weaning time (Kathambi *et al*., 2018). The weaning weight in this study is similar to the 82.08±10.25 kg reported by Soberon *et al*., (2012). Makau *et al*., (2018) reported a pre-weaning median and mean ADG of calves of 360 and 443 (s.d.=375) g/day, respectively. The ADG is affected by breed and historical disease which are associated with decreased ADG in *Bos taurus* breeds, while ADG in *Bos indicus* breeds was not affected by the disease (Makau *et al*., 2018).

2.5.2. Heifer Management

With proper feeding and management, heifers should achieve a growth rate of 500–700 g/day (Lukuyu *et al.,* 2012). This would ensure that they will come on heat at the right time, as puberty is linked to size rather than age. Reducing the interval between weaning and first calving maximizes the number of calving per lifetime thus more lactations and also results in faster genetic improvement. Lukuyu *et al.*, (2012), reported that, obtaining the first calving at 27 or less months of age is possible only if the growth rate is high. Decreasing the age at first calving and maximizing first-lactation milk production should be the primary aim of heifer management and feeding (Khan *et al.,* 2011).

Available information suggests that a pre-pubertal Average Daily Gain (ADG) of around 0.80 kg/day is suitable for high genotype of dairy heifers to maximize first-lactation milk production (Sejrsen *et al.,* 2000; Zanton and Heinrichs, 2007). Makau *et al*., (2018), in their study in Meru County in Kenya, reported mean ADG of youngstock of up to more than 15 months heifers as 0.364± 0.151 kg per day.

One of the main reproductive performance indicators is the dairy animal's age at first conception. The mean age at first service (AFS) in peri-urban areas of Eastern Kenya was 25.1 ± 8.7 months, (Mungube *et al.,* 2014). The age at first conception is largely inferred from the age at first calving (Novakovic *et al.*, 2011). A lower mean of age of dairy animal at first conception as 491.19±9.36 days or 16.15±0.31 months was reported by Novakovic *et al.*, (2011). This may reflect a higher level of feeding of the pre-pubertal heifers in the latter study. The recommended age at first insemination of heifers is 14 to 15 months at body weight of more than 350 kg, and a first calving at about 24 months (Antov *et al.*, 1998).

The Age at first calving (AFC) in Kenya Highlands was about 3 years (36 months) (Lanyasunya *et al.*, 1999; Bebe *et al.*, 2003). The mean Age at First Calving (AFC) of dairy cattle was reported as 39.42 ± 0.41 months under in tropical highland environment in Ethiopia (Wondossen *et al.*,2018). The target for AFC of 24 months, was believed to stand for the ideal to optimize productivity and business returns (Wathes *et al*., 2014). The target is hardly attained and average AFC stretches from 24.5 to 31 months (Brickell *et al*., 2009; Froidmont *et al*., 2013). A published UK research demonstrated the average of dairy cattle AFC as 29.6 months and a negative relationship between survival rate of first calving heifers and maximizing AFC (Sherwin *et al*., 2016). Studies have indicated that, lower AFC was associated with maximized survival rate of primiparous heifers (Archer *et al*. 2013; Sherwin *et al*., 2016). Increasing age at first calving to over 24 months was significantly associated with high risk of being culled at first parity. Study conducted by Sherwin *et al*., (2016), revealed the importance of keeping AFC of 23 to 24 months as increased AFC leads to a higher wastage of primiparous heifers with related financial losses.

In most of the farms, heifers are usually the most neglected group in terms of feeding, resulting in delayed age at first calving (Lukuyu *et al*., 2012). Heifers can be reared on good-quality pasture as their nutrient requirements are lower than those of a pregnant or lactating cow (Lukuyu *et al*., 2012). Concentrates supplementation is recommended at 1% of bodyweight with 12–14% CP for heifers on legume forage and 15–16% crude protein on grass forage (Lukuyu *et al*., 2012). Makau *et al*., (2018) similarly recommended supplementation with hay and/or concentrates to provide additional protein and energy for optimum growth in calves and heifers. If nutritional management of *Bos Taurus* heifers cannot be improved, then, it was suggested that crosses with *Bos indicus* may be more appropriate for the current nutritional management systems in Smallholder Dairy Farm in Meru (Makau *et al*., 2018).

2.6. Dairy Cow Management

The aim of feeding is to maximize milk yield by meeting the lactating cow's nutrient requirements (Lukuyu *et al*., 2012). The nutrient requirements are largely dependent on the quantity of milk produced, which varies with the stage of lactation. Other factors influencing nutrient requirements are pregnancy and maintenance. The amount required for maintenance is majorly influenced by the cow's body weight, environmental temperature and activity (Lukuyu *et al*., 2012) while effect of pregnancy is particularly critical in the last three months of gestation when foetal nutrients demand is high (SNV, 2017)

Mugambi *et al*., (2015), the cattle were underfed daily with roughages (52.2 Kg), concentrates (2.2 Kg) and mineral supplements (37 g); giving 15 Kg/day of milk on average. In Kenya (Embu and Meru counties), major factors affecting milk yield were the amounts of roughages, concentrates and mineral supplements, while the prices of roughages and labour led to variation in production cost (Mugambi *et al*., 2015).

This little efficiency is credited to inferior feeding, poor cattle management, the high expense of dairy farming and intensity of dairy and crop production (Mawa *et al*., 2014). Ochieng *et al.*, (2016), likewise recorded little profitability and increased expenses of farming are significant difficulties influencing dairy business. Through the expected increment of about 3-4% each year over milk utilization because of urbanization, increment in populace and ascend in salary, presence of demand in raising dairy profitability in Kenya (Wambugu *et al*., 2011).

The milk yield could be expanded by 31.3% through the appropriate use of the accessible assets, for example, forages and concentrates, whereas the expense of milk production may be reduced about 8.7% by not influencing the yield (Maina *et al*., 2018). This was inferred that, via effective utilization of the accessible sources of raw materials, similar to the forages and current innovation, financial effectiveness could be greatly expanded (Maina *et al*., 2018).

2.7. Reproductive Performance

The reproductive performance indices for dairy cattle includes; Number of Services per Conception (NSC) and Calving Interval (CI). The aim of a reproductive management practice is to ensure that cows conceive within a given time frame for effective production and maximization of profitability (Gitonga, 2010). The reproductive indices provide indications of existing reproductive shortfalls and enable the solutions to be sought before they adversely affect the dairy farms (Radostits *et al.,* 2001). These factors affect life time milk production, the number of calves born and general herd size. Reproductive performance in smallholder dairy farms in Kenya has been described as poor (Biwott *et al*., 1998; Bebe *et al* 2000; Owen *et al* 2005; Gitonga, 2010), characterized by long calving intervals. For example, Bebe *et al.,* (2003) reported a calving interval of about 633 days. The poor reproductive performance in smallholder systems is attributed to inadequate and poor-quality feed, prolonged anoestrus periods, poor oestrus detection skills, lack of proper breeding records and poor breeding techniques (Biwott *et al*., 1998; Bebe *et al* 2000; Owen *et al* 2005). These poor reproduction indices, together with high young stock mortality rates, have resulted in farmers not able to produce adequate replacement heifers. In order to solve these reproductive challenges affecting farmers, effective input services are required. Intervention from the government is required to provide services and subsidies to strengthen the farmers' cooperative societies and helps in achieving these reproductive goals (Bebe *et al* 2003). Romney *et al* (2000) revealed that farmers were willing to purchase supplemental feeds in the Kenyan highlands, when given access to credit facilities.

2.7.1. Number of Services per Conception (NSC)

Number of Service per Conception (NSC) is one of parameters for estimating dairy animal's reproductive performance which essentially relies upon the breeding system and is greater in free natural breeding and reduced in places where artificial insemination or synchronised breeding is utilized (Melaku *et al*., 2011). Number of services or inseminations per conception is defined as the number of times a cow is served to attain a successful conception (Radostits *et al.*, 2001). Tesfaye *et al.*, (2015) reported that, one service per conception is not usually obtained as there are many behavioural and physiological factors that affect it. These factors involve; inaccurate heat detection, inappropriate insemination timing and poor insemination techniques. Others such as climatic conditions, reproductive diseases and inadequate nutrition postpartum have also been linked to increase in the number of NSC

(Noakes *et al.,* 2001; McDougall, 2006). Radostits *et al., (*2001), in their study reported that, to achieve 12 months calving interval, the NSC should be 2.0. The study carried out in Kiambu and Nakuru districts in Kenya reported average number of services before conception as 2.0 (Gitonga, 2010). Wondossen *et al*., (2018) also reported a mean of 1.98 ± 0.05 Services per Conception in Ethiopia.

2.7.2. Calving Interval (CI)

The calving interval is an entire measure of the dairy cow reproductive performance as it involves heat detection, service per conception (SPC) and abortions. Calving interval is defined as the period from one calving to another and composed of the calving to conception interval (CCI) and the gestation period (Radostits *et al.,* 2001). The ideal calving interval has been stated as 365 days (Rukundo, 2018). Reproductive performance in smallholder dairy farms in Kenya has been reported as poor (Bebe *et al* 2003; Owen *et al* 2005).

The longer the calving interval is, the lower the milk production in the life time of the cow (SNV, 2017). To shorten the calving interval the cow should come on heat within 40 days after calving which would require good management practices such as provision of proper feeding, housing and health care to the cows and ensure that the cows are in good body condition. To obtain CI of 365 days, the cow should be inseminated or served within 60 to 80 days after calving (SNV, 2017).

The study conducted by Bebe *et al*., (2003), revealed prolonged calving intervals of about 633 days. Earlier studies in Kenyan smallholder dairy enterprises revealed the mean calving interval to be 665 days (Odima, 1994; Peeler and Omore1997; Biwott *et al*., 1998; Bebe *et al.,* 2000; Owen *et al.,* 2005; Gitonga, 2010). For medium and large-scale dairy farmers, a shorter calving interval of 400 days has been reported which could be attributed to improved levels of management and especially the levels of feeding (Biwott *et al.,* 1998; Ojango and Pollot, 2004).

However, the study conducted in Kenya by Mungube *et al*., (2014) revealed calving intervals (CI) as 13.6 ± 2.9 in per-urban areas of Eastern Kenya. Poor detection of heat lowers conception rates because of wrong insemination timing which leads into conception failure. These results to long calving intervals (CI) with negative impacts on the productive and reproductive performance of dairy cattle (Mungube *et al*., 2014). The prolonged CI in cows is associated with inadequate feeding, poor heat detection, herd health, the unreliability of AI and /or bull services and the absence of dairy farm records for accurate decision making (Moges 2012; Duguma et al 2012; Mungube *et al*., 2014).

Wondossen *et al*., (2018), reported an average calving interval of 469.2 ± 7.9 days (15.64±0.26 months) for dairy cattle in Ethiopia. Longer calving interval and days open was registered at the primary parity and the shortest was during the third parity (Wondossen *et al*., (2018). In general, in this study the reproductive performance of Holstein Friesian cows was poor probably due to the fact that these large dairy animals are poorly adapted to tropical environmental and management conditions. This needs a plan for technical and institutional involvement to promote the efficiency of reproductive performances through efficient heat detection, timely insemination, adequate feeding for growing heifers, and good management of postpartum reproductive problems.Interventions to improve reproductive performance would maximize the replacement rate of the herd and enhance selection among the existing small herd supporting local AI bull provision for crossbreeding program (Wondossen *et al*., (2018).

2.8. Productive Performance

The factors that influence milk production include: feeding, physical environment and animal factors (genetics, stage of lactation, parity, length of dry period among others). King *et al*. (2006) reported average milk yield in smallholder dairy farms in Kenya as 1525 kg/cow/year. Wanjala and Njehia, (2014), reported similarly low average milk yields of 1168 litres/cow/year in Western Kenya smallholder farms. Mugambi *et al* (2015) on the other hand reported milk yields of up to 4575kg/cow/year in high potential areas of Kenya depending on the level of intensification and agro ecological zones. As compared to the world's best milk production of 10133, 10035, 9816 and 9314 litres/cow/year, in Saudi Arabia, Israel, Republic of Korea and United States of America respectively (FAOSTAT, 2012) these yields are very low.

Muia *et al*., (2011) suggested the variation in production was a result of differences in availability of animal feeds, variation in livestock genotypes and farming system that was enhanced by agro-ecological zones. Producing and storing cattle feeds of good nutritional value, like leguminous plants of the genus *Calliandra* or *Sesbania*, is a good alternative to improving milk production with less need for purchased feeds, nevertheless, there is limited information pertaining to this option for improving productivity of dairy cattle (Richards, 2017). However, it is generally accepted that the genetic capacity of Kenyan dairy animals is much higher than the current milk yields and that there is room for improvement with proper management and better feeding systems (USAID/GoK, 2009).

The mean of 305-day milk production was 5807.83±78.27 kg by Friesians in Tunisia with the least yield about 2271 and highest yield of 7013 kg. The approximated mean lactation length was reported to be 309.60±7.01 days, with a minimum of 127 days and maximum of

356 days in Tunisia (Mhamdi *et al.*, 2012). According to Mhamdi *et al*., (2012) in their study in Tunisia, the mean of dry period was 97.17 ± 3.28 days. In the Holstein cattle, lactation Length was found between 284.7 and 333.9 days (Bilgic and Alic, 2005; Erdem *et al*., 2007).

Shorter lactation length of 7.67 months (230.1 days) led to reduced milk yield of 1168 litres/cow/year in Western Kenya (Wanjala and Njehia, 2014). FAO, (2011) officially reported average milk yield of Friesian breed as 4200 litres over 305 days of lactation. Different lactation lengths and average yields of 2407.47 litres in average of 239 days was documented in different parts of the country (Muhuyi *et al.,* 2001; Ongadi *et al.,* 2007,). The low yields and short lactation length were due to insufficient feeds characterised by low quantity and quality of feeds (Staal *et al.,* 1998; Wanjala and Njehia, 2014). A study conducted by Kok et al., (2017) on dry period length of 28 days revealed reduction in milk production compared with a dry period length of 56 days. Reductions in milk production depended on parity and dry period length (Kok et al., 2017).

2.9. Diseases

Livestock diseases have a massive impact on dairy productivity by changing the rates of reproduction, weight gain, decreased yield, and quality of milk (Wangila, 2016). Tick-borne diseases inflict an enormous impact in the tropical and subtropical parts of the developing world (Wangila, 2016). De Castro (1997) estimated the yearly global costs linked to ticks and tick-borne diseases in cattle as US$ 13.9 billion and US$ 18.7 billion respectively. Young *et al.,* (1988) stated that tick-transmitted diseases are economically the most important livestock diseases in Africa. The common tick - borne diseases are babesiosis, bovine anaplasmosis and East Coast fever (ECF) (Young, *et al.,* 1988). Animals that survive an acute attack often show a slow recovery, resulting in losses in both milk and meat production. Usually, mortality is between 5 and 40%, but may increase to 70% during a severe outbreak (Merck Veterinary Manual, 3rd Edition ,1997). The effects of diseases like diarrhoea, mastitis, and milk fever are associated with a significant decline in milk yield (Bareille *et al*. 2003). The costly disease in milk production is mastitis (Seegers *et al*., 2003). It leads to reduction in milk yield, public health risk due to consumption of unsafe milk, and less efficient processing of milk (FAO, 2014).

The parasitic infestation (ticks and helminths) also causes substantial economic losses in the form of milk production (Bharti, 2000). A research by Asmare *et al.*, (2017) reported that, gastrointestinal parasites are an economically important, causing lower fertility, reduced work capacity, involuntary culling, a reduction in food intake and lower weight gains, lower milk production, treatment costs and mortality in heavily affected animals. The common species of helminths affecting cattle were roundworms (Njoka) which accounted for 42%, tapeworms (Ndanguru) 15.2% while 37.1% were Flukes (Ndambara) (Njonge, 2017).

Diseases also impact on productivity of a dairy herd through mortality especially of calves. The main drivers of calf mortality documented worldwide are diarrhoea (scours) and respiratory diseases (Mulei *et al*.1995; Gitau *et al*. 1999; Wymann 2005; Wymann *et al*.2006; Wudu *et al*. 2008; Gitau *et al*., 2010). The highest mortalities are reported during the first 30 days of life and this extends up to the first 3 months of life (Mulei *et al*. 1995; Gitau *et al*. 1999; Wymann *et al*. 2006; Wudu *et al*. 2008; Chenyambuga and Mseleko 2009; Gitau *et al*., 2010). The risk factor associated with calf morbidity was calf age (Gitau et al., 1994). Megersa *et al.,* (2009), revealed important risk factors associated with calf mortality as floor conditions, calf housing and farm size.

CHAPTER THREE: MATERIALS AND METHODS

3.1. The study Site

This study was done in Nyeri County which comprises eight sub-counties including Mathira East, Mathira West, Kieni East, Kieni West, Nyeri Town, Tetu, Othaya and Mukurweini. Based on number of dairy farmers in a Sub-County, two Sub-Counties were selected for the study namely; Mathira East and Othaya (Fig 1). Nyeri County population is 759,164 based on Kenya National Bureau of Statistics (KNBS) (2019) projection and a population density of 207.8/km^2 (CGN, 2013). It is a leading innovative agricultural hub that has common boundaries with five Counties including; Meru to the north east, Laikipia to the north, Nyandarua to the west, Murang'a to the south and Kirinyaga to the east. The County is about 150 kilometres north of Nairobi and lies between latitude: 0°25′12″ S and longitude: 36°56′51″ E with altitude ranging from 3,076 meters and 5,199 meters above sea level (CGN, 2013).

The county experiences both cold and warm temperatures with an average of 12.8 ^{0}C in the cold months (June and July) and 20.8 ^{0}C in the hot months (January-March and September-October). The rainfall varies between 500 mm and 1600 mm per annum with high precipitation from April to May.

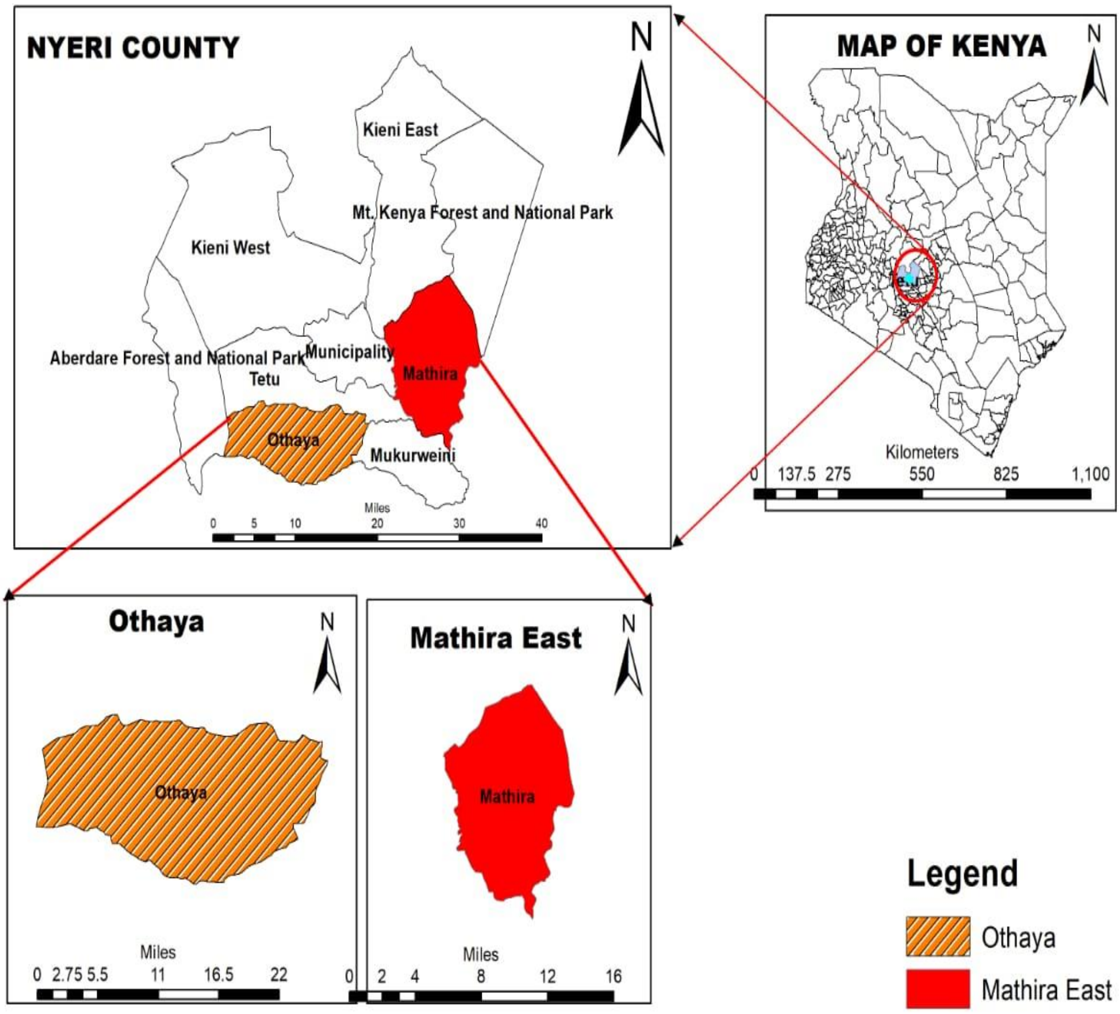

Figure 3.1 Location of study sites

3.2. Sources of data

The collection of primary data was done using a pre-tested semi-structured questionnaire administered to 400 smallholder dairy farmer's households. Data on number of smallholder dairy farmer households were given by County Department of Livestock (CDL).

3.3. Sampling Design

In the proposed Sub-Counties; Mathira East and Othaya, two wards were selected from each. In Mathira East Sub-County, Iria-ini and Magutu wards whereas in Othaya Sub-County, Chinga and Karima wards were selected for data collection. The selection criteria were based on farmers having at least one milking dairy cow. The estimated number of dairy farms in each ward was provided by County Department of Livestock (CDL). The households interviewed were purposively selected.

3.4. Determination of Sample Size

Yamane (1967:886) simplified formula was used to determine sample size at 95% confidence level and P=.5.

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n= Sample size of dairy farmers

N= Population of dairy farmers

e = 0.05; Precision level (error term).

According to County Government of Nyeri (2018), the estimated population size (N) of smallholder dairy farmers in two wards of Mathira East and two wards of Othaya Sub-Counties were approximately 9000 farmers. Using the above formula, 400 sample size of smallholder dairy farmers were interviewed; that is 100 farmers per ward.

3.5. Methods of data collection

Before data collection, field extension agents with previous knowledge on questionnaire administration and enumeration were recruited and trained. Thereafter the questionnaire was pre-tested using 5 dairy farms in each of Mathira East and Othaya Sub-Counties and revised where necessary.

The questionnaire collected data on: location, demography, socio-economic, feed resources, feeding systems, management practices, dairy cattle performance, breeding systems and housing. The filled questionnaires were checked before data entry into an Excel spreadsheet. Where problems were detected due to omission or contradiction, the respondents were revisited for clarification either physically or through telephone. During questionnaire administration, feeds samples were collected for laboratory analysis. The data collection was conducted from January to February 2019.

3.6 Chemical analysis

Feed samples were collected and analysed in the Animal Nutrition Laboratory. Dry matter, crude protein and ash were determined (AOAC, (2006); Latimer, 2016) while NDF, ADF and ADL were analysed using the method of (Van Soest, 2015).

3.7. Data analysis

The data from questionnaires was first coded and entered into Microsoft Excel from Microsoft Corporation, where it was cleaned and imported into Statistical Package for Social Sciences (SPSS), version 21.0.

Descriptive statistics were calculated using different tools of SPSS and Microsoft Excel Software; they involved computing frequencies, percentages, means, standard deviations and cross tabulations. Chi Square test was used to test for similarities and differences between wards. Interactions of variables was determined using linear regression model.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Socio-Economic Characteristics

Socio-economic characteristics of the respondents including age, gender, marital status, education, dairying experience and land size are shown in Table 4.1. Majority of the respondents in both Sub-Counties were 55 years and above (53.2%). Dairy farmers below 25 years were only found in Karima ward (Othaya sub-county) at a low frequency of 2%. This agreed with an earlier study conducted in Mirangine and Mauche (Nyandarua and Nakuru Counties respectively) where majority of dairy farmers were above 50 years (Gitau, 2013). Similar results can be inferred from a study by Mutavi and Amwata, (2018) in South Eastern Kenya who reported that most of the farmers had over 50 years' experience in farming. This trend may be explained by the fact that most young people lack the resources including land to invest in dairy farming (Mamudu *et al*., 2012). For young adults in Kenya, as in most developing countries, the usual system to obtain land is through traditional customary inheritance. Since life expectancy is increasing however, rural youth may not be youth by the time they actually inherit the land (Gitau and Goris, 2016).

Majority of the farmers were males (62.7%) an indication that most of the households were male-headed. The level of education of farmers was majorly secondary school (42.1%) followed by primary level and below (40.6%), college (12.3%) and University (5.0%). The fact that 59.4% of the farmers had secondary education and above is encouraging as this is the segment that are likely to adopt new techniques of dairy production to enhance productivity. The finding agreed with the Mamo (2013), who reported 52.2% of the farmers with secondary school certificates in Maara District and inferred that educational level of a farmer affects the productivity levels since he/she can easily adopt new technologies. Most of farming household heads were literate in South Eastern Kenya and had acquired secondary and post-secondary education (Mutavi and Amwata, 2018). Studies have shown that literate dairy farmers are more innovative and can easily understand concepts and principles of new innovations and technology (Waller *et al*., 1998; Caswell *et al*., 2001; Kinambuga, 2010; Mutavi and Amwata, 2018).

The results showed that 60.2% of the respondents in the study area had over 15 years of experience while 6.5% had 1-5 years' experience, an indicator that there were few entrants into dairying. This would explain the very few young people involved in dairying because most of them are involved in off-farm activities in towns and cities. Similarly, Maina (2018) reported farmers' average experience in dairying of 22 years in Mukurweini Sub-county of Nyeri.

The average land size in the study areas was 1.66±1.54 acres. In Chinga ward of Othaya sub-county, land size was slightly bigger at an average of 2.0 acres than the other wards. The small land holding implies that farmers will continue to intensify farming, where land is used to grow forages which are cut and carried to the dairy cows. Kirui *et al*. (2018) reported higher milk yield per cow on farms under 1 acre than for those kept on 5 acres of land due to intensification in Kericho County. Gitau (2013) also observed more smallholder dairy farmers on less than 1-acre due to high population densities in Nyandarua and Nakuru. In the future, land holdings will continue to decrease in size as a result of land subdivision through inheritance thus need for even higher intensification and adoption of new technologies.

Table 4.1: Socio-Economic Characteristics of the Respondents in the study area

Age of the Farmer (%)

Age of the Farmer	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Below 25 years	0.0	0.0	0.0	2.0	0.5
25-35 years	5.0	12.0	7.0	3.0	6.8
35-45 years	21.0	19.0	10.1	7.0	14.3
45-55 years	21.0	27.0	27.3	26.0	25.3
55 and above	53.0	42.0	55.6	62.0	53.2

Gender of the Farmer (%)

Gender	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Male	57.0	67.0	67.7	59.0	62.7
Female	43.0	33.0	32.3	41.0	37.3

Education (%)

Education	Iria-ini (N=100)	Magutu N=100)	Chinga (N=99)	Karima (N=100)	Mean
Primary level and below	52.0	35.0	31.3	44.0	40.6
Secondary	35.0	47.0	47.5	39.0	42.1
College (Diploma)	10.0	13.0	14.1	12.0	12.3
University	3.0	5.0	7.1	5.0	5.0

Farmer's Dairying Experience (%)

Experience	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
1-5 years	7.0	6.0	6.1	7.0	6.5
5-10 years	14.0	26.0	11.1	18.0	17.3
10-15 years	16.0	18.0	9.1	21.0	16.0
Over 15 years	63.0	50.0	73.7	54.0	60.2

Land Size in Acres

Land Size in Acres	Iria-ini	Magutu	Chinga	Karima	Total
Mean ± SD	1.62±1.49	1.19±1.28	2.02±1.57	1.79±1.69	1.66±1.54
N	100	100	99	100	399

4.2. Livestock Enterprises

Majority of the dairy farmers (79.4%) in the study area kept other livestock while a small proportion (20.6%) exclusively kept dairy cattle (Table 4.2). A majority (49.8%) of those who kept other livestock kept several species (Table 4.2). Of the other livestock species kept, chicken was the most common in all the wards. Chicken, goats, sheep, rabbits and pigs were kept by 38.2%, 6.3%, 3.5%, 0.9% and 0.3% of the farmers respectively. The variation between the wards of Mathira East and Othaya sub-counties in the proportion of farmers keeping other livestock species was minimal.

Dairy farmers have been reported to keep other livestock species as an insurance mechanism, store of wealth and sustainability of income generation (FAO, 2009). This system also provides the household with sustainable food security (eggs and meat) and to meet other household requirements such as health insurance and payment of school fees. This is also a vital strategy of raising emergency money to the households via the quick sale of these other livestock instead of selling the dairy cow (Rukundo, 2018).

Table 4.2: Types of livestock enterprises accompanying dairying in study area

Kept Other Livestock (%)					
	Wards				
Other Livestock	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Yes	85.0	82.0	72.7	78.0	79.4
No	15.0	18.0	27.3	22.0	20.6
Species of Livestock kept (%)					
	Wards				
Species	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Goats	4.7	1.2	11.1	9.0	6.3
Sheep	3.5	4.9	4.2	1.3	3.5
Chicken	30.6	35.4	40.3	47.4	38.2
Pigs	0.0	0.0	1.4	0.0	0.3
Rabbits	1.2	1.2	1.4	0.0	0.9
Several livestock species*	57.6	57.3	40.3	42.3	49.8
Others**	2.4	0.0	1.4	0.0	0.9

*Several livestock species were; goats, sheep, chicken, pigs and rabbits.

**Others included ducks, pigeons and geese.

4.3. Service Provision

Various services to the dairy farmers in the study area were provided by different actors in the value chain. Veterinary services were provided by private veterinary technicians (78.7%), County Government of Nyeri (CGN) (13.8%), both private veterinarians and County Government of Nyeri (7.5%) as shown in (Table 4.3). Majority of the farmers preferred private veterinarians as they were easily accessible and saved time spent looking for government services. The veterinary services provided included vaccination of livestock, treatment and artificial insemination. Similarly, majority of farmers in Narok County obtained veterinary services from private veterinarians (87.76 %), whereas only 12.24 % obtained government extension services. Government services were distant and required transport fares for the farmer thus increasing the cost of production (Onono *et al.*, 2013).

In the study area, majority of farmers had not received any training in dairying (42.9%), while those who were, 26.8% were trained by government, 16.3% by private veterinarians and 14.0% by cooperatives. Some of the trainings were not free, making them inaccessible to the farmers without money. This inadequate training to the farmers has resulted in poor dairy cattle management in terms of feeding, breeding, disease control and housing. Training by private extension staff namely Service Provider Enterprises (SPEs) resulted in farmers conserving between 0.3 and 66.2 tonnes of silage on average in Meru County yearly (Kilelu *et al*., 2017). Additional benefits of SPE services as stated by the farmers included improved dairy cattle management; effective animal health management and improved animal weight gain, decreased costs of buying feed and time saved from sourcing feed outside the farm. Construction of zero-grazing units was recognized to decrease wastage of manure (Kilelu *et al*., 2017). Similarly, Gitau (2013) reported that training of farmers in Mauche and Mirangine of Nakuru and Nyandarua Counties by government agencies resulted in the adoption of new technologies, thus increased productivity.

Most respondents (82.7%) had never taken loans during the study time. This service was provided by several players; 7.5% from saccos, 6.3% from cooperatives and 3.5% from Equity Bank. Non accessibility of loans for dairy development has been reported as a hindrance, as only 13.3% of families had accessed financing. In Iria-ini ward of Mathira East sub-county, 20% of the farmers accessed loan from saccos in which they were members while none had accessed credit in Karima ward of Othaya sub-county due to high interest rates, as stated by respondents. Loans enable farmers to expand their farms through buying heifers and improve feeding of dairy cattle by increasing fodder production. The main reason preventing farmers from taking loans was high interest rate (Mamudu *et al*., 2012; Mutavi and Amwata, 2018). Maina, (2018) reported that a majority of farmers (84.62%) accessed loans in Mukurweini sub-county, Nyeri. This was explained by the fact that these loans were offered at low interest rates by the processor through whom they sold their milk.

Table 4.3: Service Provision to the respondents in the study sites

Veterinary Services (%)					
	Wards				
Veterinary Services	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Private	60.0	83.0	89.9	82.0	78.7
CGN	21.0	14.0	4.0	16.0	13.8
Private/CGN	19.0	3.0	6.1	2.0	7.5

Training of Farmers on Dairy Management (%)					
	Wards				
Training by	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Government	35.0	35.0	24.2	13.0	26.8
Cooperatives	21.0	27.0	6.1	2.0	14.0
Private	10.0	10.0	23.2	22.0	16.3
No training	34.0	28.0	46.5	63.0	42.9

Loans for Dairy Development (%)					
	Wards				
Loan Provision	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Saccos	20.0	7.0	3.0	0.0	7.5
Equity Bank	4.0	7.0	3.0	0.0	3.5
Cooperative	16.0	7.0	2.0	0.0	6.3
None	60.0	79.0	91.9	100.0	82.7

*Saccos are saving groups formed by farmers and provide loans to the members.

4.4. Production Systems

The production systems in the study areas were both intensive and semi intensive (Table 4.4). Majority of dairy cattle farmers practiced intensive system of production (74.2%) and only 25.8% in semi intensive system. In the intensive system cattle were stall fed forages by the cut and carry method. In semi intensive system, cattle were grazed on grasses along the roadsides and supplemented with forages and minerals after grazing. Most of the farmers in the study area preferred the intensive system due to small landholdings (Table 4.1). The production systems practiced by farmers in both sub-counties were not significantly different (*p*>0.05) between the wards. Bebe *et al*., (2003), revealed that in the Kenyan highlands, the households used intensive, semi-intensive and extensive dairy farming systems in the proportion of 44%, 33% and 23% respectively. The variation could be due to different land holdings in their study site. Njarui *et al*., (2016) reported that in Kenyan highlands, where population densities are high, the intensive dairy farming system is practiced where forages and crop residues are stall fed to dairy cattle.

Table 4.4: Dairy cattle Production Systems (% respondents) in the study area

	Wards				
Systems	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Semi Intensive	23.0	33.0	22.2	25.0	25.8
Intensive	77.0	67.0	77.8	75.0	74.2

4.5. Breeds of Cattle

The breeds of dairy cattle found in the study area were Friesians (82.2%), Ayrshires (8.0%), Guernsey (4.0%), Jerseys (0.8%) and Crosses (5.0%) (Table 4.5). Breeds did not differ significantly (*p*>0.05) between the wards at 95% confidence level using Chi Square test. Friesian cattle were preferred due to high milk yield though of low butter fat. This is logically based on the fact that milk payment is based on volume rather than composition in the study area. However, while the Friesian can produce higher amounts of milk compared to the other three dairy breeds in the study area, it is the largest in size and requires larger amounts of feed to realise this potential. It is a fact, as shown later in the results that feed is a challenge to dairying on many small-scale farms. So, generally, the anticipated high milk yield from the Friesian is not realised.

Bebe *et al*., (2003) in Kenya highlands, reported that 43%, 19%, 16%, and 22% of farmers kept the Friesian, Ayrshire, Guernsey/Jersey and *Bos indicus* cows (East African Zebu, Boran, Sahiwal) repectively. On the other hand, 75% of the farmers in Mirangine of Nyandarua County kept Friesian and the rest kept Ayrshire, crosses, Guernsey and Jersey in that order (Gitau, 2013).

Table 4. 5: Breeds of dairy cattle (% respondents) kept in the study area

	Wards				
Breeds	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Friesians	83.0	70.0	84.8	91.0	82.2
Ayrshires	4.0	9.0	14.1	5.0	8.0
Guernsey	9.0	7.0	0.0	0.0	4.0
Jerseys	2.0	0.0	0.0	1.0	0.8
Crosses	2.0	14.0	1.0	3.0	5.0

4.6. Herd Size and Structure

Average herd size and structure of dairy cattle in the study area is shown in Table 4.6. The number of cattle in the study farms ranged from 1 to 12 with a mean of 2.61±1.67. The herd size between the Wards was not significantly different (p>0.05). The herd structure composed of 50% milking, 6.4% dry, 16.5% heifers and 12.7% heifer calves. Bull calves, bulls and steers constituted about 15% of the herd. The proportion of heifers (heifers and heifer calves) was greater than that of bull calves, bulls and steers combined since most of the bull calves were sold or slaughtered below one month of age. Most of farmers did not rear bull calves as majority of the farmers used artificial insemination for breeding. The recommended herd structure should constitute 50% cows, 10% heifers over one year, 11% heifers less than one year, 17% bulls and bull calves and 12% steers which was not the case in the study area (FAO, 2011). Wanjala and Njehia (2014) reported 36.4% lactating, 12% dry, 17% heifers among others in a study in Western Kenya. On the other hand, Lukuyu *et al*., (2011) reported

75% of dairy herd composed of adult cows, heifers and calves in North Rift and Central Province with bulls and steers constituting the other 25%.

This finding agreed with the observation that shortage of replacement stock on smallholder farms has been a challenge in the small-scale dairy sector in Kenya (Bebe *et al*., 2003a; Muruiki *et al*., 2004). In the dairy herd structure, average of 24% heifers is ideal for a successful farm (Mohd nor et al., 2014). It can be deduced from these results that many zero-grazed herds need outside sources of replacement heifers to ensure sustainable dairy cattle population (Bebe *et al*., 2003).

Table 4.6: Herd size and structure of dairy cattle in study area

Average Number of Cattle per Farm

Wards	N	Mean	SD	SE	Minimum	Maximum
Iria-ini	100	2.49[a]	1.460	.146	1	8
Magutu	100	2.61[a]	1.645	.164	1	11
Chinga	99	2.62[a]	1.489	.150	1	7
Karima	100	2.74[a]	2.033	.203	1	12
Total	399	2.61	1.669	.084	1	12

[a]Mean with similar superscript between the wards are not significantly different (*p*=0.773)

Herd Composition	N	Min	Max	Mean	SD	Percent
Non-Pregnant Lactating Cows	264	1	4	1.34	0.638	31.3
Pregnant and Lactating Cows	156	1	3	1.19	0.466	18.5
Dry Cows	54	1	3	1.24	0.547	6.4
Heifers	139	1	6	1.32	0.734	16.5
Heifer Calves	107	1	3	1.14	0.399	12.7
Bull Calves	77	1	2	1.12	0.323	9.1
Bulls	43	1	2	1.05	0.213	5.1
Steers	3	1	1	1	0	0.4
Total	843			1.18	0.415	100

4.7. Feed Resources and Composition

4.7.1. Feed Resources

Feed resources in the farms in study area consisted of roughages (mostly Napier grass), concentrates and mineral supplements (87.2%), roughages and mineral supplement (5.5%), roughages and concentrates (4.8%) and roughages alone (2.5%) (Table 4.7). There was no significant difference ($p>0.05$) between the wards with Chi Square test.

The roughages were mainly Napier grass, maize fodder and desmodium whereas concentrates were dairy meal (both commercial and homemade) and agro-industrial by-products (maize bran, wheat pollard, maize germ, cotton seed cake and sunflower cake). Most of the roughage-based feed sources within farms were from own production and purchase (76.7%), own production only (17.0%) and purchase only (2.3%). Farmers who experienced feed shortages attributed it to drought in addition to inadequate individual landholdings for adequate forage production. This explains why the majority of farmers (76.2%) purchased forages to supplement own production. In Magutu ward, 60.0% produced forages such as Napier grass, Brachiaria grass and maize fodder while 41.4% and 55.0% in Chinga and Karima wards respectively provided their cattle with Napier grass, weeds and crop residues. The variation was attributed to the fact that, more farmers were trained on animal nutrition and management in Magutu Ward than in the other wards (Table 4.3). The sources of forages were similar in the different wards. Lukuyu *et al*., (2011), reported the following feed resources in Central and Northern Rift Valley Provinces: pastures (Kikuyu, Star, Coach and Wire grasses) and forages such as Napier grass, Maize fodder, fodder trees (Leucaena spp., Sesbania spp. or Calliandra spp.) and legumes (Lucerne and Desmodium). The most common roughages were Napier grass, Maize fodder and Desmodium in the current study.

Napier grass was a common feed resource on all farms. It is reported as a main forage for dairy cattle in intensive and semi intensive systems and grown by more than 70% of small-scale dairy farmers in Kenya (Orodho 2006; Mulaa *et al*., 2013). Napier grass is a preferred fodder crop as it produces enormous biomass and tolerates frequent cuttings (Nyambati *et al*.,

2011) thus representing between 40 to 80% of the fodder for the small-scale dairy farms (Staal *et al*., 1998). With good management practices, Napier grass can produce 40t/ha/year in areas of high rainfall (1200 mm to 2400 mm of rainfall) and 1 acre of Napier grass planted by the Tumbukiza (micro-catchments) method can produce enough feed for 2 to 3 dairy cows for a year (Kabirizi *et al*., 2015).

Table 4. 7: Types of Feed Resources in farms in the study area

Feed Resources of the Dairy Cattle (%)

Feeds Resources	Wards: Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Roughages alone	7.0	3.0	0.0	0.0	2.5
Roughages and minerals	6.0	9.0	3.0	4.0	5.5
Roughages and concentrates	5.0	7.0	4.0	3.0	4.8
Roughages, concentrates and minerals	82.0	81.0	92.9	93.0	87.2

Sources of Roughage Feeds (%)

Sources of Feeds	Wards: Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Own production	23.0	20.0	19.1	15.0	19.3
Purchase	7.0	2.0	2.0	5.0	4.0
Own production and purchase	70.0	78.0	78.9	80.0	76.7

Available Roughage Feeds Resources (%)

Feeds Produced	Wards: Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Napier grass	31.0	21.0	16.2	13.0	20.3
Napier grass and sweet potato vines	12.0	2.0	12.1	6.0	8.0
Napier grass, Bracharia grass, and Maize fodder	31.0	60.0	18.2	21.0	32.6
Napier grass, Maize fodder and legumes*	15.0	10.0	12.1	5.0	10.5
Napier grass, weeds and crop residues**	11.0	7.0	41.4	55.0	28.6

*Common legumes: Desmodium, Lucerne and Calliandra
**Crop residues: Maize stovers, sweet potato vines and vegetable wastes

4.7.2. Chemical Composition of Various Feed Types

Chemical Composition of various forages and concentrates are shown in Table 4.8. Napier grass (*Pennisetum purpureum*) had 23.90, 6.70 and 75.30% dry matter (DM), crude protein (CP) and neutral detergent fibre (NDF) respectively. The low CP value could be due to the late cutting age of the grass in the study area (about 10 weeks). Tesfaye, (2018) reported CP of Napier grass cut at 6 and 8 weeks at 8.01 and 6.44% respectively in Ethiopia. The mean proximate composition of Rhodes grass (*Chloris gayana*) hay in the study area was 80.89%, 5.99%, and 75.85% for DM, CP and NDF respectively. The low CP and high level of NDF are indicative of poor quality which would result in low feed intake hence low performance of dairy cattle. The quality of the hay was below 8.0% CP and 70.0% NDF specifications by KEBS (2018).

The DM and CP content of Desmodium was 26.41% and 15.94% respectively. The management practices applied by farmers to Desmodium have big effect on the chemical composition. Similarly, Ndikumana and de Leeuw, (1993) reported the CP of Desmodium as 16.30% in their study in Zimbabwe. The quality of Desmodium in the study area was good. Desmodium is mixed with Napier grass by smallholder farmers in Kenya during feeding to overcome inadequacy in both quantity and quality (Murage *et al*., 2012).

Sweet potato vines composition was 29.01% DM, 18.61% CP. They were not widely used in the study area but can be a good source of CP and can be used to supplement the forages such as Napier grass which has low CP level. The CP content observed in this study concurred with Manoa, (2012) who reported a CP range from 15.08 to 17.97% in sweet potato vines.

The commercial dairy concentrate (dairy meal) was 96.34 DM, 7.56 Ash and 14.60% CP. According to NAFIS, (2019) commercial dairy concentrates CP content ranges from 14-16% under KEBS specifications. Homemade dairy meal was 95.93, 8.51 and 14.29% DM, Ash and CP respectively. According to MoLD (2012), dairy cows that produce 15, 20, 30 litres of milk per day require diets with a CP content of 15, 16 and 18% respectively. The crude protein level in the study sites was below 15% CP, thus it was insufficient for a high yielder cows to meet their full potential.

In the study, maize germ, wheat bran and wheat pollard were of 8.58, 13.39 and 13.21% CP content respectively. The CP content in the by-products in this study was lower than the 10.53, 15.15 and 13.96% respectively reported by Bouwman, (1999) and Mutuku, (2016). The nutritional value of agro-industrial by-products is often inconsistent and will vary with original crop as well as the processing methods. Protein supplements such as groundnut cake, Copra cake, Canola cake, cotton seed cake, sunflower cake, soybean meal and fish meal were 20.01, 26.24, 27.31, 29.95, 19.32, 44.34 and 42.8% CP respectively. In an early study in Kenya, groundnut cake, Copra cake, canola cake, cotton seed cake, sunflower cake, soybean meal and fish meal were 45, 23,35, 35, 26, 47 and 55% respectively (Lukuyu *et al*., 2012). The CP content of the feed supplements were fairly good however, some farmers didn’t use right amounts (Table 4.11) during early lactation.

Table 4. 8: Chemical Composition of Various Feed Types in the Study Area

Feed type	N	DM	Ash	CP	NDF	ADF	ADL
Napier grass	7	23.97	10.85	6.70	75.27	54.33	9.75
Napier grass silage	4	25.29	12.74	6.3	67.29	46.65	11.0
Desmodium	4	26.41	7.99	15.94	49.83	33.46	6.71
Sweet potato vine	4	29.01	12.5	18.61	45.89	25.29	7.56
Rhodes hay	3	80.89	8.12	5.99	75.85	57.29	9.92
Dairy Meal (Commercial)	4	96.34	7.56	14.60			
Homemade dairy meal	4	95.93	8.51	14.29			
Maize germ	3	97.39	4.90	8.58			
Wheat bran	4	93.72	5.26	13.39			
Wheat pollard	5	97.21	4.93	13.21			
Groundnut cake	2	98.21	17.38	20.01			
Canola cake	2	96.89	5.48	27.31			
Cotton seed cake	4	94.94	5.31	29.95			
Fish Meal	3	97.00	22.89	42.8			
Copra cake (coconut)	3	94.09	7.4	26.24			
Sunflower cake	4	96.89	4.89	19.32			
Soya meal	2	94.73	6.43	44.34			

4.8. Feed conservation, feeding, watering and use of commercial concentrates

4.8.1. Feeds conservation and use of conserved feeds in the study area

Only 20.8 % of the farmers conserved fodder in the form of silage (Table 4.9). This could be attributed to inadequate training (Table 4.3) as feed conservation requires technical expertise. Some of the respondents in the study area reported lack of sufficient feeds to be conserved during the study time. During the dry season when fresh feed was inadequate, 20.8% and 20.1% of farmers fed conserved silage and purchased hay respectively (Table 4.9). Lukuyu *et al*., (2011) reported that feed preservation was practiced by small proportion of smallholder dairy producers in Kenya, attributing this to insufficient information in feed conservation systems and limited access to forage storing facilities. During the time of the study, 55.4% of the farmers had not conserved any feeds, 20.8% fed silage while 20.0% fed Rhodes grass hay that was purchased. According to respondents, milk production dropped due to insufficient feeds in term of quantity and quality during the dry season. Kashongwe *et al*., (2017) reported that more than 60 % of the dairy farmers in Nakuru County faced feed shortages in the dry season due to lack of capacity in haymaking. There was minimal variation in feed conservation practices between the wards.

Table 4.9: Feed conservation and use of conserved feeds in study area

Feeds Conservation (%)					
	Wards				
Feeds Conservation	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
No	82.0	76.0	72.7	86.0	79.2
Yes	18.0	24.0	27.3	14.0	20.8
Conserved Feeds Fed to Cattle (%)					
	Wards				
Conserved Feeds Fed	Iriani (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Hay (purchased)	21.0	21.0	20.2	18.0	20.0
Silage (Conserved)	20.0	21.0	22.2	20.0	20.8
No conserved feeds	59.0	53.0	48.5	61.0	55.4
Both hay and silage	0.0	5.0	9.1	1.0	3.8

4.8.2. Responsibility of Feeding Cattle

The sharing of responsibility of feeding of dairy cattle is shown in Table 4.10. Feeding the dairy cattle was mainly done by adult females (29.6%) and males (28.6%). Only in 14.5% of the smallholder farms was feeding done exclusively by workers. The feeding was mainly done by the farmers themselves (adult females and males) which may be an indication of inadequate income that rarely supports employment of workers. Gitau, (2013) observed that households with a married couple had more labour capital to perform the daily chores. A higher proportion of farmers (19.2%) in Chinga ward employed workers than in the other wards because of employment of owners on off-farm activities.

Table 4. 10: Responsibility of Feeding Cattle (%) in the study area

Responsibility	Wards				Mean
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	
Adult Male Owner	29.0	36.0	19.2	30.0	28.6
Adult Female Owner	33.0	29.0	21.2	35.0	29.6
Children	0.0	0.0	4.0	0.0	1.0
Worker	8.0	14.0	19.2	17.0	14.5
Worker and family members	20.0	17.0	36.3	6.0	19.8
Both Male and Female Owners	10.0%	4.0%	0.0%	12.0%	6.5

4.8.3. Use of commercial concentrate and mineral supplements

The amount of concentrates fed during the different lactation stages and dry period are shown in Table 4.11. During early lactation, 47.6% of the farmers fed 2-4 kg/day, 22.1% fed 4-6 while 3.0% did not feed concentrates. Feeding concentrate during early lactation to dairy cows (first 100-150 days of lactation) increases milk production and reduces loss of weight (Biwott *et al*., 1998). Nonetheless, most farmers feed insufficient amounts of concentrate in the study area due to inadequate knowledge in dairy nutrition during stages of lactation. Concentrates are richer sources of nutrients (energy and protein) and offer higher nutrients than an equal weight of roughage (Lukuyu *et al*., 2012). Feeding 1 kg of concentrate increased milk production by 1.5 kg (SNV, 2017). Möller (2018) reported that cows in Baringo were offered an average of 4 kg of concentrate per cow per day. The level of milk production depends on the quality of the roughage and amount of concentrate provided. Biwott *et al*., (1998) fed different levels of concentrate (2, 4 and 8 kg) to cows in early lactation and reported that cows fed with 8 kg concentrates produced more milk than cows fed 4 kg concentrate during the first 8 weeks of lactation. Majority of farmers in the study area fed low quantities of concentrate in early lactation resulting in low milk production. Low levels of concentrate were fed due to insufficient knowledge on lactation curve. A lactating cow at early phase of lactation requires higher quantity of concentrate than a cow in mid and late lactation to optimize milk production (Lukuyu *et al*., 2012).

During mid and late lactation, 65.3% of farmers fed 1-2 kg/day and 19.5% fed <1 kg/day of concentrates. During the mid and late lactation, the cow has already peaked in milk production and declining, dry matter intake is maximum and thus the nutrients requirement for lactation is less. The cow can then be fed on good quality pastures or forages and provided with only 1-2 kg concentrates if fed on poor roughages (SNV, 2017). Farmers who offered high amounts of concentrates during this stage were not aware of this. There is need for farmers to be trained to feed cows depending on lactation stage which dictates the nutrient requirements.

During the dry Period, 53.9% of farmers fed <1 kg/day and 24.3% fed 1-2 kg/day of concentrates. Feeding of concentrate (steaming) to dairy cow at last two months of pregnancy before calving is encouraged to prepare the cow for calving through building reserves for next lactation (SNV, 2017). More farmers fed 4-6 kg of concentrate during early lactation in Chinga and Iria-ini wards compared to other wards and it was attributed to a slightly higher proportion of educated farmers who were more likely to understand the importance of concentrate feeding (Table 4.1**).**

Mineral supplementation to dairy cows in the study area is shown in Table 4.11. Of the respondents, 35.6% did not provide mineral supplements, 50.85% provided mineral supplements and 13.5% provided mineral blocks. Deficiency of minerals leads to infertility, low milk production and health disorders in dairy cattle (Singh *et al*, 2012). Poor body condition, stunted growth rates and low fertility are side effects related with under-nutrition of minerals (Singh *et al*, 2012). Majority of farmers in Chinga and Karima wards of Othaya subcounty relied on the minerals in the commercial dairy concentrates and did not use additional mineral supplements

Table 4.11: Amounts of commercial concentrate and mineral supplements offered to lactating cattle in study area

Quantity of concentrate at early lactation (%)

Quantity of Concentrates (kg/day)	Wards				
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
<1 kg	1.0	9.0	2.0	12.0	6.0
1-2 kg	10.0	15.0	11.1	25.0	15.3
2-4 kg	44.0	46.0	49.5	51.0	47.6
4-6 kg	29.0	21.0	29.3	9.0	22.1
6-8 kg	8.0	8.0	6.1	2.0	6.0
None	8.0	1.0	2.0	1.0	3.0

Quantity of concentrate at mid and late lactation (%)

Quantity of Concentrates (kg/day)	Wards				
	Iria-ini (n=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
<1 kg	17.0	21.0	16.4	24.0	19.5
1-2 kg	62.0	68.0	67.2	64.0	65.3
2-4 kg	12.0	10.0	14.5	11.0	11.9
None	9.0	1.0	2.0	1.0	3.3

Quantity of concentrate at Dry Period (last month of Pregnancy) (%)

Quantity of Concentrates	Wards				
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
<1 kg	57.0	59.0	48.3	51.0	53.9
1-2 kg	20.0	21.0	31.3	25.0	24.3
None	23.0	20.0	20.3	24.0	21.8

Other feeds supplements (%)

Feeds Supplements	Wards				
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Mineral block	36.0	17.0	0.0	1.0	13.5
Mineral supplements	53.0	80.0	35.4	35.0	50.85
None	11.0	3.0	64.6	64.0	35.6

*Mineral block: is a mineral block that is given to animal for licking.
Mineral supplements: are macro-elements including calcium, phosphorus, magnesium, potassium, sodium, chloride etc for the well-being of cattle.

4.8.4. Watering methods and frequency

The watering methods and frequency of watering cattle in the study area are shown in Table 4.12. The main watering methods were concrete trough (41.1%) and use of bucket (40.4%). The choice of watering method is dependent on affordability. Construction of water troughs depends on availability and cost of materials (SNV, 2017). It is noted that more dairy farmers in Othaya sub-county had constructed concrete troughs probably a reflection of having access to construction materials. The frequency of watering lactating cows was: 79.4% water *ad lib*, 11.0% twice a day, 5.8% three times and 3.8% provided lactating cows with water once a day. Most of the farmers in the wards in Mathira East and Othaya gave water *ad libitum* to the cattle and there were fairly similar watering systems. This would suggest that the farmers appreciated the importance of water for lactating cattle. Majority of farmers in the study area had access to tap water which was either directed into the concrete troughs or collected from a tap. Kirui (2014) reported that 81.4% of farmers watered their cattle 3 times a day during the dry season in a study conducted in Kosirai in Kenya and Namayumba in Uganda.

Table 4. 12: Watering methods and frequency in the study area.

Methods of watering cattle (%)

Watering Methods	Wards				
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Concrete trough only	45.0	3.0	69.7	47.0	41.1
Bucket only	40.0	56.0	28.3	37.0	40.4
Tap water	7.0	28.0	1.0	0.0	9.0
Using a split tank*	8.0	13.0	1.0	16.0	9.5

* 200litre drum spilt into 2

Frequency of watering lactating cows (%)

Frequency of watering	Wards				
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Once	4.0	2.0	0.0	9.0	3.8
Twice	10.0	13.0	9.1	12.0	11.0
Thrice	6.0	10.0	3.0	4.0	5.8
Ad lib	80.0	75.0	87.9	75.0	79.4

4.9. Management of calves and heifers

4.9.1. Calf Management

Of the interviewed smallholder dairy farmers, only 1.5% weighed the calves at birth while 98.5% did not (Table 4.13). For the small proportion that weighed their calves, the mean weight was 35.0±3.69 Kg with a minimum of 30 and maximum of 40 kg. Birth weight is an indication of physiological maturity of the calf and reflects adequacy or otherwise of preparation of the dam prior to calving. The average expected birth weights for large dairy breeds (Friesian and Ayrshire) in Kenya is reported as 42.5 kg (Wichtel and VanLeeuwen, 2012). In a study in the USA Soberon *et al.*, (2012) reported an average Friesian birth weight of 41.68±5.09. Thus, the calf birth weight in the study area was not far from what was expected. As calves should be fed milk depending on body weight, the implication is that majority of farmers in Mathira East and Othaya sub-counties lack the basis to rationally feed the calves.

Majority of the farmers (75.2%) monitored their calves' growth (Table 4.13). Of these 81.7% used estimates of weight and height to monitor the changes and 18.3% did not monitor the growth of their calves. More farmers monitored the growth of calves in Chinga and Karima wards meaning their farmers understood better calf rearing compared to Magutu and Iria-ini wards (Table 4.3). Dairy calves should be fed milk at 8 to 10% of their body weight thus the need for monitoring their growth (Sweeney *et al.*, 2010).

Table 4. 13: Calf weighing and growth monitoring in study area

Proportion of Respondents Weighing Calves (%)					
	Wards				
Weighing Calves	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karim (N=100)	Mean
No	96.0	99.0	99.0	100.0	98.5
Yes	4.0	1.0	1.0	0.0	1.5
Average Birth Weight					
	N	Min	Max		Mean±SD
Birth Weight	6	30	40		35.0±3.69
Monitoring Growth (%)					
	Wards				
Monitoring	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Yes	49.0	55.0	97.0	100.0	75.2
No	51.0	45.0	3.0	0.0	24.8
Growth Monitoring Methods (%)					
	Wards				
Methods	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Weight and height estimation	78.0	79.0	85.9	84.0	81.7
No monitoring	22.0	21.0	14.1	16.0	18.3

4.9.2. Colostrum feeding and feeding methods

Colostrum feeding and calf feeding methods of calves by respondents are shown in Table 4.14. Colostrum feeding and feeding methods were not significantly different (P>0.05) using Chi Square test. Majority of the farmers (83.5%) fed 2-4 litres of colostrum which are within the recommended amount (Sweeney *et al*., 2010; Lukuyu *et al*., 2012). The method of feeding was mainly bucket feeding (93.0%) which is expected for exotic dairy cows. According to Nafula, (2013), 97.1% of farmers used bucket feeding in Mukurweini Subcounty. It has been reported that bucket feeding is the most commonly used method in commercial dairy farms in Kenya (SNV, 2017).

Table 4. 14: Colostrum feeding and feeding methods of calves in study area

Litres of colostrum/day

	Wards				
Litres of Milk/day	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
1-2 litres	4	4	2	4	3.5
2-4 litres	86	89	79.8	79	83.5
Unknown amount (Suckling)	10	7	18.2	17	13.0

Feeding methods of calves

	Wards				
Feeding Methods	Iria-ini	Magutu	Chinga	Karima	Mean
Suckling	7	8	3	5	5.8
Bucket feeding	92	91	97	92	93.0
Both	1	1	0	3	1.2

4.9.3 Colostrum feeding time

Colostrum feeding time in study area is presented in Table 4.15. Majority of farmers (97.7%) fed the colostrum from 0-6 hours after calving. This implied that most calves were provided with colostrum during the period of maximum absorption of immunoglobulins through the intestinal wall prior to the closure of pores (SNV, 2017). Nafula (2013) in a study conducted in Kenya also reported that majority of farmers (97.7%) fed colostrum in the first six hours of calf 's life. There was similarity in feeding colostrum in all the wards in Mathira East and Othaya sub-counties. A calf should have fed at least 10% of their body weight of colostrum as a common rule, in its first 24 hours of life, preferably half of this within 6-12 hours of birth (SNV, 2017). Good calf rearing depends on sufficient intake of high-quality colostrum within the first day of life and good feeding to promote early rumen development (Goopy and Gakige, 2016).

Table 4. 15: Time of Colostrum feeding after birth in study area

	Feeding Time after Calving (%)				
	Wards				
Feeding Time	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
0-6 hours	99.0	99.0	96.0	97.0	97.7
6-12 hours	1.0	0.0	4.0	2.0	1.8
24 hours and above	0.0	1.0	0.0	1.0	.5

4.9.4. Calf feeding to weaning in study area

Types of feeds fed to calves from one week to one month, amount of milk fed and feeds from one month to weaning at three months are shown in Table 4.16. Most of the farmers (83.2%) fed mainly milk, 7.0% fed milk and calf starter and 9.8% fed milk and forages to their calves from one week to one month. Majority of farmers did not introduce solid feeds to their calves during the first month which is encouraged to hasten rumen development. The average amount of milk fed to calves from one week to one month was 5.17 litres which is within the recommended amount at 10% body weight intake (Lukuyu *et al*., 2012). Between the ages 1-3 months, majority of the farmers (78.2%) fed milk and forages to calves, where the forages were of high quality such as sweet potato vines. The current study shows that the calves were under good nutritional management that would ensure effective rumen development (Ueno *et al*., 2014).

Table 4. 16: Types of calf feeds to weaning in study area

Types of feeds for calves from one week to one month (%)

	Wards				
Feeds	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Milk only	80.0	81.0	83.8	88.0	83.2
Milk and calf starter (pellets)	10.0	5.0	12.1	1.0	7.0
Milk and forages	10.0	14.0	4.0	11.0	9.8

Amount in litres of milk fed to calves from one week to one month.

Wards	N	Mean±SD	SEM	Min	Max
Iria-ini	100	4.69^{a} ±1.372	.137	2	8
Magutu	100	4.55^{a} ±1.373	.137	2	8
Chinga	99	5.67^{b} ±1.300	.131	2	10
Karima	100	5.78^{b} ±1.574	.157	2	9

[a]Means with different superscripts between the wards are significantly different (P=0.00).

Feeds from One Month to three months (%)

	Wards				
Feeds	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Calf Starter and forages*	13.0	8.0	3.0	12.0	9.0
Milk and forages	60.0	84.0	86.9	82.0	78.2
Milk, calf starter and other feeds**	27.0	8.0	10.1	6.0	12.8

*Forages; Maize fodder, Napier grass and Sweet potato vines

**Other feeds; Concentrates and forages

4.9.5. Calf weaning

Time, criteria and method of calf weaning in the study area are shown in (Table 4.17). Majority of farmers (59.6%) weaned calves at 3 months and 36.6% from 3-6 months. This implied that most of the farmers used age instead of weaning weight, a good indicator of proper management. The recommended average weight at weaning for larger breeds (Friesians and Ayrshire) is 80 kg (Lukuyu *et al*., 2012). Majority of the calves are weaned from 12 - 16 weeks (3-4 months) in Kenya (SNV, 2017).

The criteria for weaning were mainly age of the calf (86.0%) and ability of the calf to consume a large amount of forages (9.8%). Sex of the calf was also a criterion used by 1.8% of the farms whereby male calves were sold off as early as 1 week of age when the milk is usually suitable for sale after calving while the rest of the farmers raised male calves to weaning. This is a common practice on commercial dairy farms where AI is used, thus male calves are not required for breeding. The recommended weaning criteria in Kenya are based on the ability of the calf to consume 1.5% of its body weight of dry feeds, attains twice the birth weight and age of the calf (Lukuyu *et al*., 2012; SNV, 2017). In a study conducted in Meru, average daily weight gain of calves was 0.50±0.45 kg/day and mean body weight of 85.2±32.8 kg at weaning time (Kathambi *et al*., 2018). In this study, the weight at weaning was unavailable and thus the growth rate could not be estimated.

An average 94.75% of the farmers used intermittent weaning while 7.8% used the process where they abruptly stop feeding the calf with milk. Majority of farmers chose intermittent weaning to avoid stress that affects the calf after abrupt weaning. Abrupt weaning was practiced mainly in Karima ward of Othaya sub-county compared to other wards probably due to insufficient training of farmers on good calf management practices (Table 4.3). According to Sweeney *et al*., (2010), calves fed large amounts of milk and weaned at 6thweek of age, by gradually decreasing the milk allowance over a period of 10 days, resulted in the best general weight gains.

Table 4. 17: Weaning age, criteria and method of calves in the study area

Weaning age (%)					
	Wards				
Weaning Time	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
<3 Months	2.0	1.0	1.0	2.0	1.5
3 Months	48.0	42.0	67.7	81.0	59.6
3-6 Month	48.0	55.0	27.3	16.0	36.6
6-9 Months	2.0	2.0	4.0	1.0	2.3
Weaning Criteria (%)					
	Wards				
Weaning Criteria	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Age of the calf	71.0	94.0	93.9	85.0	86.0
Sex of the calf	2.0	4.0	1.0	0.0	1.8
Ability to consume large amounts of forage	23.0	2.0	3.0	11.0	9.8
Weight estimation	4.0	0.0	2.0	4.0	2.5
Weaning Process %					
	Wards				
Weaning Process	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Immediate cessation	3.0	7.0	0.0	11.0	5.25
Intermittent cessation	97.0	93.0	100.0	89.0	94.75

4.9.6 Diseases affecting calves

The problems affecting calves, common calf diseases and their control measures are shown in Table 4.18. The main constraints to calf rearing as perceived by respondents were diseases, inadequate feeds and poor housing (52.4%, 7.8% and 2.5% respectively). About 37.3% of farms did not report any problem affecting their calves. The common diseases affecting calves were calf scours, pneumonia, anaplasmosis and east coast fever (ECF) as reported by 32,6%, 16%, 4.5% and 5.8% of respondents respectively. The high incidences of calf scours in the study areas were attributed to calves being housed in unhygienic conditions as well as use of plastic feeding equipment which are difficult to clean effectively as observed in the study sites. Approximately 41.1% of farms had not experienced incidences of diseases, an indication of good calf management practices as reported by the respondents. Again, it is noted that the highest proportion of respondents who reported no disease incidences was in Othaya sub-county. In a study conducted in Mukurweini subcounty, 37% of the farms also reported calves suffering from diarrhoea (VanLeeuwen *et al*., 2012; Peter *et al*., 2016). On 31.1% of the farms, diseases occurred after weaning while for 12.0% this was at 2-4 weeks of age. The high incidence of diseases (scours, pneumonia, ECF) after weaning implied that some calves were poorly managed; leading to stress and diseases. The main causes of calf death were diseases of the alimentary tract (31.3%); mainly gastroenteritis (70.4%) due to colibacillosis, salmonellosis, coccidiosis and helminthiasis, and bloat (18.5%). Mulei *et al*., (1995), reported other major causes of calf mortality as diseases of the respiratory tract (1 6.8 %); mainly pneumonia (72.4%), and east coast fever (ECF) (80.4%).

Vaccination was the main method of disease control (50.9%), hygienic and proper feeding of colostrum and milk (23.8%), through tick control (19.0%) and deworming (6.3%). Attention to proper management and feeding, hygienic conditions and improved health care of dairy neonates is recommended for reduced morbidity and mortality (Megersa *et al*., 2009).

Table 4. 18: Problems Affecting Calves in the study area (%)

	Wards				
Problems	Iria-ini	Magutu	Chinga	Karima	Mean
	(N=100)	(N=100)	(N=99)	(N=100)	
Diseases	65.0	76.0	29.3	39.0	52.4
Inadequate feeds	5.0	11.0	4.0	11.0	7.8
Poor housing	0.0	0.0	7.1	3.0	2.5
None	30.0	13.0	59.6	47.0	37.3
Common Calf Diseases					
	Wards				
Common Calf Diseases	Iria-ini	Magutu	Chinga	Karima	Mean
	(N=100)	(N=00)	(N=99)	(N=100)	
Calf scours	29.0	51.0	25.3	25.0	32.6
Pneumonia	33.0	21.0	4.0	6.0	16.0
Anaplasmosis	8.0	5.0	4.0	1.0	4.5
East Coast Fever	3.0	2.0	4.0	14.0	5.8
None	27.0	21.0	62.6	54.0	41.1
Age of Diseases Occurrence					
	Wards				
Age	Iria-ini	Magutu	Chinga	Karima	Mean
	(N=100)	(N=100)	(N=99)	(N=100)	
1-2 weeks	5.0	2.0	4.0	9.0	5.0
2-4 weeks	16.0	22.0	7.1	3.0	12.0
4-8 weeks	5.0	14.0	3.0	12.0	8.5
8-12 weeks	9.0	5.0	3.0	2.0	4.8
After weaning	34.0	38.0	27.3	25.0	31.1
None	31.0	19.0	55.6	49.0	38.6
Control of calf diseases (%)					
	Wards				
Control	Iria-ini	Magutu	Chinga	Karima	Mean
	(N=100)	(N=100)	(N=99)	(N=100)	
Proper feeding of colostrum and milk	4.0	1.0	69.7	21.0	23.8
Vaccination	59.0	60.0	22.2	62.0	50.9
Tick control	32.0	32.0	1.0	11.0	19.0
Deworming	5.0	7.0	7.1	6.0	6.3

4.9.7 Calf housing

The presence of calf house, type of floor and bedding materials are shown in Table 4.19. A majority of 87.0% of the respondents housed their calves with 69.7% of the houses having earthen floor, 22.3% concrete floor and only 8.0% with slated floor. Type of floor used by a farmer has been associated with calf diseases such as diarrhoea and pneumonia as it determines ease of cleaning. According to SNV (2017), the floor of calf house should be made with concrete for ease of cleaning. Straws and grass bedding were used by 47.4%, of the respondents, 18.0% wood shavings and sawdust and 1.8% used calf mattresses while 32.8% had none. Well managed bedding can improve cleanliness and health of the calf. In the study site, calf houses were dirty with slurry for the farmers that had earthen flour without bedding. Kiugu (2018), reported dirty calf pens, especially of concrete or wooden floor plus poor bedding material management in his study in dairy farms in Meru, Kenya.

Table 4. 19: Presence of calf house, types of floor and bedding in study area.

Calf housing (%)

	Wards				
House	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
No	15.0	18.0	4.0	15.0	13.0
Yes	85.0	82.0	96.0	85.0	87.0

Types of floor (%)

	Wards				
Floor Types	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Concrete	18.0	13.0	33.3	25.0	22.3
Earth floor	77.0	68.0	61.6	72.0	69.7
Slated	5.0	19.0	5.1	3.0	8.0

Bedding materials (%)

	Wards				
Bedding Materials	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Wood shavings and sawdust	1.0	44.0	15.2	12.0	18.0
Calf Mattresses	1.0	1.0	2.0	3.0	1.8
Straws and grasses	71.0	29.0	51.5	38.0	47.4
None	27.0	26.0	31.3	47.0	32.8

4.10. Heifer Feeding and management

4.10.1. Feeds

The types of feeds fed to growing heifers are shown in Table 4.20. Majority of farmers (58.6%) fed forages and concentrates to their heifers with 16.8% feeding forages only. Most of the farmers fed heifers with Napier grass and supplemented with concentrates like dairy meal, maize germ and Desmodium. Napier grass (fresh or silage) was of poor quality due to late harvest (Table 4.8). Supplementation was done to improve feed quality for healthy growth and performance of heifers. However, some farmers fed poor quality forages without supplementation, leading to poor body condition of the heifers which could adversely affect age at first calving and first lactation milk production. Higher proportion of farmers in Magutu ward fed their heifers exclusively with forages compared to the other wards as the farmers indicated, the high cost of supplements. Chinga recorded the highest proportion at 72.7% of respondents feeding heifers on forages supplemented with concentrates. In a study in Meru, Makau *et al*., (2018) reported that 90% of farmers fed heifers on Napier grass and 64.6% supplemented the forage with dairy meal. They recommended supplementation of heifers with concentrate during the dry season to achieve optimum growth. Provision of poor-quality feed during the dry season can reduce skeletal growth and weight gain (Lukuyu *et al*., 2012; Makau *et al*., 2018).

Table 4. 20: Types of feed fed to heifers in study area

Feeding of Heifers (%)					
	Wards				
Feeding	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Pasture only	4.0	12.0	0.0	1.0	4.3
Pasture and concentrates	8.0	19.0	3.0	3.0	8.3
Forages	23.0	26.0	2.0	16.0	16.8
Forages and concentrates	62.0	39.0	72.7	61.0	58.6
Pasture, concentrates and forages	3.0	4.0	22.2	19.0	12.0

4.10.2 Constraint to heifer rearing

Constraints encountered during heifer rearing included disease occurrence (26.8%), inadequate feeds (17.3%) and infertility (16.0%) while 39.9% reported no problems (Table 4.21). Health problems could be associated with poor feeding regimes from early age leading to lower immunity against diseases and delayed first heat. Prolonged underfeeding of heifers can lead to infertility. Heifers which are underfed as young calves are at higher risk of diseases or never become productive (Johnson *et al*., 2011; Makau *et al*., 2018). According to Windeyer *et al*., (2014), calf-hood diseases affect subsequent heifer survival, productivity, economic value and welfare in a dairy farm.

Table 4. 21: Problems and control measures during heifer rearing in study area
Problems facing heifers (%)

	Wards				
Problems	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Infertility (delayed first pregnancy)	29.0	24.0	3.0	8.0	16.0
Diseases	38.0	36.0	27.3	6.0	26.8
Inadequate feeds	13.0	29.0	3.0	24.0	17.3
None	20.0	11.0	66.7	62.0	39.9

Measures to Control problems (%)

	Wards				
Control	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Supplementation with mineral salt	18.0	24.0	1.0	1.0	11.0
Vaccination, deworming & Tick control	60.0	56.0	60.6	17.0	48.4
Sell stock and culling	6.0	2.0	1.0	1.0	2.5
Grazing at road sides	4.0	5.0	17.2	2.0	7.0
Repeated insemination and Natural mating	3.0	2.0	0.0	20.0	6.3
None	9.0	11.0	20.2	59.0	24.8

The measures taken to alleviate these problems associated with raising heifers emphasize focus on diseases in the area either by the farmers or the services providers. A majority of respondents (48.4%) practiced vaccination, deworming and tick control. Higher proportion of farmers in the Othaya based wards had fewer problems raising their heifers and not surprisingly a higher proportion of those who took no measures (Table 4.21). Proper heifer management and feed conservation could reduce the problems of worms' infestation, inadequate feed and infertility. The rate of repeat inseminations and usage of bulls was high in Karima ward compared to other wards probably an indication of poor feeding and management of heifers. According to study conducted in Kenya by Lukuyu *et al*., (2012), improved heifer feeding and management can lead to high conception rate, good health and performance.

4.11. Reproductive performance of heifers

The age at first service (AFS) varied among respondents. 37.8% served their heifer at 15-18 months, 32.1% at 18-20 months, 24.1% above 20 months (Table 4.22**)**. However, in all the wards the majority of heifers were served by 20 months of age. Majority of farmers in Chinga and Karima served heifers at 18-20 months compared to Iria-ini and Magutu. This can be attributed to differences in heifer management between the sub-counties. The age at first service (AFS) in peri-urban areas of Eastern Kenya was reported as 25.1 ± 8.7 months (Mungube *et al*., 2014). In Malawi, Watanabe *et al.*, (2017), reported mean age at first service as 25.2 ± 9.5 (mean±SD) months in small scale dairy farms. The age at first service is not always related to age at first calving as the first service may not result in a conception. Heifers are expected to be first inseminated at 14 to 15 months at body weight of more than 350 kg for larger breeds (Friesians and Ayrshire), to attain first calving of about 24 months (Antov *et al*., 1998). The age at first service was too long in the study area compared to the recommended AFS of 14-15 months (Novakovic *et al.*, 2011). The long AFS was attributed to poor heifer management.

Table 4. 22: Reproductive performance and growth monitoring of heifers

Age at First Service (%)

Age at First Service	Wards Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
15-18 months	54.0	52.0	26.3	19.0	37.8
18-20 months	24.0	31.0	39.4	34.0	32.1
20 months and above	20.0	17.0	27.3	32.0	24.1
Never came on heat	2.0	0.0	7.1	15.0	6.0

Age at First Calving in Months

Wards	N	Mean±SD	SEM	Min	Max
Iria-ini	100	28.46[a] ± 2.434	.245	25	36
Magutu	100	28.03[a] ±2.298	.230	26	34
Chinga	99	28.37[a] ±3.295	.345	24	36
Karima	100	29.02[a] ±3.270	.355	25	37

[a]Means with no/similar superscripts are not significantly difference between the Wards (P>0.05)

Monitoring of Heifer Growth (%)

Monitoring of Heifer	Wards Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
No	41.0	42.0	5.1	12.0	25.1
Yes	59.0	58.0	94.9	88.0	74.9

Monitoring Criteria of heifer growth (%)

Wards Monitoring Criteria	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Weight and height estimation	44.0	55.0	81.8	88.0	67.2
No monitoring	56.0	45.0	18.2	12.0	32.8

The Age at First Calving (AFC) ranged from 25 to 36 months in the study sites with average of 28.45±2.844 months which was not significantly difference between the Wards (P>0.05) as shown in Table 4.22. However, the Age at first calving (AFC) in the study site was lower than the 36 months reported in Kenya Highlands (Lanyasunya *et al*., 1999; Bebe *et al*., 2003). A study in Malawi reported an even later age at first calving of 43.4 ± 13.8 months (Watanabe *et al.,* 2017).

Monitoring heifer growth is a good strategy to evaluate adequacy or otherwise of management and especially the feeding. In the current study, 74.9% of respondents monitored heifer growth mainly through weight and height estimation (67.2%) while 32.8%

did not use recommended method for growth monitoring but only use observation (Table 4.22). In order to avoid late first calving, heifer growth should be monitored to allow adjustment in feeding program to allow an average AFC at 24 months (Wathes *et al*.,2014).

4.12. Reproductive Performance of the dairy cows

The number of services per conception (SPC) and calving interval (CI) are shown in Table 4.23. The proportion of farmers that had their cows inseminated once were 58.6%, twice were 33.3%, thrice were 6.0% and four times were 2.0%. Number of services per conception is a measure of cow fertility and efficiency of the breeding system. Farmers in Karima ward of Othaya sub-county reported the highest conception rate at 66% after first service. This high performance could be attributed to the age of farmers where majority of them in Karima ward were 55 years and above (Table 4.1.). The older farmers were reported to be more accurate in heat detection and AI timing, resulting into successful conception compared to younger farmers (Gitau, 2013; Mutavi and Amwata, 2018). Similarly, the results in the current study agreed with Rukundo, (2018), who reported a 58.6% first service conception rate for small scale farmers in Rwanda.

According to Diskin, (2008), heat detection efficiency relies on the ability and commitment of the person responsible in identifying the signs of heat before artificial insemination. Number of services per conception (SPC) is one of parameters used for estimating dairy animal's reproductive performance and is affected by breeding method being higher in free natural breeding and lower in places in which artificial insemination is utilized (Melaku *et al*., 2011). Good nutrition also leads to high rate of conception (Table 4.7.). More farmers in Karima ward fed their cattle on forages, concentrates and mineral salts which may explain the low SPC compared to other wards in the study area. Nutrition has been shown to be a vital factor affecting fertility and conception in dairy cattle (Santos, 2008; Tesfaye *et al*., 2015).

The mean of calving interval in the study area was 15.22±5.11 months (Table 4.23.). The mean between the wards were not significantly different (P>0.05). However, CI in the current study was shorter than calving intervals of 21.1 months reported in Kenya (Bebe *et al* 2003). A more recent study reported a lower CI of 13.6 ± 2.9 months in per-urban areas of Eastern Kenya (Mungube *et al*., 2014) compared to 15.22±5.11 months in the current study. The recommended CI of 12 months (365 days) would ensure that a cow gives a calf every year (Kollalpitiya *et al.,* 2012). The length of CI measures the productivity of dairy cow in term of calf crops and milk yield in a lifetime. It is affected by factors such as nutrition, quality of semen, knowledge of farmer and AI technicians and reproductive health of the cow. The current finding concurred with the results by Wondossen *et al*., (2018) who reported an average calving interval of 469.2 ± 7.9 days (15.64±0.26 months) in Ethiopia. Calving interval in the current study is longer than 12 months could be explained by inadequate feeding due to feeds scarcity and poor management practices (Table 4.29).

Table 4. 23: Reproductive Performance of dairy cows in the study area

Number of Services per Conception (%)					
	Wards				
Number of Services	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
One	57.0	57.0	54.5	66.0	58.6
Two	38.0	33.0	36.4	26.0	33.3
Three	5.0	7.0	6.1	6.0	6.0
Four	0.0	3.0	3.0	2.0	2.0
Calving Interval in Months					
Wards	N	Mean±SD	SEM	Min	Max
Iria-ini	100	15.71±5.80[a]	.5804	12.0	31.0
Magutu	100	14.14±3.36[a]	.3355	12.0	24.0
Chinga	99	15.62±5.08[a]	.5110	12.0	30.0
Karima	100	15.41±5.74[a]	.5739	12.0	31.0

[a]Mean with the same Superscripts between the Wards are not significantly different (P=0.106)

4.13. Breeding Systems

The breeding systems practiced in the study area were artificial insemination (AI) and natural mating and the results are shown in Table 4.26. Most of smallholder dairy farmers used AI (94.5%) with only 3.5% using natural mating. This implied that most of the farmers know the importance of AI such as reduction in reproductive diseases and the cost of maintaining a bull. Breeding systems do not differ significantly at 0.05 confidence level using Chi Square test. This concurred with observations in Meru County where AI services were readily available and used by majority of smallholder farmers (Muraya *et al*., 2018)

Artificial Insemination was provided by private institution (70.7%), government (18.8%), more than one provider (8.0%) and dairy cooperatives (2.5%). There was no significant difference (p>0.05) between the wards in AI provision in the study area. The higher usage of private AI technicians was attributed to ease of accessibility by the farmers when their cows were on heat. Similarly, Muraya *et al*., (2018), reported that AI services were mainly provided by private AI technicians in Meru County.

Table 4. 24: Breeding Systems and AI providers in study area

Breeding Methods (%)					
	Wards				
Breeding Methods	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Artificial insemination (AI)	98.0	94.0	94.0	92.0	94.5
Natural mating	2.0	3.0	6.1	3.0	3.5
Both	0.0	3.0	0.0	5.0	2.0

Artificial Insemination (AI) providers (%)					
	Wards				
AI Providers	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Government	30.0	22.0	6.1	17.0	18.8
Private institution	61.0	70.0	80.8	71.0	70.7
Cooperatives	1.0	4.0	1.0	4.0	2.5
More than one provider	8.0	4.0	12.1	8.0	8.0

More than one provider involved government, private institutions and cooperatives.

4.14. Productive Performance of lactating cows

The daily milk yield (MY) and lactation length (LL) in the study farms is shown in Table 4.24. Of the study farms, 37.4% of the cows produced 5-10 litres, 24.6% 10-15 litres and 15.8% 15-20 litres of milk per day. A larger proportion of farmers reported higher milk yield per cow in Othaya (Chinga and Karima) than Mathira East subcounty (Iria-ini and Magutu). This difference was attributed to good feeding regimes in Othaya where more farmers feed combination of roughages, concentrates and minerals than in Mathira East subcounty (Table 4.7). Trained farmers are more informed on the effects of quality and quantity of feeds on milk production. The big variation in the amount of milk produced in the farms is an indication of the different levels of quality and quantity of feeds in the farms (Table 4.9&Table 4.11). Breed contributed to more milk in litres reported in Othaya subcounty as there were more Friesians than in Mathira East subcounty of Nyeri County (Table 4.5).

Njonge, (2017) in a similar study on smallholder dairy farmers in Kirinyaga County, reported that 25% of farmers recorded yields of > 8 litres per day, 15% 4- 8 litres and 60% 1-4 litres per day. In the current study, the average milk yield in litres/day was 10.7±5.9. Using the daily milk production for the different wards, the 305 days lactation yield would range from 1464 to 5063 litres/year to average of 3263.5 litres/year. The milk yields were significantly different between the wards P<0.05). KDB, (2016) reported average milk production ranging from 7-9 litres/cow/day in Kenya compared to 19 litres of milk/cow/day in South Africa.

The lactation length ranged from 6 to 26 months with the average of 10.0±4.9 months (300±147 days). Lactation lengths were significantly different between the wards in the study site (P<0.05). For calving interval of 365 days to be realized, a dairy cow should have a lactation length of 305 days. The average lactation length in the study area was about 300 days which would be similar to this standard. However, the lactation length varied from 7.48± to 12.48±5.73 months. This was lowest for Magutu and highest for Karima (Table 4.24). The short lactation length could be explained by poor feeding of dairy cow during early lactation and probably during last two months of gestation, dry period, when the cow builds up body reserves to support high milk production in subsequent lactation (Wafula, 2018). The resulting low amounts of milk production prompted some farmers to dry their cows within 5 months of lactation (Table 4.29). Wafula, (2018) reported a similar average lactation length of 300 days in Meru County. He further observed that milk yield and lactation length were influenced by good management, feeding, herd fertility management, calf rearing and health of the cows.

Table 4.25: Productive Performance of dairy cows in study farms

Milk Yield in litres					
	Wards				
Milk Yields	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
1-2 litres	3.0	2.0	2.0	4.0	2.8
2-5 litres	18.0	22.0	9.1	14.0	15.8
5-10 litres	40.0	42.0	37.4	30.0	37.4
10-15 litres	26.0	19.0	26.3	27.0	24.6
15-20 litres	9.0	9.0	14.1	14.0	11.5
20 and above	4.0	6.0	11.1	11.0	8.0

Milk Yields litres/day at the Farm Level

Wards	N	Mean±SD	SEM	Min	Max
Iria-ini	100	9.77±4.99[a]	.504	2	25
Magutu	100	9.82±5.92[a]	.595	2	30
Chinga	99	12.25±6.16[c]	.619	2	31
Karima	100	10.94±5.97[b]	.603	2	31

Mean with different superscripts are significantly different between the Wards at (p<0.05)

Lactation Length (months)

Wards	N	Mean±SD	SEM	Min	Max
Iria-ini	100	8.09±2.69[a]	.2687	6.0	18.0
Magutu	100	7.48±1.79[a]	.1789	6.0	19.0
Chinga	99	11.98±5.78[b]	.5811	7.0	33.0
Karima	100	12.48±5.73[c]	.5734	7.0	34.0

[a]Means with different superscripts between the Wards are significantly different (p<0.05)

4.15. Factors associated with reproductive and productive performance in the study area

Factors affecting milk production, calving interval and age at first service in the study area are shown in Table 7. Milk production was positively associated (coefficient .247) with quantity of concentrate fed at early lactation. Breeds of cattle and diseases were negatively associated (-.059 and -.081) with milk production level. Milk production and quantity of concentrate fed during early lactation were significantly (p<0.05) related. Muia *et al*., (2011) suggested the variation in production was a result of differences in availability of animal feeds, variation in livestock genotypes and farming system that was enhanced by agro-ecological zones. Good feeding of heifers was positively correlated (.254) with age at first service then breeds and diseases which were negatively associated. There was significant ($p<0.05$) association between feeding heifers and age at first service. Proper management of heifers can reduce age at first service and improve productivity (Watanabe *et al*., 2017). Calving interval was positively correlated (.018) with quantity of concentrate fed at mid and late lactation and negatively associated with other factors. Association between calving interval and quantity of concentrate fed during the mid and late lactation was non-significant ($p<0.05$). The prolonged CI in cows is associated with insufficient feeding, poor heat detection, herd health, the unreliability of artificial insemination and /or bull services and the lack of dairy farm records for correct decision making (Moges 2012; Duguma et al 2012; Mungube *et al*., 2014).

Table 4.26: Linear Regression Model Results of Factors Affecting Reproductive and Productive Performance in Nyeri County.

Variables	Std. Error	Coefficient	*P*-Value
Milk Production			
Breeds of Cattle	.143	-.059	.230
Quantity of concentrate at early lactation	.410	.247	.001
Quantity of concentrate at mid and late lactation	.401	.032	.663
Diseases Control Measures	.251	-.081	.095
Age at first service			
Breeds of Cattle	.023	-.068	.171
Diseases Control Measures	.040	-.041	.399
Feeding of Heifers	.046	.254	.000
Calving Interval			
Breeds of Cattle	.129	-.064	.203
Quantity of concentrate at early lactation	.372	-.032	.674
Quantity of concentrate at mid and late lactation	.365	.018	.817
Diseases Control Measures	.227	-.042	.399
Number of observations	399		
Confidence Level	.05		

4.16. Milk Marketing

The farm gate price per litre of milk and the buyers are shown in Table 4.25. Majority of the farmers (95.5%) sold their milk at a price range from Ksh 30-40 ($ 0.28-0.37) per litre and only a small proportion (4.5%) sold their milk at a higher price from Ksh 40-50 ($ 0.37-0.46) per litre. Most farmers (42.6%) sold their milk to cooperatives and processors at lower prices in their milk collection centres with installed milk coolers probably because they were assured of a market for their milk. The milk collection centres were also located in all the wards close to the farmers. A small proportion of farmers (26.8%) sold their milk to neighbours and local hotels at higher prices. An additional advantage of farm gate sales was that there was no cost of transportation and storage of milk. Producers would also pay cash by neighbours and local hotels unlike the formal market where farmers are paid monthly by processors. There was similarity among the wards in the study area in term of selling price. The farmers who sell their milk to cooperatives and processors complained about low prices compared to high cost of animal feed. Farmers suggested that, prices of milk should be based on the cost of production for them to realize a profit. The milk buyers in the study area were mainly Processors (22.8%) and Dairy Cooperatives (19.8%). The findings of this study agreed with Wafula, (2018), who reported that processors and cooperatives are the main buyers of smallholder dairy farmers' milk in Meru County.

Table 4. 27: Farmgate milk price and buyers in the study area Farmgate price per litre (%)

	Wards				
Price	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
30-40 Kshs	96.0	99.0	91.9	95.0	95.5
40-50 Kshs	4.0	1.0	8.1	5.0	4.5

Milk Buyers (%)

	Wards				
Milk Buyers	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Neighbours	17.0	13.0	10.1	21.0	15.3
Local shops/hotels	18.0	17.0	2.0	9.0	11.5
Middlemen	23.0	19.0	2.0	15.0	14.8
Processors	1.0	5.0	56.6	29.0	22.8
Dairy cooperatives	20.0	36.0	15.2	8.0	19.8
More than one buyer	21.0	10.0	14.1	18.0	15.8

More than one buyer included Processors, Neighbours, Middlemen, Dairy Cooperatives etc.

4.17. Dairy Cattle Diseases

The common diseases of cattle and control measures are shown in Table 4.27. The most common diseases reported by dairy farmers included anaplasmosis (44.1%) and mastitis (26.1%) in the study area. The high cases of anaplasmosis in Mathira East (Iria-ini and Magutu) indicated that majority of farmers had not taken tick control seriously. Diseases like diarrhoea, mastitis and milk fever are associated with great decline in milk production (Bareille *et al.* 2003). The very costly disease in milk production is mastitis (Seegers *et al.*,2003). Mastitis causes include mainly interaction between management practice and infectious agents, however, with other factors, such as genetics, udder shape or climate. (Awale *et al.,* 2012).

To mitigate against diseases, dairy farmers should put in place control measures such as vaccination (59.6%), controlling endo- and ectoparasites (30.1%) (Table 4.27). The fact that only 2.0% of the farmers had not carried out any disease control measures in the last two months suggests that the farmers appreciated the consequences of disease would have on productivity of the animals (Table 4.27). According to Rukundo (2018), most of the farmers in Rwanda regularly used disease control measures such as vaccination, deworming and spraying against ticks.

Table 4. 28: Common Dairy Cattle Diseases and control measures in study area

Common Cattle Diseases (%)

	Wards				
Cattle Diseases	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Anaplasmosis	49.0	64.0	38.4	25.0	44.1
Milk fever	3.0	0.0	2.0	2.0	1.8
Mastitis	17.0	22.0	40.4	25.0	26.1
Abortion	1.0	1.0	1.0	5.0	2.0
Lumpy Skin Disease	6.0	7.0	2.0	1.0	4.0
Foot rot	1.0	1.0	2.0	0.0	1.0
None	23.0	5.0	14.1	42.0	21.1

Diseases Control Measures (%)

	Wards				
Control Measures	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Vaccination	50.0	52.0	86.9	50.0	59.6
Controlling parasites	39.0	36.0	3.0	42.0	30.1
Mineral supplementation	2.0	1.0	2.0	0.0	1.3
Proper feeding	3.0	0.0	6.1	5.0	3.5
Maintaining hygiene	5.0	9.0	0.0	0.0	3.5
None	1.0	2.0	2.0	3.0	2.0

4.18. Cattle Housing

Cattle housing, types of floor and types of bedding are shown in Table 4.28. Of the respondents, 96% housed their cattle with only 4% keeping their cattle in open bomas with no roof. The farmers who housed their dairy cattle had the advantage of better feeding management, clean milk production, efficient use of land, good calf rearing, effective heat detection, manure and urine collection among others. In a study conducted around Nairobi, it was reported that 83.80% of farmers housed their cattle (Aleri *et al*., (2012).

The floors in the cattle houses were either concrete (65.9%) or earthen (34.1%). Majority of farmers had houses with concrete floors in all the wards which implied that they were willing to invest more capital in housing. According to SNV, (2017), houses with concrete floor are expensive thus farmers use earthen floor with straw bedding to reduce cost. The types of bedding provided by farmers to their cattle were; straws and grasses (21.6%), wood shavings and sawdust (13.0%) and cow mattresses (7.0%) while 58.4% of farmers had cattle lying on the concrete floor. Housing cattle on concrete floor is thought to negatively influence the health of the legs and feet of cattle due to its inflexible nature. Providing a softer layer of rubber on the concrete surface was reported to reduce leg and claw lesions compared with concrete or wood flooring alone (Vokey *et al*., 2001). Abrasion on concrete surfaces or collision with stall partitions of the hocks and knees appears to cause injury to the cattle when they lie down and stand up. Usually, sand, sawdust, or straw bedding in stalls cause less damage to joints than mats (Wechsler *et al*., 2000).

Table 4. 29: Cattle Housing, floor and bedding types in study area

House for Cattle (%)

House	Wards Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
No	3.0	10.0	0.0	3.0	4.0
Yes	97.0	90.0	100.0	97.0	96.0

Types of Floor (%)

Floor Types	Wards Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Concrete	75.0	58.0	67.7	63.0	65.9
Earthen Floor	25.0	42.0	32.3	37.0	34.1

Types of Bedding (%)

Bedding Types	Wards Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Cow mattresses	7.0	5.0	8.1	8.0	7.0
No bedding	58.0	65.0	47.5	63.0	58.4
Wood shavings and sawdust	10.0	17.0	9.1	16.0	13.0
Straws and grasses	25.0	13.0	35.4	13.0	21.6

4.19. Challenges to dairying and coping mechanisms in study area.

The challenges and coping mechanisms in smallholder dairy farms in the study area are shown in Table 4.29. The major challenges for smallholder dairying in the study sites included fodder/feeds shortages (30.6%) and related to this the high cost (17.8%) as well as low quality of feeds (7.3%) then low milk prices and poor marketing (28.3%).

The shortage of feeds was especially acute during the dry season as noted at the time of data collection which resulted to low milk production. Low prices of milk were also a major constraint faced by farmers due to the high cost of concentrate feed. More farmers in Karima ward of Othaya sub-county cited marketing as a constraint than the other wards as prices were low and processors (buyers) took long to pay. Dairy farmers in Kirinyaga County reported that, the major problems they faced were feed shortages (77 %), land availability (10 %), diseases (6.3%), and worms (5.4%) (Njonge, 2017).

The losses from diseases could have been through low fertility, involuntary culling, a reduced feed intake thus lower milk production, treatment costs and mortality in heavily parasitized animals (Mceod, 1995). The impacts of these infections, even when the worm load is mild, can be increased by other factors which lead to stress, such as frequent drought or concurrent infections which may be existing in such areas. These low levels of infection have been reported as the most economically important form of infection that may cause unthrifty animals which become easily prone to other infections (Ocaido *et al.*, 1996).

Nevertheless, farmers came up with various coping mechanisms to overcome these challenges including purchase of fodder and crop residues (42.1%), renting land for fodder production (21.1%), selling milk to neighbours, middlemen and shops (11.3%), consulting veterinarians (10.8%). Other coping strategies adopted by some farmers are shown in Table 4.29. Rukundo (2018) reported that farmers fed crop by products, reduced amount of feeds, purchased fodder and crop residues during the periods of feeds shortages to cope with the challenges.

Table 4. 30: Challenges and coping mechanisms in Smallholder Dairy Farming (%)

Challenges	Wards				
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Fodder and feeds shortages	26.0	37.0	39.4	20.0	30.6
High cost of feeds	18.0	25.0	22.2	6.0	17.8
Silent heat and infertility	0.0	2.0	5.1	8.0	3.8
Low quality feeds	6.0	2.0	5.1	16.0	7.3
Low farmgate milk prices	30.0	22.0	17.2	44.0	28.3
Livestock diseases	18.0	10.0	9.1	3.0	10.0
Lack of training in dairy management	2.0	2.0	2.0	3.0	2.3

Coping mechanisms (%)

Coping	Wards				
	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Renting land for fodder production	14.0	28.0	27.3	15.0	21.1
Supplementation with mineral salts	1.0	0.0	4.0	0.0	1.3
Homemade dairy meal	7.0	1.0	4.0	1.0	3.3
Substitution of commercial feeds with fodder	8.0	6.0	2.0	3.0	4.8
Purchase of fodder	38.0	37.0	32.3	61.0	42.1
Provide less feeds and crop residues	4.0	6.0	2.0	0.0	3.0
Consult Veterinarian (Vet)	11.0	12.0	15.2	5.0	10.8
Selling milk to neighbours, middlemen and shops	11.0	9.0	11.1	14.0	11.3
Selling stock, culling and changing AI providers	6.0	1.0	2.0	1.0	2.5

4.20. Benefits of Smallholder Dairy Production

The benefits of smallholder dairy production were food security, income, manure and biogas and employment (Table 4.30). Majority of dairy farmers ranked food security as the main purpose of dairy farming (46.9%) followed by manure and biogas (28.1%), household income (20.3%) and employment (4.8%).

The main purpose of keeping dairy cattle by smallholder farmers was food security as part of the milk produced was consumed by the household. Majority of farmers in Othaya sub-county (Chinga and Karima) prioritized food security whereas farmers in Mathira East sub-county prioritized manure and biogas. Farmers in Mathira East mainly used manure as fertilizer on crop fields and to produce biogas for cooking. Similarly, FAO, (2018), reported the benefits of smallholder dairying as enhanced milk consumption, increased crop production through use of cow manure, increased revenues from sales, all of which can enhance food security and nutrition. Smallholder dairying is usually practice in many parts of the developing countries, including Ethiopia, providing nutritional source and income to millions of households (World Bank, 2011). As being potential source of income and employment generation to smallholder dairy farmers through high-value dairy products, hence development of the dairy industry in Ethiopia haas the potential to contribute significantly to poverty reduction and improve nutrition in the country (Staal *et al*., 2001).

Table 4. 31: Benefits of Smallholder Dairy Farming in the study area

	Wards				
Benefits	Iria-ini (N=100)	Magutu (N=100)	Chinga (N=99)	Karima (N=100)	Mean
Food Security	15.0	16.0	87.9	69.0	46.9
Income	31.0	34.0	6.1	5.0	19.0
Manure and Biogas	52.0	45.0	1.0	14.0	28.1
Employment	2.0	5.0	5.1	12.0	6.0

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The research was carried out to evaluate feed resources, management of young and growing stocks, reproductive and productive performance of the dairy cattle under small scale farms in Nyeri County, Kenya. The conclusion was that;

1. There were feed shortages in the study site aggravated especially during the dry period and was attributed to small landholdings and poor forage management. Supplementation with concentrates was insufficient.
2. The age at first service (AFS) and age at first calving of dairy heifers were longer than expected in the study area which could be attributed to poor feeding and management as feed shortages were observed.
3. Both reproductive and productive performance of the dairy cattle were poor in the research area. The long calving interval, more services per conception and low milk yield per cow per day were attributed to feed shortages.

5.2. Recommendation

As of the current findings, I made the following recommendations:

1. There is need for government and other stakeholders to intervene in solving feed shortages in the study site through training farmers on feed conservation and feeding of dairy cattle.
2. There should be training of farmers on dairy management, nutrition, breeding, and disease control to maximize productivity. Farmers should also be trained on how to keep farm records for good management and decision making.

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APPENDICES

Appendix 1: Smallholder dairy farmers' questionnaire

INTRODUCTION

This questionnaire is on the evaluation of Dairy Cattle Productivity in Smallholder Farms in Nyeri County. The survey will target smallholder dairy farmers in Mathira East and Othaya Sub-counties.

SECTION A: Effects of demographic characteristics on dairy performance.

Start with identification of farmer, location of farm and contact of farmer.

Questionnaire number……………………... Date……………………….

Name of enumerator……………………… Contact……………………….

Name of sub –county/Wards/Location…………………………………………………

1. Name of the farmer……………………………………………………………...
2. Contact of the farmer…………………………………………………………….
3. Gender of the farmer

Male ☐ b. Female ☐

4. Marital status?

a. Married☐ b. Single ☐ c. Divorced ☐ d. Widow(er) ☐

5. Tel. number of respondents……………………………………………
6. Gender of respondent

a. Male☐ b. Female ☐

7. Education level of the farmer?

a. Primary level and below ☐ b. Secondary ☐ c. Post-Secondary ☐

8. For how long has the farmer been in dairy farming?

a. 1-5 years☐ b. 5-10 years ☐ c. 10-15 years ☐ d. Over 15 years ☐

9. Household size ……………………………………………….

10. Age of the farmer?

a. Below 18 years ☐ b. 18-25 years ☐ c. 25- 35 years ☐ d. 35-45 years ☐ e. 45-55 years ☐ f. 55 years and above ☐

11. Which is your land size under fodder production?

a. Under 1 acre ☐ b. 1-2 acres ☐ c. 2-4 acres ☐ d. 4-6 acres ☐

e. Above 6 acres (specify)………………………………………………

12. Do you have land for food and cash crop production? a. Y ☐ b. No ☐

If yes, what is the size of the land in acres…………………………………………

13. What is your total acreage? ……………………………………………………

14. Does your household have the following animals? (indicate number kept)

a. Goats…………………. d. chicken………………

b. Sheep…………………. e. Rabbits………………...

c. Donkeys………………. f. Pigs…… g, Others……….

SECTION B: Dairy Production System and Herd Structure

15. Production system used?

a. Semi intensive ☐ b. Intensive ☐ c. Other…………………….

16. Which breeds of dairy cattle are in this farm?

a. Friesian ☐ b. Ayrshire ☐ c. Guernsey ☐

d. Jersey ☐ e. Crosses ☐ f. Other (specified) ……………………………….

17. How many dairy cattle belong to each breed?

a. Friesians……. b. Ayrshires………... c. Guernsey………. d. Jersey………...

e. Crosses………. f. Other (specified)………………………….

18. Herd Structure

Fill in the table below the number of each category of the herd composition.

	Herd Composition	Number Cattle
1	Non-pregnant Lactating cows	
2	Pregnant and lactating cows	
3	Dry cows	
4	Heifers	
5	Heifer calves	
6	Bull calves	
7	Bull	
8	Steers	
	Total Cattle	

19. Who take (s) the responsibility of feeding dairy animals?

a. Adult owner male ☐ b. Adult owner Female ☐ c. Children ☐ e. Worker ☐

f. All ☐

SECTION C: Calf Management and feeding

20. Do you weigh your calves when they are born? a. Yes☐ b. No☐

21.If so, what is the average birth weight?

…………………………………………………………………………………………………

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

If yes, explain how?

……………………………………………………………………………………………………

…………………………………………………………………………………………………

23. Which method of feeding calf (ves) is used?

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

24. Depending on feeding method, when does feeding calf start?

a. to 6 Hrs ☐ b. 6 to 12 Hrs ☐c. 12 to 24 Hrs ☐d. 24 Hrs and above ☐

25. Do you weigh or measure calf feed? a. Yes ☐ b. No ☐

26. Depending on feeding method, how many litres of milk are fed to the calf under one week per day?

a. 1-2 litres☐ b. 2-4 litres ☐ c. Other (Specify)…………………

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

a. Milk only ☐b. calf starter ☐ c. Milk replacer and forages ☐

d. forages ☐e. Milk and forages ☐ f. Other (specify)…………

28. What amount (Kg or L) of the followings is fed to the calf under one week to one month?

a. milk……. L b. calf starter…….kg c. milk replacer.......kg d. forage……kg

e. other……………kg

29. Which of the following are fed to your calf from 1 month to 3 months?

a. Milk only ☐ b. calf starter ☐ c. Milk replacer and forages ☐ d. forages ☐

e. Milk and forages ☐ f. Other (specify)…………………… ☐

30. What amount of the following is fed to the calf from 1 month to 3 months?

a. milk…...L b. calf starter……kg c. milk replacer……kg d. forage…...kg

e. Other……………kg

31. When is the calf weaning?

a. < 3 months ☐. 3 months ☐. <6 months ☐

d. 9 months and above ☐. other……………………….

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

…………………………………………………………………………………………………

…………………………………………………………………………………………………

33. Which of the following weaning process is used?

a. Immediate weaning ☐ b. Intermittent feeding weaning ☐

34. Problems facing calves.

a, Diseases ☐ b. Inadequate feeds (milk) ☐ c. poor housing ☐ e. Other……………..

35. If diseases, at what age are they common?

a. 1 to 2 weeks ☐ b. 3 to 4 weeks ☐ c. 4 to 8 weeks ☐ e. 8 to 12 weeks ☐

f. after weaning ☐

36. Which are the common calf diseases?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………...

37. How many calves under one month were sick and recovered in the last 2 months?

....

38. How many calves died

………………………………………………………………………………………………

39. What are the measures taken to control calf diseases?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………

40. Is there a house for the calves?

Yes ☐ b. No ☐

If yes, which type of floor/wall?

a. Concrete ☐ b. non-concrete ☐ c. Other (specify)………………...

41. Which bedding material is used

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

42. Which type of calf housing in system?

a. Single calf pen ☐ b. Group pen ☐ c. Other……………………

SECTION D: Heifer Management

43. Feeding of heifers

a. Pasture only ☐ b. pasture and concentrate ☐ c. forages ☐ d. Forages and concentrate ☐ f. Other (specify)………………

44. In case of grazing, how are heifers grazed?

a. Together with cows ☐ b. Separate from cows ☐ c. After cows ☐ Before cows ☐ e. Other (specify)…………………………

45. What are the common problems facing heifers?

……………………………………………………………………………………………

…………………………………………………………………………………………

46. What control measures are applied in this farm to control the problems above?

……………………………………………………………………………………………

……………………………………………………………………………………………

………………………………………………………………………………………

47. At which age do you serve your heifers?

a. 15-18 months ☐ b. 18-20 Months ☐ c. 20 Months and above ☐ d. Other (specify)……………………………

48. Which of the following method is used in serving heifers?

a. Artificial insemination ☐ b. Natural mating ☐

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

…………………………………………………………………………………………………

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

If you do, how?

……………………………………………………………………………………………………

…………………………………………………………………………………………………

51. Do you sell heifers? a. Yes ☐ b. No ☐

If so how do you select the ones to retain?

……………………………………………………………………………………………………

…………………………………………………………………………………………………

SECTION E: Feeds and Feedings

52. What are the feed resources that you give to dairy cows?

a. Roughages and concentrates ☐ b. Roughages alone ☐

c. Roughages and salt lick (mineral lick) e. Other………………☐

53. What are the sources of fodder/feeds for your animal/s?

a. Own production ☐ b. Purchased ☐ c. Natural pastures ☐ d. Other (specify)…………………

54. If own production, what are the feeds resources you produce?

……………………………………………………………………………………………………

……………………………………………………………………………………

55. Do you conserve feed? a. Yes ☐ b. No ☐

56. Which of the following conserved feeds do you give to your dairy cow?

a. Hay ☐ b. Silage ☐ c. other specify……………………

57. Do you weigh feeds of your cattle? a. Yes ☐ b. No ☐

If yes, what quantity of roughages (kg) do you feed to dairy cows(s) in early lactation daily?

……………………………………………………………………………………………

58. What quantity of roughages (kg) is fed to dairy cows in mid lactation daily?

……………………………………………………………………………………………

59. What quantity of roughages (kg) is fed to dry cow at late pregnancy daily?

……………………………………………………………………………………………

60. What quantity of concentrates (kg) is fed to a dairy cow in early lactation daily?

……………………………………………………………………………………………

61. What quantity of concentrates (kg) is fed to a dairy cow in mid and late lactation daily?

……………………………………………………………………………………………

62. What quantity of concentrates (kg) is fed to dry cow at late pregnancy daily?

....

63. What other feed supplements do you provide to dairy cows?

……………………………………………………………………………………………………

……………………………………………………………………………………

64. How much do you spend on the dairy meal (concentrates) per month in Kshs?

……………………………………………………………………………………………

65. How much do you spend on salt lick per month in Kshs?

……………………………………………………………………………………………

66. Which method do you use to water your cattle?

……………………………………………………………………………………………..

67. How frequent do you water lactating cow per day?

……………………………………………………………………………………………..

SECTION F: Management Practices

68. Which type of mating do you use in your farm?

a. Natural Mating (Bull) ☐ b. Artificial insemination ☐

c. Both ☐

69. If artificial insemination, which of the following provide you with semen?

a. Government ☐ b. private institution ☐ c. Cooperatives ☐

70. Time from calving to first heat of your cow (s) in months?

…………………………………………………………………………………………..

71. Conception at first service (number of cattle)?

…………………………………………………………………………………………..

72. Conception at second service (number of cattle)?

…………………………………………………………………………………………..

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

……………………………………………………………………………………………………

………………………………………………………………………………………

74. What disease control measures do you take in your farm?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………

75. From whom do you get the following services?

S/N	Services	Provider
1	Veterinary services	
2	Training	
3	Loan	
4	Other……………………………..	

SECTION G: Dairy Cattle Performance

76. What is the calving interval of your dairy cows in months?

………………………………………………………………………………………

77. What is the lactation length of your dairy cattle in months?

………………………………………………………………………………………

78. How do you stimulate milk let down?

a. Use of calf ☐ b. massaging ☐ c. other (Specify)……………………

79. Types of milking

a. Machine ☐ b. Hand ☐ c. Both ☐

80. How frequent do you milk a dairy cow in a day?

a. Once ☐ b. Twice ☐ c. Thrice ☐ d. other………

81. How many litres of milk does your cow produce in a day?

a. 1-2 litres ☐ b. 2-5 litres ☐ c. 5-10 litres ☐ d. 10-15 litres e. 15 -20 ☐ litres ☐ f. 20 litres above (specify)………………………

82. What total amount of milk does the farm produce in litres per day?

………………………………………………………………………………………………

………………………………………………………………………………

83. Select the selling price of a litre of milk on your farm.

a. 30-40 Kshs ☐ b. 40-50 Kshs ☐ c. Above 50 Kshs specify………………

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

………………………………………………………………………………..

85. What amount of milk in litres is sold per day?

…………………………………………………………………………………

86. Who are the buyers of your milk?

a. Neighbours ☐ b. local shops/hotels ☐ c. Middlemen ☐

d. processors ☐ e. dairy cooperatives ☐

87. What challenges do you face in smallholder dairy farming?

…………………………………………………………………………………………

88. What attempts do you make to overcome the above challenges?

…………………………………………………………………………………………………

89. What are the benefits of dairy farming?

…………………………………………………………………………………………………

……………………………………………………………………………………………

SECTION H: Housing

90. Is there a house for your cattle?

a. Yes ☐ b. No ☐

91. Types of floor?

a. Concrete ☐ b. non-concrete ☐ c. Other (specify)…………………….

92. Types of bedding

a. Cow mattress ☐ b. No bedding ☐ c. Other (specify)………………..

The End