EVALUATION OF PERFORMANCE OF SMALL RUMINANTS IN SMALLHOLDER CLIMATE SMART VILLAGES OF LOWER NYANDO, KENYA

WINFRED SILA, BSc

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DECLARATION

This thesis is my original work and has not been previously presented for the award of a degree in this or any other university.

Winfred Sila (BSc)

J56/89096/2016

Signature…… …… **Date**……09/12/2020……

This thesis has been submitted to Graduate School with our approval as academic supervisors

Prof C. K. Gachuiri (BVM, MSc, Ph.D.)

Department of Animal production,

University of Nairobi

Signature…… ……**Date**…09-12-2020……

Dr. Julie M. K. Ojango, (BSc, MSc, Ph.D.)

Senior Scientist Livestock Genetics, Biosciences

International Livestock Research Institute.

Signature…… ……. **Date**……09/12/2020……

DEDICATION

I dedicate this work to my beloved husband Dan Okello, son Arnold Kenga, daughter Jolene Pendo, family members, and friends for their prayers, encouragement, and unwavering support throughout this period.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADG:	Average Daily Gain
AGRA:	Alliance for a Green Revolution in Africa
CC:	Climate Change
CCAFS:	Climate Change, Agriculture and Food Security
CCPP:	Contagious Caprine Pleuropneumonia
CGIAR:	Consultative Group for International Agriculture
CIAT:	The International Center for Tropical Agriculture
CSA:	Climate-Smart Agriculture
CSV:	Climate Smart Villages
FAO:	Food and Agriculture Organization
FGD:	Focus Group Discussion
GDP:	Gross Domestic Product
ILRI:	International Livestock Research Institute
IPCC:	Intergovernmental Panel on Climate Change
KNBS:	Kenya National Bureau of statistics
KPH:	Kenya Population and Housing Census
LSM:	Least Square Mean
MT:	Metric Tonnes
NICRA:	National Imitative on Climate Resilient Agriculture
ODK:	Open Data Kit
RELMA:	Regional Land Management Unit
SE:	Standard Error
SIDA:	The Swedish International Development Cooperation Agency
SPSS:	Statistical Package for the Social Sciences
SSA:	Sub Saharan Africa
USA:	United States of America

ABSTRACT

The productivity of small ruminants in developing countries remains low although the animals play an integral role in the livelihoods of smallholder farmers. Current information on their productive performance and contribution to the household incomes of smallholder farmers in Eastern Africa is limited. This study was implemented as part of an on-going small ruminant improvement project by the Climate Change Agriculture and Food Security (CCAFS) and the International Livestock Research Institute (ILRI) in Kericho and Kisumu Counties of the Lake Victoria basin of Kenya. The objective of this study was to evaluate productive performance and contribution to the household incomes of introduced improved small ruminants to the smallholder Climate Smart Villages of Lower Nyando. The information will contribute to knowledge on the productivity and costs of producing small ruminants and their roles in enhancing livelihoods of smallholder farmers grouped into "Climate Smart Villages"(CSV). Data collated from 162 farms on growth performance of improved indigenous small ruminants (Red Maasai and Red Maasai-Dorper cross sheep, and Galla goat) introduced in the CSV from 2014-2019 was analyzed. Additionally, a cross sectional survey and community focus group discussions were carried out to collate information on the costs and revenues from small ruminants on the smallholder farms. Results showed that land holdings and demographic characteristics of households in the CSV have not changed since 2013, however, the number of improved sheep and goats reared by the farmers had doubled. The introduced improved indigenous breeds and their crosses with local breeds (non-descript Blackhead Persian sheep and Small East African goat) had superior growth performance and were >15 Kg heavier at one year of age compared the local breeds resulting in a three-fold increase in sale prices (from 2014 to 2018) for the animals. The highest revenue was from the sale of both sheep and goats in Kericho and Kisumu representing 82% and 75.1% of the income from the animals respectively. Farmers sold both male and female animals depending on their availability, the anticipated sale price and the existing need for cash in the household. Milk was only obtained from the goats, and this contributed to 5.7% and 5% of the total revenue from the animals in Kericho and Kisumu respectively. Households headed by farmers with non-formal education earned >55% of the returns from their animals compared to those with formal education. In both counties, the net returns from goats (KSH 91,675.90) contributed 70.5% of the total returns compared to that of sheep (KSH 39,790.10). The introduced indigenous breeds had adapted well to the climatic conditions of Nyando and were able to maintain their productivity despite the change in

location. Production of improved indigenous sheep and goats in the CSV of Nyando has contributed to higher returns from small ruminant production and should be expanded within the region.

Key words: Small ruminants, revenues, cost of production, climate change, growth performance

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Worldwide, sheep and goats, jointly referred to as small ruminants comprise more than 50% of the domesticated ruminants and are an important source of livelihood to farmers, especially those in developing countries (Wodajo *et al.,* 2020). In Kenya, small ruminants comprise a significant proportion of the livestock population, estimated at 19 million sheep and 28 million goats (KNBS, 2019). These livestock are key resources to the keepers for their role in the provision of food, socio-economic needs, and cultural activities (Herrero *et al.,* 2013; Alary *et al.,* 2015; Fantahun *et al.,* 2016). They also support income generation through sales of live animals, and their products of meat, milk, and manure which is used to promote crop production (Alilo *et al.,* 2018). Small ruminants have unique attributes that attract smallholder resource-constrained farmers, these include flexible feeding habits, high reproduction rates, adaptability to extreme climatic conditions, and efficient utilization of low agriculturally productive lands (Kosgey *et al.,* 2006; Monteiro *et al.,* 2017).

In Kenya, small ruminants are kept under different production systems as outlined by Muigai *et al.,* (2017), namely, smallholder mixed crop-livestock systems, smallholder intensive systems, extensive pastoral and transhumance systems, and, large scale ranching systems. Management practices differ across the systems and within systems depending on the resource endowment of the livestock keepers. In arid and semi-arid areas occupied by pastoral livestock keepers, small ruminants are reared in large numbers, herded in the open pasture alongside cattle, and at night confined in temporal structures or kept outside the homestead.

In the mixed crop-livestock systems, the animals are either grazed or confined within temporal structures depending on the available landholding but, in some instances, they may

graze on communal resources, crop residues, cultivated forages, or naturally grown bushes and shrubs (Tadesse *et al.,* 2014). Smallholder intensive systems and large scale ranching systems are more commercially oriented, targetting the production of specific products of good quality for the markets (Muigai *et al.,* 2017).

Changing climatic conditions manifested by prolonged periods of dry weather and extreme temperatures pose a major challenge to smallholder farmers compelling them to change their farming practices to be more sustainable (IPCC, 2014). The Lower Nyando area in the Lake Victoria basin of Kenya is one of the fifteen areas selected by Climate Change Agriculture and Food Security (CCAFS) programme for the implementation of "Climate Smart Agricultural practices" (Kinyangi *et al.,* 2015). In this area, food security and agriculture have been adversely affected by unfavorable climatic events of drought, floods, and unpredictable rainfall patterns (Thorlakson & Neufeldt, 2011). Improving the small ruminant production is one of the mitigation measures used owing to the role of the animals in improving the livelihoods of farmers affected by climate change (Ojango *et al.,* 2016).

Productivity is a crucial aspect of livestock production as it forms the basis for the survival of stock populations as well as creation of income through sales of breeding animals (Lamy *et al.,* 2012). In non-wool and low milk producing small ruminant breeds, productivity is measured by the number of lambs/kids per ewe/doe in a year (Bosman, 1995). Lamb/kid production is also a key measure of farmers' income from the small ruminants, thus there is a need to maximize reproduction if returns through sales of animals are to be optimized (Cloete *et al.,* 2000). The productivity of small ruminants in rural mixed crop-livestock systems has been very low (Salem & Smith, 2008; Ayantunde, 2016). In these systems, farmers keep indigenous breeds, although there have been some efforts to upgrade the existing breeds in different regions (Mbuku *et al.,* 2015; Haile, 2017; Haile *et al.,* 2019). Despite their low productivity, the indigenous small ruminants continue to be retained in moderate numbers.

Interventions for improving productivity within these systems include improved breeding management practices, feeding, and disease control strategies (Kosgey *et al.,* 2008; Salem, 2010; Mayberry *et al.,* 2018; Haile *et al.,* 2019). In order to determine the impact of improving the productivity of small ruminants in targeted farming environments affected by climate change, it is important to understand the contribution of the small ruminants to the incomes and livelihoods of the livestock keepers.

1.2 Statement of the problem

Agriculture is the main means of livelihood for smallholder resource-constrained farmers in developing countries (Chambwera & Stage, 2010; Harvey *et al.,* 2014). However, climate change has become a big threat to the sustainability of agricultural productivity (Nelson *et al.,* 2010; Williams *et al.,* 2017; Fadairo *et al.,* 2020). Small ruminants comprise an important pathway for the establishment of constant and regular food and income for smallholder farming families in the climate-challenged areas (CIAT, 2015). The productivity of small ruminants especially in developing countries remains low although there is potential for improvement (Ådnøy, 2014; Monteiro *et al.,* 2017). Information on the current productivity levels of sheep and goats in the changing production systems affected by adverse climates in Eastern Africa is limited.

Information on the economic contribution of small ruminants to smallholder farmers' livelihoods in climate constrained areas is also scarce. Studies undertaken on smallholder farming systems have dealt with the more general economic contribution of rural communities to the national economy (Kumar *et al.,* 2010; Adams, 2015) and in pastoral systems (Omondi, 2008). Gaps in information greatly impact the potential planning of interventions for improvement of flock productivity and profitability. The paucity of information on costs and returns results in undervaluation of small ruminants in comparison with large ruminants such as cattle despite their enormous contribution to the livelihoods of

smallholder farmers (Panin, 2000). To better guide intervention options for improving small ruminant productivity, there is need for information on the current productivity levels, costs of achieving different productivity levels, and economic viability of the small ruminant enterprises.

1.3 Justification

Farming systems and their ability to provide food and improve livelihoods in the tropics is challenged by climate change stresses (Singh & Singh, 2017). There is, therefore, a need to adopt farming practices suitable for the changing climatic conditions. Small ruminant production in the smallholder systems support the socio-economic livelihoods of the communities living in climate challenged areas and has been acknowledged as one of the mitigation measures to climate change (Monteiro *et al.,* 2017). Studies have focused on the productivity of small ruminants especially those raised under smallholder farming systems in resource-constrained environments (Chikagwa-Malunga & Banda, 2006; Tibbo, 2006; Ahuya *et al.*,2009; Mhlanga *et al.,* 2018). However, there is little documentation on the current productivity levels of small ruminants in climate constrained environments. This gap in information is restrictive to undertaking new initiatives to improve the livelihoods of smallholder farmers using small ruminant improvement programs.

Adequate information on the current levels of productivity of small ruminants is key in addressing the challenge of improving the livelihoods of smallholder farmers. Enhanced small ruminant productivity translates to improved livelihoods through increased incomes from the sale of products. Information on the economic returns to small ruminant production under changing climatic conditions is also required. This study contributed to information on the productivity and costs of producing small ruminants, and the role small ruminants play in enhancing livelihoods of communities in the climatically challenged smallholder systems of Nyando in the Lake Victoria basin of Kenya.

1.4 Objectives

1.4.1 General objective

To evaluate the productivity and contribution of small ruminants to household incomes in smallholder farming systems under the "Climate Smart Villages" of Nyando.

1.4.2 Specific objectives

i. Investigate and document the contribution of small ruminants to household incomes of smallholder farmers in "Climate Smart Villages" of Nyando.
ii. Evaluate the growth performance of improved small ruminant breeds introduced to the smallholder farming systems in "Climate Smart Villages" of Nyando.

1.5 Hypothesis

1.5.1 Null hypothesis H_O

i. Small ruminants do not contribute substantially to the household incomes of smallholder farmers in the climatically challenged environments of Nyando.
ii. The growth performance of improved small ruminant breeds introduced to the smallholder farmers in "Climate Smart Villages" is not different from that of existing breeds.

CHAPTER TWO: LITERATURE REVIEW

2.1 Importance of small ruminants

Small ruminants form an integral part of nutritional, economic, and ecological niche in the agricultural systems of rural communities in developing countries (Oluwatayo & Oluwatayo, 2012). They play a key role, especially to the smallholders, in the provision of products such as milk, meat, wool, and skin which are important sources of food and income (Wodajo *et al.,* 2020). Small ruminants are valued livestock species due to their unique attributes including short reproductive cycles, multiparous nature, feeding behavior, innate resistance in different breeds to gastrointestinal parasites, and their ability to thrive in large numbers per unit area of land compared to larger ruminants such as cattle (Baker *et al.,* 2001; Devendra, 2002). Some small ruminant breeds are reported to be resistant to intestinal nematodes, thus reducing their rearing costs (Baker *et al.,* 2001; Baker & Gray, 2004).

Small ruminants have lower initial capital requirements making them less costly to rear and manage when compared to the large ruminants (Pollot & Wilson, 2009). They have also been shown to enable smallholder farmers recover and re-establish herds faster after challenging periods due to their high rate of reproduction (Peacock, 2005). Their small bodies have economic, managerial, and biological advantages making them the first-choice livestock species to be sold for emergency household needs (Oluwatayo & Oluwatayo, 2012). For instance, their small carcasses can be easily handled and consumed by a household without spoiling (Alarcon *et al.,* 2017). Moreover, in many households, during dry seasons, goats are the sole milk providers as cattle tend to be severely hit by drought (Tulicha, 2013). Small ruminants do not compete with human beings and other livestock for grain-based feeds as they can exclusively thrive on natural pastures and shrubs (Duku *et al.,* 2010; Salem, 2010). Currently, small ruminants are widely distributed in pastoral and smallholder production systems in Africa (Muigai *et al.,* 2017).

2.2 Small ruminant production in Kenya

2.2.1 Contribution to the national economy

The livestock sub-sector plays a significant role in the Kenyan economy as it contributes approximately 4.9% of the national GDP, 19.6% of agricultural GDP and employs 50% of the total agricultural labor force (CSA, 2018). The total population of small ruminants in Kenya is estimated to be 19 million sheep and 28 million goats, which supply about 84,074MT of the national meat (KNBS, 2019). According to FAO, (2016) worlds small ruminant populations have been increasing and are projected to continue to rise in numbers by 60% by 2050.

2.2.2 Production systems found in Kenya

In Kenya, small ruminants are produced under four main production systems- smallholder mixed crop-livestock production systems, extensive pastoral and transhumance systems, large scale ranching systems, and smallholder intensive systems (Legese & Fadiga, 2014; Muigai *et al.,* 2017). The grouping in production systems is influenced by the flock densities, agroecological conditions, economic and resource endowment of producers, management practices, and market options for the small ruminant products (AU-IBAR, 2019; Herrero *et al.,* 2014). Production systems are not static and change due to the effects of both internal and external factors. In recent years, change is greatly influenced by the globally changing climatic conditions (IPCC, 2019). Understanding the systems under which small ruminants are produced is important to allow the designing and implementation of strategies to improve productivity and marketing of small ruminant products, and in turn improving the livelihoods of smallholder producers (Fernández-Rivera *et al.,* 2004).

Smallholder Mixed Crop-Livestock Production Systems

Mixed crop-livestock production systems are mainly found in the humid/sub-humid zones of Kenya, classified as Agro-ecological zones I to III (Jaetzold & Schmidt, 1983) covering areas of the central highlands, Rift Valley, Western Kenya and a narrow strip along the Coastal lowlands (Njarui *et al.,* 2016). In the high potential areas of Kenya (Agro-ecological zones I-II), small ruminants are raised in smaller numbers under either medium or smallholder mixed crop-livestock production systems (Kosgey *et al.,* 2008). In these systems, farmers practice integration of crops with livestock farming where one enterprise supports the other (Gizaw *et al.,* 2015). The small ruminant production enables diversification in land use and provides an additional source of income when crop production is negatively impacted by adverse climatic effects (Oluwatayo & Oluwatayo, 2012). These areas are characterized by small land holdings and high population densities leading to competition in land use (AU-IBAR, 2019). The small ruminants are raised alongside other livestock species with minimal husbandry practices and low use of inputs. A large proportion of the farmers practicing mixed crop-livestock production keep small ruminants for subsistence rather than commercial purposes, thus very little attention is given to profitability (Muigai *et al.,* 2017). The farmers rear a mixture of exotic breeds and their crosses with the indigenous (AU-IBAR, 2019). Crop residues, cultivated forage, and naturally grown bushes and shrubs are the main feeds for the small ruminants in these production systems, with some provision of supplements in the form of industrial by-products such as molasses. During cropping seasons, the animals are carefully herded or tethered in pastures far from the cultivated farms.

Extensive pastoral and transhumance systems

Extensive pastoral and transhumance systems are found in arid and semi-arid areas where potential for crop farming is very low (Muigai *et al.,* 2017). Arid and semi-arid areas comprise 80% of Kenya's land providing a livelihood to about 20 million people (Amwata *et*

al., 2015). In these systems, livestock comprise the essential livelihood asset for the communities (Krätli *et al.,* 2013; Nyariki & Amwata, 2019). Pastoralists practice communal system of land ownership. Animals are grazed on the communally owned land and move from one place to the other in search of pasture and water (AU-IBAR, 2019). Livestock keepers in this system use mobility in search of water and grazing lands and keep large numbers of a wide variety of livestock species for their survival. The large herds are an assurance of subsistence and income, confer status on the owners, and provide food for communities in periods of drought (Moritz *et al.,* 2011; Manoli *et al.,* 2014; Opiyo *et al.,* 2015). Pastoralists keep mixed herds comprising cattle, sheep, goats, and camels. Female animals comprise a larger proportion of the herds relative to males, as male animals are occasionally sold (Ayantunde *et al.,* 2007). Castration of males is rarely practiced as farmers believe that it slows growth. Moreover, there is uncontrolled mating leading to lambs/kids being born throughout the year. The pastoralists generally keep indigenous breeds which take a long time to attain market weight (Muigai *et al.,* 2017). In the transhumance systems, the livestock keepers are more sedentary and coexist with crop farmers in such a way that their livestock graze on the crop fields after harvesting (Namgay *et al.,* 2013; Tamou, 2017). Constrains affecting productivity in this system include inadequate feed, diseases, parasites, and environmental challenges of recurrent droughts and flooding (Tegegne *et al.,* 2016).

Large scale commercial ranching systems

Large scale commercial ranching systems are owned by individuals, government, or private organizations (Muigai *et al.,* 2017). These systems are characterized by large parcels of land and animals are kept under extensive, semi-intensive or intensive production systems. The animals are fed on naturally growing pastures, planted fodder, and sometimes with commercial supplements. Ranches keep locally adopted exotic breeds and their crossbreds with the indigenous breeds, with some breeding initiatives aimed at improving the indigenous

breeds (AU-IBAR, 2019). The animals are kept for their products of milk, meat, and skin. Animals are housed in open sheds but are allowed to graze freely. Generally, reproduction is carefully monitored, and mating is well planned. Other management practices such as docking, weighing before sale and, parasite, and disease control are also practiced (König *et al.,* 2017). An example of a large scale small ruminant commercial ranch is the Kapiti ranch in Machakos County.

Smallholder intensive systems

Animals in these systems are kept in structures built on small land parcels in close proximity to urban centres. Both intensive and semi-intensive management practices are adopted as the animals are kept for both milk and meat production (AU-IBAR, 2019). The animals are fed on natural pastures, planted fodder, and crop residues and commercial feeds. Farmers generally keep exotic or improved indigenous breeds, and their crossbreds (Muigai *et al.,* 2017).

2.3 Factors influencing productivity of small ruminants in smallholder production systems

Small ruminant production in smallholder farming systems is influenced by several factors that are greatly dependent on the resource endowment of the livestock keepers (Salem, 2010; Ayantunde, 2016). Key factors reported to influence productivity achievable include feed and water resources, endemic disease and parasites, housing facilities provided, breed-types available for rearing, and the market and marketing system for products (Salem & Smith, 2008; Joshi *et al.,* 2018; Teklebrhan, 2018).

2.3.1 Feed and water resources

Unavailability of adequate feed all year round is a major constraint in small ruminant farming (Salem & Smith, 2008). Overgrazing, environmental degradation, and overstocking have led

to overexploitation of fragile ecosystems especially in arid and semi-arid areas (Irshad *et al.,* 2007; Abdi *et al.,* 2013). Leaving animals to graze in open fields without any inputs in pasture production, and with no supplementation from other feed, sources results in slow growth rates and stunting of animals (Kawas *et al.,* 2010; Tedeschi *et al.,* 2019). Studies on small ruminant production under smallholder farming environments in Ethiopia, South Sudan, and Ghana have reported feed scarcity attributed to recurrent droughts, land shortage and failure to practice fodder conservation (Timpong-Jones *et al.,* 2014; Ochi *et al.,* 2015; Etalema & Abera, 2018). Seasonality in feed availability and availability of water resources generally depend on the prevailing climatic factors of temperature, humidity, and precipitation (Chukwuka *et al.,* 2010). The globally changing climatic conditions experienced in recent decades have negatively affected the quantity and quality of available feeds and water for livestock that are dependent on natural resources (Rojas-Downing *et al.,* 2017). The increased ambient temperatures past the thermo comfort zone for many animals results in inefficient feed intake and digestibility leading to poor nutrition and stress, which affects the growth rate and survivability especially in young animals (Chukwuka *et al.,* 2010).

Addressing water and feed challenges in small ruminant production is a critical element in improving the offtake achievable from animals in smallholder systems (Omondi *et al.,* 2008). The smallholder farmers need to grow fodder in addition to crops. Introducing drought-resistant fodder cultivars and supplementation of the small ruminants with agro-industrial by-products and mineral salts especially during the dry seasons will enable more optimized growth of the animals and reduce nutritional deficiency related mortalities (Salem, 2010).

2.3.2 Animal health

Diseases and parasites threaten small ruminants as they lead to losses due to poor growth rates and mortality (Zvinorova *et al.,* 2016; Muhammad *et al.,* 2018). High mortality and morbidity rates in small ruminants have been reported to result from disease conditions such

as Peste des petits ruminants and Pasteurellosis (Adama *et al.,* 2011; Timpong-Jones *et al.,* 2014). Mortality mostly affects young animals that have lower immunity than more mature animals. Up to 63% mortality has been reported among goats under one year of age in Northern Ghana as a result of nutritional and health concerns (Amankwah *et al.,* 2012**).** Studies done in Kenya have reported diseases to be a key challenge in small ruminant production (Kagira & Kanyari, 2001; Abdilatif *et al.,* 2018). The main diseases affecting small ruminants in central and northern Kenya were helminthosis, Contagious Caprine pleuropneumonia, and tick-borne diseases. In central Kenya, pneumonia and coccidiosis were reported to be the main causes of pre-weaning mortality in small ruminants contributing 31% and 23% of mortality respectively (Kagira & Kanyari, 2001). Smallholders in rural areas generally lack capital to purchase veterinary inputs, and even in the instances where capital is available the veterinary inputs are not available in adequate quantities for existing flocks (Belt *et al.,* 2015; FAO, 2017). High costs of veterinary inputs have been reported in different countries by several authors (Adama *et al.,* 2011; Lado *et al.,* 2015; Etalema & Abera, 2018). Improved management practices with careful attention to animal hygiene would greatly reduce the challenge of diseases in small ruminant production.

2.3.3 Breeds and breeding programmes

Most smallholder farmers rear indigenous breeds of small ruminants or crosses between the indigenous and exotic breeds (Kosgey *et al.,* 2006; Peacock *et al.,* 2011; Manirakiza *et al.,* 2020; Monau *et al.,* 2020). Breeding programmes for small ruminants in smallholder farming systems are limited. However, there have been some interventions to enhance productivity by projects such as The FARM Africa goat project, The small ruminant collaborative Dual Purpose Goat project, community based breeding for genetic improvement of sheep and goats (Peacock, 2005; Bett *et al.,* 2007; Haile *et al.,* 2019). The productivity of indigenous animals has however remained low as targeted selection within indigenous breeds is limited (Nugroho

et al., 2019). In many flocks, female and male animals are left to run together with no control of mating. This has resulted in high rates of inbreeding within flocks as it is not uncommon to have one breeding male retained in a flock for as long as 5 years (Kosgey, 2004). Gradual improvement in husbandry and breed improvement practices introduced through interventions of extension programs is evident in a few areas (Peacock, 2005; Gebremedhin *et al.,* 2015). Community-based breeding programs have been successfully introduced in some areas and need to be scaled to impact a larger population (Mueller *et al.,* 2015; Haile *et al.,* 2019). Identifying and selecting for existing traits in indigenous breeds that are of value to livestock keepers would greatly enhance productivity in smallholder farming systems (Nugroho *et al.,* 2019).

Smallholder small ruminant farmers have been reported to keep small-bodied local breeds which take a very long period to attain maturity and attract very low returns when marketed (Ojango *et al.,* 2016). In larger-scale systems, breeding programmes have been implemented to improve productive traits of small ruminants using breeds that are adaptive to specific environments (Baker & Gray, 2003; Ojango *et al.,* 2010). There are a wide variety of indigenous strains of small ruminants that have evolved to adapt to prevailing environmental conditions and traditional husbandry systems (Baker & Rege, 1994). Attempts to crossbreed local indigenous strains with exotic germplasm though initially well planned, over time have resulted in haphazard crossbreeding as most cross-breeding programs are only sustained for the duration of support provided through external funding (Shrestha & Fahmy, 2007; Peacock *et al.,* 2011; Shrestha and Pokharel, 2012). Some efforts to improve productivity have led to replacement with exotic germplasm which over time do not survive in the environments (Baker & Gray, 2003). Smallholder farmers may adopt exotic germplasm for short term benefits, but fail to sustain their productivity and resort to abandon small ruminant productivity as a viable enterprise (Kiwuwa, 1992).

A good breeding programme should put into consideration the needs, views, and production environment of the farmer (Shrestha & Pokharel, 2012; Haile *et al.,* 2019). It's also important to introduce market-oriented improvement through breeding initiatives aimed at improving the economic status of the farmer (Bett *et al.,* 2009). To optimize gains from environmental influences, the genetic parameters and attributes of the animals for economic traits should be appraised regularly (Shrestha and Fahmy, 2005; Shrestha & Fahmy, 2007).

2.3.4 Markets and marketing systems

Markets and marketing systems for small ruminants tend to be quite diverse (Amankwah *et al.,* 2012; Mtimet *et al.,* 2014; Wanyoike *et al.,* 2015; Alarcon *et al.,*2017; Gemeda, 2017). Several challenges have been noted to hinder marketing of small ruminants, including unpredictable fluctuations in prices of animals, inadequate information on demand for small ruminant products which provides an opportunity for the secondary traders to exploit producers (Amankwah *et al.,* 2012; Legese & Fadiga, 2014; Alemayehu, 2015; Etalema & Abera, 2018). Lack of well-developed infrastructure leading to high transaction costs and lack of clear policies on sheep and goat marketing are also a great challenge (AU-IBAR, 2019). Low prices offered to farmers for the sale of animals directly at their farm gates also hinder additional investments in improving the productivity of the small ruminants. The limited information on pricing that is based on subjective rather than objective measures on animals is an additional hindrance to improving animal productivity (AU-IBAR, 2019; Muigai *et al.,* 2017).

The small-scale production of small ruminants often results in unavailability of their products in informal markets (Ogola *et al.,* 2010**).** A large number of intermediary market actors each seeking to make an income from sales of animals results in very low producer prices (Mtimet *et al.,* 2014). In many areas, there is need for improvement of infrastructure such as roads and water supply in markets to enhance their operability (Katiku *et al.,* 2013). Livestock keepers

need a better understanding of the market demand and the strengths of marketing animals as communities rather than individuals (Haile *et al.,* 2019). Adoption of technologies such as mobile phone messaging services could help in dissemination of marketing information for farmers thereby limiting exploitation by middlemen (Krell *et al.,* 2020).

Smallholder farmers in many regions have limited access to credit facilities hindering the development of small ruminant enterprises (Anang *et al.,* 2015). In most scenarios, smallholders adopt low input and low return production options over technology intensive ones as they are guaranteed greater stability (Kebebe, 2015; Oyinbo *et al.,* 2019). As noted by Omonona *et al.,* (2010), access to credit enhances the production efficiency of small-scale farmers thereby reducing rural poverty and food insecurity. Access to credit influences farm productivity since credit-constrained farmers are more likely to use lower levels of inputs in production compared to those who are well endowed. Improving access to credit, therefore, has the capacity to facilitate optimal input use leading to a positive impact on productivity.

To enhance productivity and address constraints to production, there is a need for a multidimensional approach incorporating technical and policy measures. Improvement in productivity makes a valuable contribution to resource-poor farmers (Assan, 2015). The integration of nutritional, breeding and appropriate management practices is important in promoting small ruminant productivity (Deribe & Taye, 2013; Lado *et al.,* 2015). Proper linkage between market, workable regional and national policies, community breeding programmes, and collaborative research work with government are key in minimizing productivity constraints.

2.3.5 Changing climatic conditions

Changing climatic conditions resulting in significant fluctuations in the global temperature, precipitation, and wind patterns over long periods have a significant effect on livestock production (Nardone *et al.,* 2010). The fluctuating climates adversely affect communities

that rely entirely on natural resources with limited development interventions (Sejian, 2013). In addition to negatively affecting the available feed resources for livestock, climate change affects animal growth, reproduction, and health of animals resulting in economic losses (Marai *et al.,* 2007; Craine *et al.,* 2010;). Several studies have demonstrated the effect of climate change on feed production and farming practices, leading to reduced quantities and quality of feed available for livestock (Thornton & Herrero, 2010; Wheeler & Reynolds, 2012). Ruminant livestock on the other hand are said to contribute to a higher concentration of greenhouse gasses which accelerate the negative impacts of climate change (Sejian *et al.,* 2012). Small ruminants are reported to contribute to an estimated 6.5% greenhouse gas emissions globally (FAO, 2016). Improving the production efficiency of small ruminants through better management and higher product output per unit of input could reduce their green-house gas emissions (Marino *et al.,* 2016). Small ruminants, notably goats are the most versatile ruminant species with unique characteristics which enable them adapt to climate change (Pragna *et al.,* 2018). These include characteristics of thermotolerance, drought tolerance, efficient utilization of poor quality pasture, and the ability to thrive in areas of feed scarcity (Silanikove, 2000; Kosgey *et al.,* 2008; Yami *et al.,* 2008; Yadav *et al.,* 2013).

2.4 Small ruminant productivity indices

The value of a species in livestock production increases in relation to its ability to make a socio-economic contribution and its potential for improving productivity (Devendra, 1999). Productivity can be measured by the animal's reproduction, growth, and the quantity and quality of products. The increasing human population coupled with changes in eating patterns is likely to increase demand for livestock products that will be met through an increase in productivity (Herrero & Thornton, 2013). There exists a gap in demand and supply of livestock products that needs to be bridged (Kebebe, 2019). Livestock productivity is affected

by both genetic and environmental factors (Greyling, 2000). Several studies have proposed the improvement of small ruminant productivity, especially in smallholder systems as a means of safeguarding the livelihoods of communities facing environmental challenges (Mwacharo & Drucker, 2005; Sahoo *et al.*, 2013). Determining production indices in small ruminant populations provides evidence for potential product output to meet the growing demand. Fertility indices include the rate at which animals reproduce and how many survive to reproduction age, while growth indices include rates at which animals gain weight at different stages of life (Cloete *et al.*, 2000).

2.4.1 Fertility Indices

Livestock production efficiency is to a large extent dependent on the reproductive performance of the livestock populations (Chukwuka *et al.*, 2010). Reproductive performance in small ruminants entails parameters such as conception rate, litter size, weaning rate, and mortality rate (Cloete *et al.*, 2000; Song *et al.*, 2006). It is a composite of several processes that are influenced by environment, development, genetic and management factors (Greyling, 2000). Reproductive traits such as age at first conception, age at first lambing/kidding, and lambing/kidding interval vary greatly due to non-genetic or environmental factors (Joshi *et al*., 2018).

Fertility, reflected by the number of ewes/does lambing/kidding per lambing/kidding opportunity (Hunter, 2010) is influenced by among other factors good feeding which results in increased egg shedding and a higher lambing/kidding percentage. The inherent genetic potential of the animals also affects their fertility, as some animals may be naturally infertile (Petrovic *et al.*, 2012). The expression of the genetic potential in reproduction by female animals is influenced by environmental factors such as climatic conditions, management,

health, nutrition, age and weight of the ewe/doe, and fertility and libido of the ram/buck (Gardner *et al.,* 2007; Shrestha *et al.,* 2012; Joshi *et al.,* 2018).

The reproduction rate in a population refers to the number of lambs/kids weaned per ewe/does mated per annum. Flock reproductive rates affect the selection intensity and the rate of genetic improvement in the selected traits (Abegaz *et al.,* 2002). Despite the high reproductive potential of many indigenous breeds of livestock, there is low productivity due to reproduction wastage (Mukasa-Mugerwa et al.,1992). Increasing the reproduction rate spreads the maintenance cost of breeding females, increases the availability of replacement animals and animals available for sale (Abegaz *et al.,* 2002; FAO, 2009; Holland & McGowan, 2018).

Conception rate

Conception rate is defined as the number of pregnant ewes/does per ewe/does mated is influenced by management and environmental factors which account for up to 96% of the variation seen (Mufti *et al.,* 2010). Environmental factors if not well managed result in metabolic disorders, challenges in reproductive health, heat detection and insemination practices (Kathy, 2004). Balanced feed rations have been shown to improve reproductive efficiency as feed directly affects body mass which in turn affects conception rates and overall lifetime productivity (Kolachhapati, 2005; Delgadillo & Martin, 2015;).

A study in Horro sheep showed that animals with very low weights had low conception rates, however as body weight increased, conception rates tended to improve (Abegaz *et al.,* 2002). Animals also tend to have higher weights in the second to fourth parity, and as a result have a higher rate of ovulation from the well-developed reproductive system (Khan *et al.,* 2015; Segura-Correa *et al.,* 2017). This however declines as the dams grow older. Flock management practices that enable producers retain a larger proportion of dams in the second

to fourth parity at mating should receive due consideration in order to improve conception rates (Abegaz *et al.*, 2002). Assisted technology such as oestrus synchronization and artificial insemination can be adopted as options for improving conception. Seasonal breeding in small ruminant flocks may increase conception rates as the dams are given more time to be in good body condition prior to mating.

Age at first lambing

An early age at first lambing/kidding and short lambing/kidding interval translate to better lifetime productivity (Shrestha & Pokharel, 2012). Small ruminants lambing/kidding early in life are reported to have longer lactations and higher milk yields compared to those lambing/kidding for the first time when they are older (Mioč *et al.*, 2008). The availability of sufficient feed for growing animals results in early sexual maturity and adult female animals that are well fed cycle faster following lambing (Parajuli *et al.*, 2015)**.**

In Southern Ethiopia, different ages at first lambing have been reported for sheep in three agro-ecological zones, whereby sheep in midland areas lambed at an earlier age (400.7±8.11 days) than in lowland and highland areas (412.3±3.05 and 411.4±4.23 days respectively) (Hussein, 2018). Differences reported for goats in the study by Hussein (2018) reflected a lower age at first kidding for animals in the lowland areas (385.6±4.31 days) relative to those from midland areas (408.6±7.75 days). In extensive production systems found in Arid areas of Northern Kenya, the average age at first kidding in goats was recorded to be 18 months (540 days), but this varied depending on the climatic conditions. In dry years, does have a later age at first kidding compared with those in wet areas which kid at an earlier age lower than 18 months (Warui *et al.*, 2007).

Average litter size and weaning rate

The number of lambs/kids born per ewe lambing/kidding (litter size) is highly influenced by the breed of the animal and the weight at mating and age of the of the dam (Abegaz *et al.*, 2002). The average litter size increases with age and parity due to increased ovulation rate and uterine capacity, traits that constitute the reproductive ability of the dam (Fahmy, 1990). Like other reproductive traits, litter size in indigenous sheep breeds of Ethiopia is reported to have a low heritability making genetic improvement for this trait through direct selection to be very slow. The average litter size reported for local goats in extensive production systems in the Arid areas of Northern Kenya is 1.02 kids per doe (Warui *et al.*, 2007). In semi-Arid environments of Kenya, the average litter size for exotic Toggenburg goats, indigenous Galla goats, and their crosses is reported to be 1.00, 1.291±0.03, and 1.255±0.02 respectively (Ndeke *et al.*, 2015).

The number of lambs/kids weaned per lambs/kids born in a year (weaning rate) depends on the average litter size and the mortality rate in a given flock. Small ruminant production in the traditional extensive production systems is characterized by very low weaning rates (Sebei *et al.*, 2004). Weaning rate is affected by genetic, environmental, and management practices (Peacock, 1996; Joshi, 2018).

High mortality among lambs/kids and slow growth among those that survive are the critical constraints to small ruminant production (Sebei *et al.*, 2004). High mortality has been reported to be greatly influenced by the environment (Merkine *et al.*, 2017). In Ghana, Sahelian lambs born in the dry season have been reported to have higher mortality rates (35%) compared to those born in the rainy season (25%). This is due to shortage and poor quality of feed hindering the ability of ewes to produce adequate milk for lambs leading to malnutrition, and stress (Turkson & Sualisu, 2005). Pre weaning mortality rates of 3.8% have

been reported in Gabra and Rendille goats raised under extensive production systems in Northern Kenya (Warui *et al.,* 2007). In Adamitulu Ethiopia, high mortalities for kids have been reported in the first month of birth (Petros *et al.,* 2014). A higher pre-weaning mortality rate was reported for lambs/kids born from dams in parities later than the fifth due to reduced milk yield from the old animals (Chowdhury *et al.,* 2002; Zeleke, 2007). Dams with low milk production may be unable to provide adequate nutrition especially in twin birth leading to malnutrition and low immunity thus high chances of mortality. In environments where little or no supplementation is provided for the animals, multiple born offspring struggle for food since the mother has to suckle many offspring, while the single born animals get more nourishment (Parajuli *et al.,* 2015). Hailu *et al.,* (2006) also reported lower survival rates for Borana and Arsi-Bale kids born in the dry season (<20%) than those born in wet seasons (42%) due to differences in feed availability.

Diseases such as pneumonia and nutritional disorders have also been reported to cause mortality in lambs/kids (Donkin & Boyazoglu, 2004). In Gabra and Rendille goats in Northern Kenya post weaning mortality rates of 27.8% and 16.7% have been reported (Warui *et al.,* 2007). These deaths were mainly associated with diseases and drought (Warui *et al.,* 2007). Lamb/kid mortality results in reduced economic returns from small ruminants, and affects the genetic progress in populations (Petros *et al.,* 2014). The survival of lambs/kids ensures high productivity and greater economic returns. Other factors that affect the survival of lambs/kids include their birth weight and the mothering ability of the dam (Mustafa *et al.,* 2014; Subramaniyan *et al.,* 2016). Lambs/kids with very low weights at birth also tend to have lower survival rates (Lehloenya *et al.,* 2005).

2.4.2 Growth Indices

Growth, described as a change in volume, size, and shape over time is an important characteristic in the production of meat sheep and goats (Lupi *et al.,* 2015). Growth is an important indicator of animal productivity (Belay & Taye, 2013; Thiruvenkadan *et al.,* 2009). In traditional production systems found in many countries of Africa, productivity in terms of growth tends to be very low (Safari *et al.,* 2005; Ojango *et al.,* 2016; Mayberry *et al.,* 2018) leading to low meat supply. The gap between demand and supply of meat can be bridged by improving the growth performance of animals (Thornton, 2010; Sarma *et al.,* 2019).

The growth performance of an animal is a function of its genetic merit and the environment (Al-Shorepy *et al.,* 2002; Alade *et al.,* 2008). Environmental factors affecting growth impact the ability of the animals to express their real genetic potential (El-Hassan *et al.,* 2009). Growth rate is affected by the breed of the animal, maternal traits such as age and size, nutrition available, sex of the lamb/kid, the prevailing climatic conditions, and whether or not the animal is born as a single animal or in a multiple litter (Murithi *et al.,* 2002; Fasae *et al.,* 2012; Deribe & Taye, 2013). Information on animals' growth rate is important when selecting for improved meat productivity (Lupi *et al.,* 2015). Management of nutrition, prevention of stressful environments, and ensuring good health of animals collectively favour optimal growth rates and ultimately improvement in meat and carcass quality (Casey & Webb, 2010).

Growth traits of interest in small ruminant production are weights at birth, weaning and at maturity, and the growth rates between the different ages (Kolachhapati *et al.,* 2012). Galla does have been reported to be 15% heavier than Small East African. The mature weights of the two breeds have been reported to be 31Kg and 35kg respectively (Ruvuna *et al.,* 1991). Other studies have reported different average daily weight gains for Galla goats fed by

various feeds in 12 weeks duration with the highest gain being 45.21g/day (Ngila *et al*., 2017). In Eastern Kenya mature weights of 25Kg, 45Kg and 65Kg were reported for Small East African, Galla*Small East African cross and Galla breed respectively (Njoro, 2001). Studies done in Mozambique and Kenya have reported the mature and yearling weight of Blackhead Persian and Red Maasai breeds to be 15Kg and 36Kg respectively (Rocha *et al*., 1990; König *et al*., 2017).

Weights at birth, weaning, and maturity

Birth weight is important in evaluating the breeding potential of livestock as it affects the survival of the animal. The weight of an animal at birth is strongly correlated with growth rate and adult size (Fasae *et al.,* 2012). Environmental factors, notably the prevailing climatic conditions tend to influence the weight of animals at birth. Lambs/kids born during wet seasons are reported to have higher birth weights than those born in dry seasons as the ewes/does get better nutrition in the last stage of pregnancy during wet seasons (Soundararajan *et al.,* 2006; Tibbo, 2006). The weight of the dam is also reported to affect the weight of newborn. Lambs/kids born to heavier dams are heavier than those from light-weight dams (Ahuya *et al.,* 2009). Birth weights for small ruminants are reported to range from 1.68 to 2.87 Kg in goats in West Africa (Fasae *et al.,* 2012). In the South Omo zone of Ethiopia, crosses between Boer and the local breed are reported to have birth weights of 2.89±0.38Kg (Girma, 2016).

Weaning weight is an important parameter in determining the production potential of small ruminants as it has a high relative economic importance in defining the market value for animals and in the selection of breeding stock (Nugroho *et al.,* 2018). It is influenced by genetic, physiological, and environmental factors (Mandal *et al.,* 2006). Several studies have

reported weaning weights to be influenced by factors such as year of birth, sex of lambs/kids, type of birth and breed (Sebei *et al.*, 2004; Browning & Browning, 2011; Oyebade *et al.*, 2012; Nugroho *et al.*, 2018).

The weight of animals at maturity is important as it marks the weight at which the animals can be sold. In small ruminants raised in tropical environments, maturity is achieved from 9 to 12 months of age (Smith *et al.*, 2004; Kosgey, 2004). However, under extensive and semi intensive production systems in developing countries, indigenous small ruminant breeds have been reported to take a very long time (3 to 4 years) to attain market weight compared to the improved breeds (Abraham *et al.*, 2018; Nirajan *et al.*, 2019).

Annual and seasonal differences in precipitation influence availability of pastures for animals, which affects growth. Male animals also tend to grow faster than females of the same age group, hence generally have higher weights at weaning and maturity (Nugroho *et al.*, 2018). Across different production systems, improved exotic breeds of small ruminants and their crosses are reported to have higher weaning and yearling weights than the indigenous breed (Murithi *et al.*, 2002; Oyebade *et al.*, 2012).

Growth rates at different stages

The average weight that an animal gains each day characterizes its growth rate (Pulina *et al.*, 2013). Growth rates differ depending on the stage of growth, hence, is generally measured prior to weaning (pre weaning average daily gain) and from weaning to maturity (post weaning average daily gain). As with the weights at specific ages, the average daily gain is influenced by genetic, physiological, and environmental factors (Alemneh and Getabalew, 2019) including climatic conditions, breed, age of dam, sex of the animal, type of birth and rearing and the nutritional status of the dam (Neopane & Pokharel, 2008; Zahraddeen *et al.*,

2008; Fasae *et al.,* 2012; Sapkota *et al.,* 2012; Bhattarai *et al.,* 2016). The availability of nutritious fodder ensures that the dam is well nourished and can provide adequate milk to the young ones to enable good growth rates (Neopane & Pokharel, 2008). Male animals tend to be more aggressive at suckling and feeding, and with their innate genetic potential for growth, tend to gain more weight than the female animals especially pre-weaning (Sapkota *et al.,* 2012). Management practices that enable dams to be in good body condition prior to lambing/kidding such as steaming up and provision of supplements help to boost growth rates of young animals.

2.5 Contribution of small ruminants to smallholder household economies

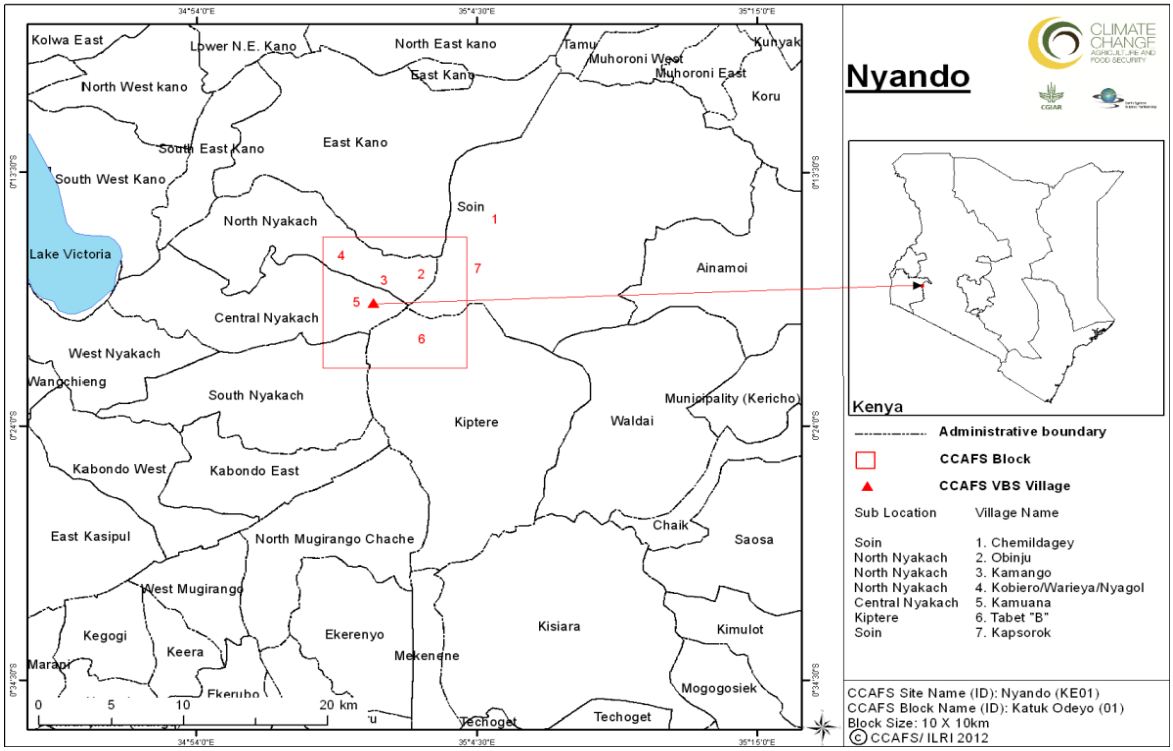
Small ruminants contribute significantly to the livelihoods of smallholder farmers as they improve food security through enabling farmers generate income from sale of livestock products (Legesse *et al.,* 2010; Bettencourt *et al.,* 2015; Wodajo *et al.,* 2020). Potentials of small ruminants are however often undervalued (Kumar & Roy, 2013). Several studies reflect the role of small ruminants in the provision of household incomes for smallholder farmers (Peacock, 2005; De Vries, 2008; Kumar & Roy, 2013). Small ruminants have been reported to contribute up to 63% of the household incomes for farmers in Egypt (Metawi, 2015) and up to 39.7% of incomes for farmers in Ethiopia (Legesse *et al.,* 2010). In Nigeria and Tanzania they are used as a resource to meet household needs such as the purchase of food, payment of school fees, and emergency needs such as hospital bills for up to 67.5% of smallholder farmers (Chenyambuga *et al.,* 2012; Oluwatayo & Oluwatayo, 2012). Interventions to help improve the incomes from small ruminants should emphasize measures that improve efficiency in productivity rather than keeping larger numbers of animals (Muigai *et al.,* 2017).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Description of the study area

The study was carried out in Kisumu and Kericho Counties of Lower Nyando (Figure 1) located in the plains of Lake Victoria. The study site covered an area of 100km^2 known as Nyando block, with a population density of >400 persons/km^2 being the highest populated rural locality in East Africa (Recha *et al.,* 2017). The area receives bimodal rainfall, with annual mean rainfall ranging from 1100mm to 1600mm. The long rains occur between March and May and short rains between September and November. The maximum and minimum temperatures range from 19-27°C and 5-12°C respectively (Raburu & Kwena, 2012).

Seven villages namely Kamuana, Kamango, Kobiero, and Obinju in Kisumu County and Chemildagey, Kapsorok, and Tabet "B" in Kericho County were selected for the study. The study location was selected based on observation by CCAFS Program as a principal hotspot for climate change mitigation and food insecurity in the East African highlands (Ericksen et al., 2011). The project is part of an on-going program that seeks to improve the livelihoods of smallholder farmers grouped in communities to implement improved agricultural practices termed "Climate Smart Villages" (CSV).



Source: **CCAFS 2011 Baseline Survey** (Mango *et al.*, 2011)

Figure 1. Map of Nyando showing study sites

3.2 Household sampling

A total of 162 farmers from Kericho and Kisumu Counties were sampled for this study based on their ownership of either of the sheep, goats, or both (77 in Kericho and 85 in Kisumu). All households having any of the introduced improved sheep and goat breeds were included in the study. The households sampled were in the seven CSV of Nyando currently involved in the project on sheep and goat improvement. In the initial design of the CSV, 139 households were randomly selected from seven villages which in turn were randomly selected from 106 villages within a 10×10 km^2 block of land in the Nyando basin of Lake Victoria. The sample size was chosen to enable CCAFS measure changes in a series of pre-determined indicators over a 5-to-10 year period (Mango *et al.*, 2011).

3.3 Data Collection

3.3.1. Contribution of small ruminants to household incomes of smallholder farmers in "Climate Smart Villages" of Nyando.

Data was collated using a cross-sectional survey that was conducted in the months of November and December 2018. A detailed questionnaire was developed and used to obtain information from farmers through enumerators engaged by the CCAFS project on sheep and goat production. The questionnaire developed is presented in Appendix 1. The information from the farmers was obtained using the "Open Data Kit" (ODK) information technology platform (https://opendatakit.org/) for paperless data capture. This enabled direct entry of information provided by each household in an electronic format to a central database. Information was obtained from either the head of the household, spouse or a household member above 18 years.

The questionnaire captured information on farmer demographic characteristics, total livestock holdings, resource endowment, and key factors influencing costs and revenues in sheep and goat production. Information collected included the number of animals sold in 2018, prices of the animals by age and sex groups, distribution of sales over seasons comprising 2-3 month periods in the year, and reasons for sale. The questionnaire developed was the third in a series of structured questionnaires implemented in the CSV since 2014 that focused on sheep and goat productivity in Nyando. Information obtained from the individual farmers was verified at the community level through focus group discussions held with the community members in 2019. Farmers were grouped into the three community-based organizations (CBO) which are based in the area. The farmers selected within themselves 30 farmers per CBO, then 5 farmers per group within the CBO.

3.3.2. Growth performance of small ruminant breeds in "Climate Smart Villages" of Nyando

The sheep and goats reared in Nyando were housed in elevated wooden structures for the night and left to graze in fields once crops were harvested or were tethered within the farmers premises. Details on the differential management practices adopted by the farmers in Kisumu and Kericho counties were obtained. The main goat breeds reared were indigenous Small East African, introduced Galla, and crosses between the two breeds, while the sheep breeds comprised local non-descript animals, indigenous Blackhead Persian, introduced Red Maasai and Red Maasai Dorper crosses, and crossbreds among the various breeds. The introduced sheep and goats with their offspring were identified using ear-tags. All kids/lambs born within the flocks following the introduction of new breed-types were tagged and their growth performance was monitored by weighing using a portable 100kg hanging scale at birth and subsequently every 3 months until the age of one year. The weights were monitored from 2014 to 2019. The data were collated using a paperless data capture tool developed for ODK (Appendix 2) and stored in a MySQL database.

3.4 Data Analyses

3.4.1 Contribution of small ruminants to household incomes of smallholder farmers in "Climate Smart Villages" of Nyando.

Analysis to characterize the sheep and goat production systems was carried out using STATA Version 15.1. STATA is a consistently structured and integrated statistical software ideal for developing and advanced statistical procedures (Acock, 2005). The analyses entailed generating descriptive statistics on farmer demographic characteristics and key resources available for sheep and goat productivity; sheep and goat flock characteristics and the dynamics in the flocks reared; management practices for sheep and goat production. Analysis

of information on sheep and goat flock characteristics took into consideration differences in the gender of the household head as this has been shown to significantly influence management decisions in the smallholder farming systems (Ojango *et al.*, 2016). Variation in practices were analyzed and tested for significance using either Chi-square ($\chi 2$) or t-tests. The data generated from the description of the farming systems were then used together with information on costs of different inputs and revenues from sales of sheep and goat products in Kisumu and Kericho Counties to determine the cost of sheep and goat production in the smallholder farming systems.

3.4.2 Growth performance of small ruminant breeds in the smallholder farming systems in "Climate Smart Villages" of Nyando

The data collected on weights at different stages of growth on animals born for a period of five years from 2015 to 2019 were analyzed using STATA Version 15.1. The growth rate of the introduced breeds against that of existing indigenous animals at different stages of growth was evaluated. This entailed evaluation of variation in weights at 3 months, 6 months, 9 months, and at one year of age. A total of 2231 records were available for analyses, 1,008 on sheep, and 1223 on goats. Variations in live weight for the different sheep and goat breeds within the Kericho and Kisumu Counties were analyzed and tested for significance using either Chi-square ($\chi 2$) or f-statistic.

The average daily gain was calculated as;

$$ADG_{t1-t2}=(Wt_2-Wt_1)/t_2t_1 \qquad \text{Equation 1}$$

Where; ADG_{t1-t2} is the average daily gain in weight at different times (t_2 and t_1, t_{i-n}= birth date, weaning date, 6-month date, 9-month date, and yearling date)

Wt_1 is the weight at age t_1

Wt_2 is the weight at age t_2,

t_2t_1 is the number of days between t_1 and t_2.

A general linear model was used to evaluate the variation in growth resulting from different environmental factors (County, year of birth, sex, and breed). Growth at different stages and the average daily gain were analyzed separately for the sheep and goats using the general model:

$$Y_{ijkl}=\mu+ C_i + B_j+ S_k + e_{ijkl} \quad \text{Equation 2}$$

Where:

Y_{ijkl}=Trait of animal l (Traits were birth weight, weaning weight, 6-month weight, 9-month weight, yearling weight and average daily gain from birth to yearling)

μ=Overall mean for a given trait

C_i= Fixed effects of County (*i*=Kericho, Kisumu)

B_j= Fixed effects of the breed of the animal (*j*= **Sheep breeds**: Indigenous, Red Maasai, Red Maasai x Dorper, Red Maasai x Indigenous; **Goat breeds**: Small East African, Galla Pure, Galla x Small East African)

S_k=Fixed effects of the sex of the animal (*k*=Male, Female)

e_{ijkl} = Residual variance

The resultant least square mean weights at different stages of growth for the different breed-groups were used to plot growth curves for the different breeds of each species.

3.4.3. Costs and revenues in sheep and goat production

Costs of production and revenue streams for the farmers from sheep and goats over a 12 month period were determined from responses in the questionnaire (Appendix 1). Costs of production were based on prices for inputs supporting sheep and goat production in 2018, while revenues comprised income from the sales of sheep and goats and their products, and home consumption in the same year. New born lambs and kids on the farms provided a

potential revenue stream, but as they were reared on the farms for the period of the study, they contributed to the costs of production.

Costs were categorized as either fixed or variable (Table 1). Fixed costs are the costs incurred at the outset of an enterprise and do not vary with production levels, while variable costs fluctuate over time. The farmers provided information on the prices at which they sold their animals in 2018 in addition to details on animals consumed at home. The value of animals consumed at home was assumed to be equivalent to the farm gate price for the given animal.

Table 1. Factors contributing to costs of production and revenues in sheep and goat production in Nyando

Factors affecting costs of production	Factors contributing to revenues
Fixed costs • Family labour *Variable costs* • Water • Animal health services • Animal replacement/mortality • Breeding	• Sales of live animals • Sales of milk • Sales of manure • Value of animals consumed at home • Value of milk consumed at home

Land holdings in Nyando were very small (0.1-3ha), and thus there was no land set aside specifically for sheep and goat production. Costs of factors with low-input demand in traditional production systems are generally assumed to be negligible (Turkson & Naandam, 2011). In this study, the costs associated with land, depreciation of tools, equipment, and sheep and goat housing were assumed to be negligible.

Feed resources for sheep and goat production in the study area comprised of natural pasture, crop residues, and household waste. There were no feed purchases within the study area and a common feeding cost was assumed across the farms. Feeding cost was therefore not included in the model. Costs for water provision included costs incurred in the purchase and transportation of water as noted by the livestock keepers. Animal health costs were computed from the actual costs of veterinary inputs and services provided for sheep and goat

production. Animal replacement costs were derived from reported statistics on mortality within the flocks (Ojango *et al.,* 2016), and animals purchased purposely for flock replacement within a year. Estimation of the value of dead animals was based on farm gate prices depending on the age of an animal. Breeding costs entailed costs incurred in the purchase and hiring of animals for mating.

Majority of the households (99%) did not have hired labour for the management of their sheep and goats as these animals were mostly managed by family members. The costs related to hired labour were therefore found to be negligibly and was therefore excluded from the study. The opportunity cost of family labour was computed as a fixed cost. Family labour costs for an adult family member was valued as half of the casual wage. This was based on the assumption that the opportunity cost of family labour is below the wage rate since off-farm employment was not constantly readily available (Staal *et al.,* 2003; Legesse *et al.,* 2010). Labor by children was mainly for herding sheep and goats and was calculated as a quarter of the waged labor as proposed in a study by Zegeye *et al.,* (2000).

The milk produced by the goats was primarily for household consumption with small quantities sold at the farm gate. All the milk produced was valued at the farm gate price. Manure from the animals was mostly used on the farms with minimal sales. There was, however, no specific price for a given quantity of manure, ranging from 0.05 to 0.25USD per wheelbarrow. The income was therefore assumed to be negligible.

Net income from sheep and goats was segregated by land holdings, flock size, and flock structure and was calculated as total gross revenues minus total costs;

Net sheep and goats' returns= (Revenue) - (Total fixed Costs + Total variable costs)

Equation 3

The impact of different factors within the systems on the costs and revenues of production of sheep and goats was evaluated using regression analyses. The model incorporated fixed effects and their interactions as follows;

$$Y_{ijkmn}=\mu+C_i+G_{k:\,i}+S_{k:i+}\,F_{l:i}+\,H_{m:\,i}\,+\,(GF)_{jl:i}\,+\,(GH)_{jm:i}\,+e_{ijklmn}$$ Equation 4

Where:

Y_{ijklmn} =The cost of production /returns from observation *n* in KSH (Kenyan Shilling, Currency)

µ=overall mean cost/ return

C_i= County (*i*= Kisumu, Kericho)

$G_{j:i}$= Gender of the farmer within the county *i* (*j*= Female, Male)

$S_{k:i}$=Education level of the farmer within the county *i* (*k*=Non formal, primary, secondary and tertiary)

$F_{l:\,i}$= Size of the land holding within the county *i* (*l*=4, <1, 1-3, 3.1-5, >5 hectares)

$H_{m:\,i}$= Flock size within the county *i (m*= 1-5, 6-10, 10-15, >15 animals)

$(GF)_{jl:i}$=Interaction between gender of the farmer and land holding within the county *i*

$(GH)_{jm:i}$=Interaction between gender of the farmer and flock size within the county *i*

e_{ijklmn} = residual

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Characteristics of the farmers

The demographic characteristics of the sampled households are presented in Table 2. A larger proportion of respondents interviewed in the two Counties were men. There were more households headed by men in both Counties with the ratio of male: female household heads differing significantly (P<0.01) between the Counties (Table 2). Women heading households were either widowed or single mothers. Majority of the families (68.7%) were headed by people older than 45 years. This demographic was similar to results from a study by Guo *et al.,* (2015) who noted that the elderly form the largest population of the worlds' agricultural work force. A report by FAO, (2017) indicated that the population structure in rural areas is greatly affected by rural to urban migration. Often young and energetic people in rural areas move to urban areas in search of employment, leaving the elderly and weak individuals in charge of the farming activities. This may in the long term negatively impact Agricultural productivity.

Table 2. Demographic characteristics of households in Kericho and Kisumu

County	**Kericho (N=77)**		**Kisumu (N=85)**	
Gender of household head	**Female**	**Male**	**Female**	**Male**
Proportion of households (%)	11.7%	88.3%	37.6%	62.4%
Age group of the household head (%)	**Proportion within gender groups**			
Elder (>45 years)	66.7%	54.4%	78.1%	75.5%
Young adults (21-45 years)	33.3%	45.6%	21.9%	24.5%
Education level of the household head (%)				
Non-formal education	77.8%	32.4%	31.3%	1.9%
Primary and Secondary education	22.2%	54.4%	65.6%	79.2%
Tertiary Education	0.0%	13.2%	3.1%	18.9%

The education levels achieved by household heads were higher in Kisumu than in Kericho County (P<0.01), with a greater proportion having at least secondary education. Education levels affect livestock production in that, farmers with higher education levels are more likely to adopt advanced agricultural technologies when compared to those with low education

levels. The average household size for Kericho (4.9±1.7) and Kisumu (4.1±2.3) did not differ significantly. A study conducted in Abia Estate in Nigeria revealed productivity of small ruminants to be highly affected by the age of the farmer and household size. Large sized households and those with young members had energetic and readily available labour force for their animals therefore high productivity (Offor *et al.,* 2018). Further, they reported small ruminant enterprises to be a laborious activity especially to the elderly leading to a negative effect on the output.

The integration of crop, livestock, and poultry production was the core economic activity for household heads in this study (Figure 2). Farmers, especially in Sub-Saharan Africa (SSA), adopt agricultural diversification approaches as a way of strengthening resilience and improving food production (World Bank, 2019). According to Gollin, (2014) agriculture practices incorporating sheep and goat production in addition to other enterprises are a key source of livelihood to the smallholders.

Off-farm activities such as non-agricultural formal employment and business activities (formal and informal) served as an alternative economic activity for the household heads in Nyando.

In Kisumu, a significantly greater proportion of men heading households participated in alternative economic activities than women who headed households ($P<0.01$) as compared to Kericho (Figure 2). In the community focus group discussions, it was reported that fewer women had the opportunity to engage in non-agricultural income-generating initiatives. In SSA women are expected to be responsible for basic household duties, besides being actively engaged in agricultural related labor-intensive activities (Peterman *et al.,* 2013; World Bank, 2014; FAO, 2015).

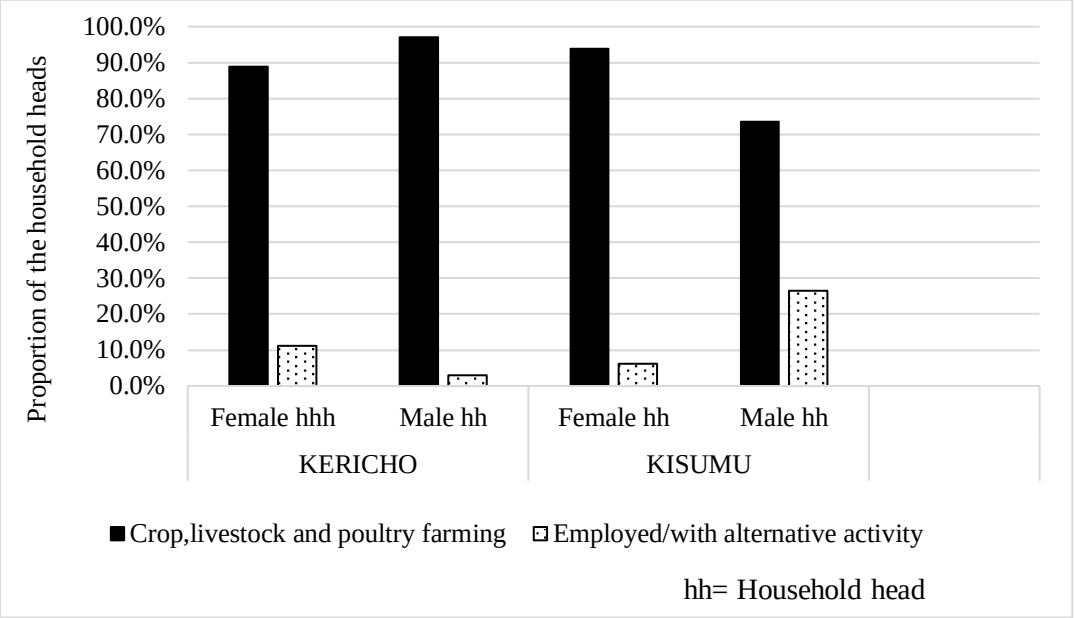


Figure 2. Proportionate participation of household heads (HH) by gender groups in various economic activities in Kericho and Kisumu Counties

4.2 Resource ownership and use by farmers in Nyando

4.2.1 Land ownership

The sizes of land owned disaggregated by gender of the household head, and the allocation of land to different farming activities by households in Nyando is presented in Table 3.

Table 3. Average land size owned, and use, categorized by gender of the household head (hh) in Kericho and Kisumu Counties

	Kericho				Kisumu			
Gender of hh	Female		Male		Female		Male	
Land use	Average size±SE	Proportion of hh	Average size±SE	Proportion of hh	Average size±SE	Proportion of hh	Average size±SE	Proportion of hh
Arable	2.0±0.5	39.1%	2.4±0.1	41.0%	1.3±0.1	50.0%	1.1±0.1	49.1%
Forest	1.2±0.7	17.4%	1.4±0.2	16.9%	0.3±0.2	9.4%	0.4±0.2	11.1%
Grazing	2.5±0.5	43.5%	2.2±0.1	42.1%	0.4±0.1	40.6%	0.7±0.1	39.8%
Overall size	2.1±0.5		2.2±0.1		0.9±0.1		0.9±0.1	

Land is the key resource for small ruminant production. Land holdings were significantly larger in Kericho with an average size of 2.2±0.2 ha than in Kisumu 1.9±1.7 ha ($P<0.01$). In Kericho, the population density tended to be lower compared to Kisumu in agreement with the projections of 374 persons/Km^2 and 602 persons/Km^2 respectively by KPHC (2009). Seventy percent of the interviewed households had title deeds to their land. Security of land tenure is important for sustainable land use as the producers tend to invest more in what they own. Where tenure is assured, the land owners more readily invest in infrastructure, adopt technologies, and use improved management approaches in their enterprises (Kisamba-Mugerwa *et al.,* 2006).

In both Counties, 75% of the land was reported to be owned by men, and differences in land size owned depending on the gender of the household head were not significant. This is because in most scenarios the land owned by women was inherited from their spouses after their death. Other studies have reported that in African settings there may be biases against women, restricting them from owning and inheriting land (Oluwatayo & Oluwatayo, 2012; Njuki *et al.,* 2013; Deininger *et al.,* 2017). Land in Nyando was used for both arable and grazing activities with no significant differences in use depending on the gender of the household head. Population growth has exerted a lot of pressure on land, leading to farmers allocating less land to livestock production as a single commodity (Nyariki *et al.,* 2017).

4.2.2 Water sources

Sources of water for both the household and livestock use in Nyando are presented in Figure 3. Water for livestock was mainly obtained from the rivers in Kericho County, and either from a water company or harvested from rainwater in Kisumu County (Figure 3).

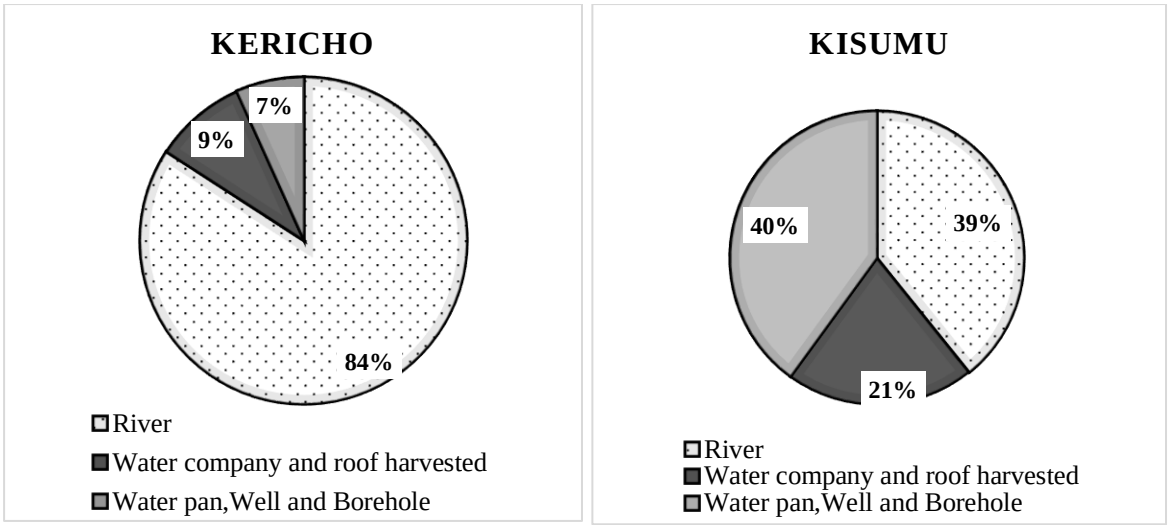


Figure 3. The proportionate contribution of different sources of water to households in Kericho and Kisumu

Availability of water is vital for sustainable livestock production as it plays a crucial role in physiological and reproduction processes. There were significant differences in access to water depending on the season (P<0.01). Masese *et al.*, (2008) reported that water availability was a challenge in Nyando area due to increased drought occurrences resulting from climate change. Restricted water intake in livestock leads to limited feed intake affecting their productive potential (Beede, 2012). The livestock keepers in both Counties walked for longer distances in search of water for their livestock during drier seasons (1.3±0.9 Km) than rainy seasons (0.8±0.5Km). Sejian *et al.*, (2012) reported that long walking distances by animals lead to weight loss, and in the long run, may affect market weight. The worst scenario occurs when in addition to limited water there is limited feed intake as the animal tends to utilize body reserves on the physical activities.

4.2.3 Ownership of various livestock species

The proportion of different species of livestock reared by the farmers in Nyando differed significantly (P<0.01) between the two Counties as shown in Figure 4. In both Counties,

farmers kept at least 3 livestock species. Poor smallholder farmers keep multiple livestock species as a food security measure due to their provision of a wide variety of products including milk, meat, and eggs. The livestock also serves as a store of wealth, income generation, and enable the producers to spread their risks across assets (Perry *et al.*, 2002).

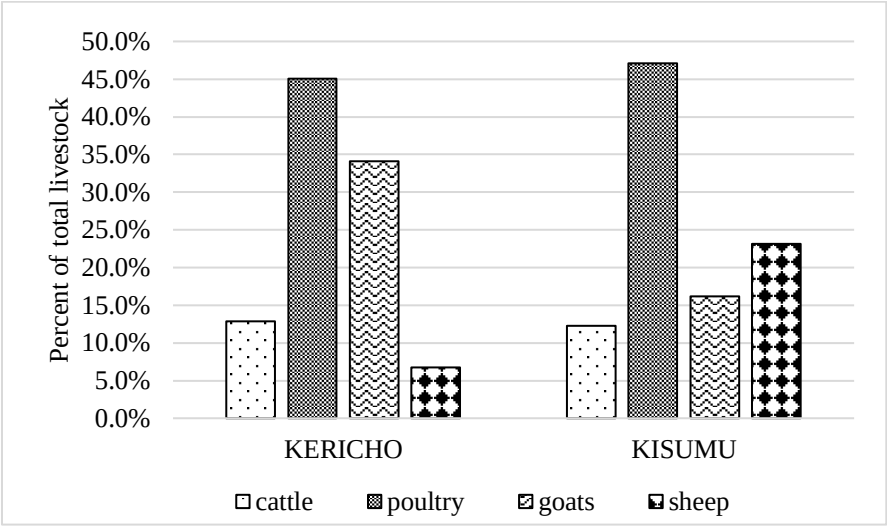


Figure 4. Proportion of livestock of different species kept by households in Kericho and Kisumu

In Nyando, sheep and goats were the second most frequent livestock reared after poultry (Figure 4). Several studies have elaborated on the importance of sheep and goats as a resource for poor smallholders through their adaptation to various climate risks, ability to maintain productivity even in extreme climatic conditions, emitting less methane, and resistance to parasites (Peacock, 2005; Monteiro *et al.*, 2017; Sejian *et al.*, 2018; Berihulay *et al.*, 2019). In Kericho County, farmers tended to keep more goats than sheep and vice versa in Kisumu County. As illustrated in Figure 4, farmers in both counties kept poultry. Poultry was also an important livestock in the area due to its high multiplication rate. When considering the ruminant livestock reared, in Kericho County, the households kept more goats followed by cattle then sheep, while in Kisumu County, farmers kept more sheep then goats and cattle. The data collected showed that women heading households kept a larger

proportion of poultry and sheep (66.7%) in both Counties. Other studies on smallholder production systems in Africa Ayoade *et al.,* (2009)and Kristjanson *et al.,* (2010) show that women tend to own livestock species that have a lower economic value such as poultry and small ruminants.

4.3 Sheep and goat production in Nyando

4.3.1 Flock size and structure

A total of 118 sheep and 960 goats were kept by the 77 households interviewed in Kericho, and 537 sheep and 301 goats were kept by the 85 households interviewed in Kisumu. The average flock sizes by land holding and gender of the household head are presented in Table 4.

Table 4. Average sheep and goat flock sizes reared by households with different land holdings in Kericho and Kisumu

KERICHO			**Average flock size (Mean±SE)**			
	Proportion of households headed by different gender groups		**Goats only**		**Sheep and Goats**	
Size of land holding	Female (N=9)	Male (N=68)	Female hh	Male hh	Female hh	Male hh
<1 ha	-	6.5%	-	4.0±0.3	-	6.0±0.0
1-2 ha	77.8%	59.7%	5.0±0.9	6.9±0.3	13.8±0.7	13.4±0.5
>2 ha	22.2%	33.9%	8.0±0.0	12.0±0.5	18.0±0.0	14.7±0.6

KISUMU			**Goats only**		**Sheep and Goats**		**Sheep only**	
Size of land holding	Female (N=32)	Male (N=53)	Female hh	Male hh	Female hh	Male hh	Female hh	Male hh
<1 ha	30.8%	32.6%	4.5±0.3	6.0±1.2	11.7±0.6	12.8±0.8	4.2±0.0	7.0±0.2
1-2 ha	50.0%	60.5%	4.5±0.8	6.8±0.8	13.4±0.1	16.2±1.2	11.3±1.2	-
>2 ha	19.2%	7.0%	6.0±0.0	10.0±0.0	11.0±0.9	17.0±1.5	10.0±1.9	15.0±3.2

Irrespective of the land size and the gender of the household head, all the farmers interviewed owned either sheep or goats or both sheep and goats. This indicated the importance of sheep and goats to the farmers in the area. Across the Counties, flock sizes tended to increase relative to the size of land holdings (Table 4). The average flock sizes in the two Counties

were 5.0±0.3 and 9.2±0.4 for sheep and 14.0±0.5 and 7.2±0.3 for goats in Kericho and Kisumu respectively. These flock sizes were larger than those reported for the households in 2014 by Ojango *et al.,* (2015), an indication of expansion of small ruminant production on the farms. From the FGD farmers attested that sheep and goats were easy to manage compared to cattle. In livestock keeping communities of Africa, the number of animals reared tends to be associated with the quantity of land owned (Gizaw & Tegegne, 2010). Studies on livestock ownership by gender indicate that women, especially those in rural areas generally keep less livestock than men (FAO, 2009).

The small ruminant species kept by the households in Nyando differed significantly depending on the gender of the household head. A larger proportion of male headed households 87.2% and 65.6% in Kericho and Kisumu Counties respectively owned goats relative to female headed households. Female headed households in Kericho also tended to keep both sheep and goats rather than single species flock ($p<0.01$, Table 4). In Kisumu County, differences in small ruminant species ownership by gender of the household head were not significant. A greater proportion of the households in Kisumu County kept flocks of a single species (either sheep or goats) compared to those in Kericho County.

The difference in species reared between the two Counties could be related to the diverse vegetation cover where the greater shrub vegetation found in Kericho County favors goat production, while the area with fewer shrubs and more grass vegetation of Kisumu County is more favorable for sheep production. The grazing behavior of sheep and goats is such that sheep tend to feed on grasses in a more controlled manner while goats are browsers and tend to spread out in search of shrubs, thus roam over larger areas (Agrawal *et al.,* 2014). Different values were also attached to sheep and goats by the two communities. In Kisumu County, the community has been reported to prefer sheep to goats (Ojango *et al.,* 2016) as part of their culture. However, farmers in Kisumu appreciate goats for their ability to control

bush encroachment on the land and produce milk for household consumption. Goats provide both milk and meat in diverse ecosystems and sustain lactations over long periods. This makes them an important asset in the climate challenged environments (FAO, 2017).

The structure of the flocks kept by the farmers is presented in Table 5 (sheep) and Table 6 (Goats). There were significant differences in animal numbers by age and sex, with mature female animals dominating the flocks for both species in the two Counties ($P<0.01$). The population structure of a flock is a key indicator of its production potential. Flocks with larger numbers of breeding females indicate good opportunities for multiplication of animals unlike flocks with a large number of mature males (Taye, 2008).

Table 5. Proportion of sheep of different categories kept within households headed by men and women in Kericho and Kisumu Counties

Gender of the household head	**Female**		**Male**	
Kericho	No. of households	Proportion of the flock	No. of households	Proportion of the flock
Mature Females	9	92.7%	30	62.9%
Immature females			13	3.0%
Mature Males			19	26.0%
Immature Males	2	5.5%	12	5.8%
Lambs	9	1.8%	3	2.3%
Kisumu				
Mature Females	32	66.0%	53	61.9%
Immature female	10	9.6%	24	10.1%
Castrates	8	6.8%	12	1.7%
Mature Males	16	5.4%	23	7.7%
Immature Males	5	6.8%	10	14.8%
Lambs	9	5.4%	13	3.8%

Table 6. Proportion of goats of different categories kept within households headed by men and women in Kericho and Kisumu Counties

Gender of the household head	Female		Male	
Kericho	No. of households	Proportion of the flock	No. of households	Proportion of the flock
Mature Females	9	51.1%	68	52.6%
Immature female	5	33.7%	25	14.4%
Castrates		0.0%	6	2.0%
Mature Males	4	10.5%	35	14.7%
Immature males	1	1.2%	27	14.4%
Kids	7	3.5%	10	1.9%
Kisumu				
Mature Females	13	41.4%	14	33.9%
Immature female	3	6.2%	6	4.3%
Castrates	1	0.6%	9	9.3%
Mature Males	2	11.7%	12	17.0%
Immature Males	4	8.0%	3	9.6%
Kids	6	32.1%	8	25.8%

Farmers in Kericho County kept a significantly higher proportion of rams ($p<0.01$) compared to those in Kisumu County (Table 5). In Kisumu County, more farmers castrated young male animals that were not earmarked for breeding (Table 5 and Table 6). These would be raised for sale in the markets as meat animals. During the FGD, farmers in Kericho County indicated that they raised mature male animals for sale to other farmers who would use them as breeding males. The movement of breeding males across the Counties was one way in which the farmers were able to reduce inbreeding within their flocks.

Notably, in Kericho County, female headed households did not have rams within their sheep flocks. Since the animals in the flocks from different households tended to meet at watering points, the farmers indicated that their sheep would be mated at the watering points. The farmers were however more specific in identifying bucks to mate their does, and in most cases kept their own breeding bucks (Table 6).This demonstrated that farmers in this area value goats than sheep.

The number of both male and female immature sheep and goats were low compared to other age and sex structures in both Counties (Tables 5 and 6). During the FGD, farmers reported

that they sold younger animals, and there was also some mortality in the young animals due to diseases and undernutrition as the mothers were not well fed due to recurrent droughts. Other studies (Alam, 2000; Amankwah *et al.*, 2012) have reported low proportions of young animals as a result of high offtake rates either through sale, or mortality. This has a negative effect on flock growth as it leads to a lower overall reproductive rate (Amare *et al.*, 2018). The flock structures and species composition on the smallholder farms in Nyando differed with the culture of the two different communities of Kisumu and Kericho and depending on the quantity of land owned.

4.3.2 Sheep and goat breeds reared

The different breeds of sheep and goats reared by farmers in Nyando are presented in Table 7. The Red Maasai and their crosses with Dorper sheep and Galla goat breeds introduced through the CCAFS project since 2014 have been widely adopted in the two Counties. The farmers also had other improved breeds and crosses of goats such as Alpine, Toggenburg, and Saanen although these were kept in small numbers (Table 7).

Table 7. The average flock sizes and proportion of male and female farmers keeping various sheep and goat breeds

		KERICHO (N=77)			KISUMU (N=85)		
		Proportion of Farmers			Proportion of Farmers		
	Breeds	Female hh (n=9)	Male hh (n=68)	Average flock size (Mean±SD)	Female hh (n=32)	Male hh (n=53)	Average flock size (Mean±SD)
Sheep	Red Maasai and crosses	71.4%	71.4%	3.4±3.2	70.2%	70.7%	3.1±2.9
	Local breed and crosses*	14.3%	25.7%	1.4±1.3	17.0%	25.3%	2.8±2.6
	Dorper and crosses	14.3%	2.9%	2.0±0.0	12.8%	4.0%	2.4±2.0
Goat	Alpine and crosses	5.0%	16.0%	7.8±5.0	0.0%	2.4%	12.0±6.1
	Galla and crosses	20.0%	8.0%	6.1±5.5	15.4%	18.1%	3.0±2.8
	Saanen and crosses	40.0%	20.7%	5.7±5.3	34.6%	27.6%	3.4±3.0
	Small East Africa & cross	5.0%	5.3%	11.4±10.8	1.9%	9.4%	1.5±0.7
	Toggenburg and crosses	30.0%	50.0%	8.3±5.3	48.1%	42.5%	2.2±2.1

*Local breeds entailed the non-descript and Blackhead Persian breeds of sheep

More than 70% of the households kept improved breeds and their crossbreds (Table 7). Kristjanson *et al.,* (2010) reported that men are more likely to own improved breeds than women as they have better resources and are well equipped to handle them, however, results from this study show that both men and women equally adopted the improved breeds. The results also reflect that there has been a great increase in improved breeds and their crosses from 50% in 2014 and 2015 Ojango *et al.*, (2014, 2015) to 80% in 2018 with a resultant decline in unidentified and local breeds. Productivity in small ruminants like other livestock is determined by both genetic and environmental factors (Gizaw *et al.*, 2010). The improved breeds introduced were noted to have desirable characteristics such as fast growth rate, resilience, and prolificacy, hence they were well received by the farmers. From the FGD, it was established that the improved breeds had adapted well to Nyando and took a shorter time to reach desirable market weight.

New sheep and goat breeds introduced in Nyando through the CCAFS project were able to thrive and were thus well accepted and adopted by both male and female farmers.

4.3.3 Dynamics in the Sheep and goat flocks reared

Sheep and goat flock sizes in Nyando expanded and contracted during specific periods through the natural process of birth of young animals or when animals were either sold or died. However, the livestock keepers did not have any specific optimum flock size for their land holding.

Animal entries

Within the period of study, there were more kids/lambs born in Kisumu than in Kericho (Table 8). A comparison in births between sheep and goats showed more kids born to goats (54%) relative to lambs born to sheep (46%). Sheep and goats purchase also contributed substantially (16%) to the flock size in both Counties. Animals were mostly bought during

the drier months of the year followed by wetter periods which enabled the farmers to fatten animals prior to sale and avail them in good body condition. The availability of more animals in the markets meant that farmers seeking to improve their flocks would be able to choose from more animals and negotiate the prices.

Table 8. Sources of new animals for farmers' flocks in Kericho and Kisumu

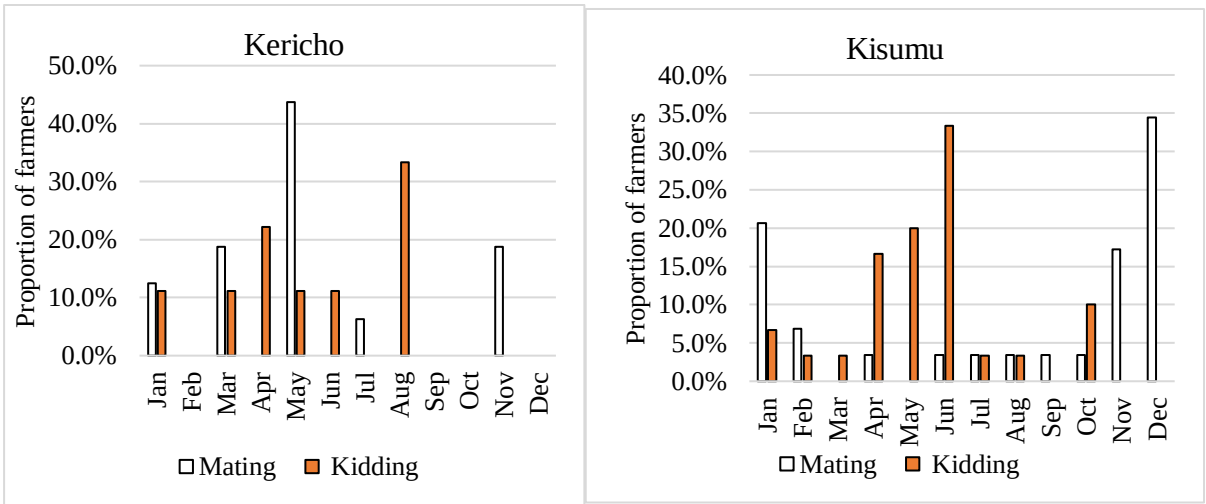
		Sheep		Goats	
	Mode of animal entry	Female animals	Male animals	Female animals	Male animals
Kericho	Birth	28.6% (10)	71.4% (25)	21.9% (7)	78.1% (25)
	Bought from market /another farmer	100% (12)		72% (18)	28% (7)
Kisumu	Birth	62.3% (43)	37.7% (26)	39.1% (34)	60.9% (53)
	Bought from market /another farmer	83.3% (20)	16.7% (4)	45.5% (5)	54.5% (6)

Approximately 70% of the animals purchased by farmers in both Counties were female animals with 100% and 83.3% of the purchases from sheep in Kericho and Kisumu Counties respectively being for female animals. Significant differences were observed in the age of animals purchased for both sheep and goats ($P<0.01$). Seventy percent of the purchased animals were immature with most farmers (>90%) preferring to purchase improved breeds in both Counties. Traders who purchased animals in Nyando selected animals based on size and weight rather than breed. Different types of traders operate in Nyando and either purchase animals for re-sale in other markets, or for slaughter (Ojango *et al.*, 2018). The farmers reported that the improved breeds had faster growth rates and higher dressing percentage and thus fetched better market prices. During the FGD farmers reported improved breeds to be animals of choice when purchasing animals for their flocks.

In the FGD, farmers mapped the main breeding and lambing/kidding seasons for their sheep and goats as illustrated in Figure 5. In Kericho County, lambing occurred mostly in the drier months of July, September and December (85.7%) while the rest of the mating occurred in

the rainy season March, while kidding took place over several months from January to August with drier months constituting 54% of the kidding. In Kisumu, most lambing and kidding in occurred from April to June with more lambing taking place in rainy than the dry seasons (54.3%) while approximately 70% of the kidding took place in dry seasons (Figure 5). The birth of young animals was in the drier periods of the year (December-February and June-September). When asked if lambing/ kidding was planned, the farmers indicated that there was no planning. Female animals left to graze in fields or meeting at watering points would be mated if on heat by the nearest male. Knowing the good potential of the improved animals that had been introduced in the area, farmers would graze their animals in close proximity to the improved males to increase the mating opportunities. Through the FGD it was noted that some supplementary feeding of the female animals would be required to enable nourishment for young animals born in the drier seasons.

Seasons for Goats



Seasons for sheep

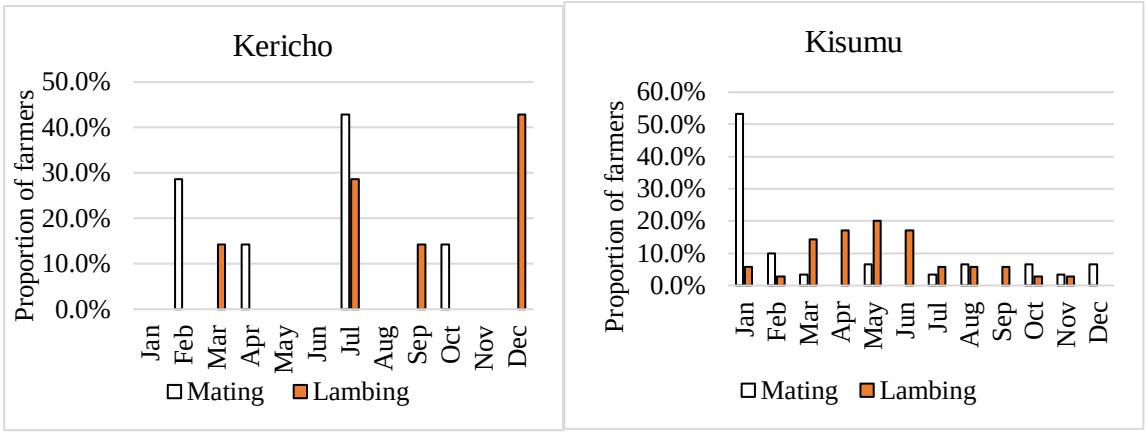


Figure 5. Mating and lambing/kidding for sheep and goats in Kericho and Kisumu

Animal exits

Results from the questionnaire tool and monitoring of animals on the farms showed that the primary modes of outflow of animals from the flocks in both Counties were through sales of live animals (90.0%) followed by death (7.7%). Other means of outflow were animals being given away, lost, or stolen (2.3%). In Kericho County, 74% of animals leaving flocks were female, while in Kisumu 57.6% were male animals. The monthly sales for sheep and goats from the farmers in the two Counties in 2018 are illustrated in Figure 6.

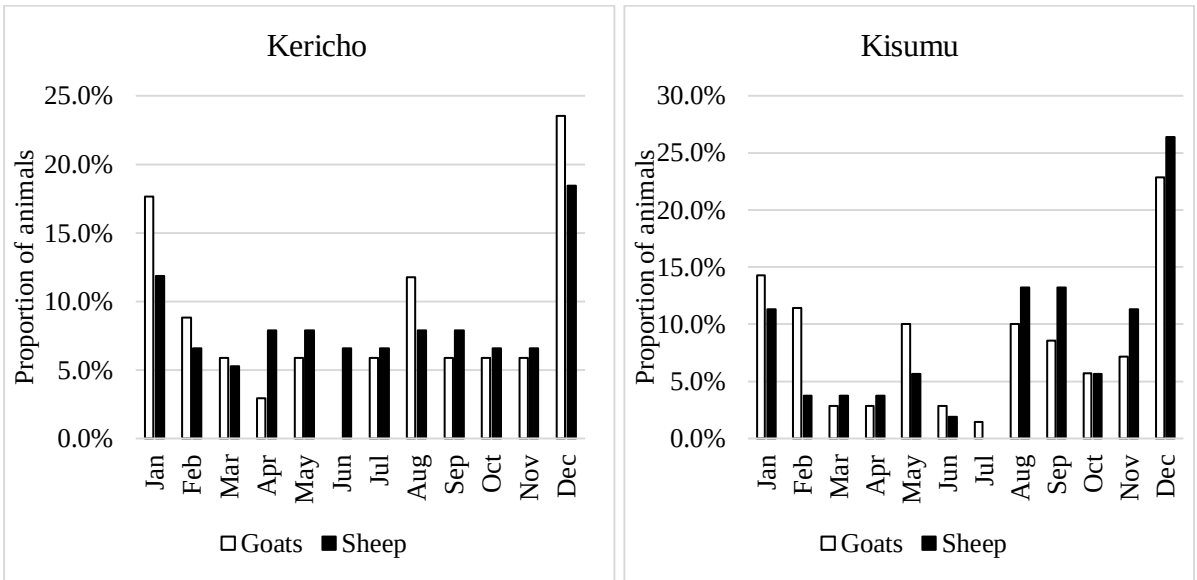


Figure 6. The proportional distribution of sheep and goats sold by farmers in Kericho and Kisumu over 12 months in 2018

There were significant differences ($p<0.01$) in the species of animals sold between the two counties. In Kericho County, farmers sold more goats (88.5%) than sheep, while in Kisumu County, farmers sold more sheep (76.0%) than goats. Eighty-one percent of animal sales were by male headed households. In the FGD, farmers indicated that goats attracted higher market prices than sheep in both counties.

The proportional mortality of sheep and goats in the study area in 2018 is shown in Figure 7.

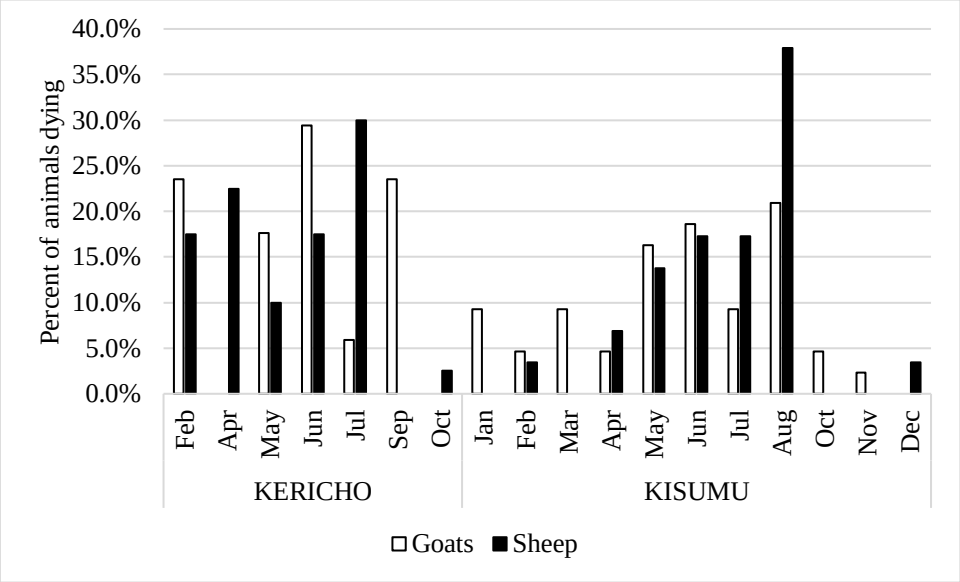


Figure 7. Proportional mortality of sheep and goats in Kericho and Kisumu over 12 months in 2018

In both Counties, farmers reported the main causes of mortality in their sheep and goats to be diseases, old age, injury, and accidents, contributing to 89.3%, 6.1%, and 4.6% of the losses respectively. There was a significant difference in disease related mortalities between the Counties ($P<0.01$). Kisumu County lost more animals to diseases than Kericho as represented by 46.6% and 42.8% of all deaths in 2018 respectively. Contagious Caprine Pleuropneumonia (CCPP), sheep and goat pox, and diarrhea were the main diseases reported and contributed to 48.3%, 16.4%, and 9.5% of the deaths respectively. Sixty-five percent of all deaths were of immature animals. The farmers indicated that most deaths of immature

animals took place during or immediately after rains due to helminthiasis and environmentally related diseases such as pneumonia which could be a challenge to manage.

In both Counties, mortality was reported to be significantly higher in sheep (60%) than in the goats (40%). Studies from India and Ethiopia (Agrawal *et al.,* 2014; Merkine *et al.*, 2017) associated higher mortality rates in sheep than goats to effects of climate change, respiratory and gastrointestinal tract related diseases. These studies noted that sheep are more likely to succumb to droughts and flooding compared to goats. When comparing results from the current study on flocks in Nyando with a previous study in the area (Ojango *et al.,* 2015), there has been a 30% decline in mortality in the flocks and an increase in the proportion of animals sold in Kisumu County by 18%.

4.4 Sheep and goat management practices adopted

4.4.1 Housing and equipment

Lower Nyando has poor drainage due to recurrent floods. The farmers built elevated housing structures to contain their sheep and goats over the wet months of the year in order to prevent environmental related diseases such as foot rot and pneumonia. The housing structures comprise either fully or semi-enclosed sheds which are attached to or separated from the main residential housing. The structures were mostly constructed of wooden floors with iron sheet roofs, and sticks, wood or wire mesh on the walls. A substantial number (59.3%) of households in both counties had structures purposefully for housing sheep and goats while rest of the farmers housed the animals within their living premises. Lack of proper housing facilities for sheep and goat production in smallholder systems has been reported to be a major challenge (Dossa, 2007; Fikru & Omera, 2015). The proportion of farmers with different housing structures differed significantly between the Counties ($P<0.01$). More farmers had temporary housing structures in Kericho (52.5%) than Kisumu (47.5%) where

more farmers had semi-permanent and permanent housing structures. Through the FGD, farmers in Kericho reported that it was costly to build the semi-permanent to permanent structures for their flocks which were much larger than the flocks in Kisumu as presented in Table 4.

Tools and equipment used in sheep and goat management comprised spraying pump, burdizzo, ear tag applicators, hoof clippers, machete, hoe, and Scythe. Eighty-seven percent of households in Kericho owned either a tool or equipment compared to Kisumu (73%). Tools and equipment owned were used by the farmers to carry out routine management activities such as hoof trimming, identification, and operations related to the production of fodder for the animals.

4.4.2 Feeding management

The feed sources and feeding systems for sheep and goats in the study are presented in Table 9. The farmers reported feed to be a major challenge to livestock production in Nyando as the small land holdings owned were used for both subsistence food crop farming and fodder production. Crop residues and grasses growing alongside roads and in communally owned areas were the principal sources of feed for the sheep and goats. Crop residues comprised maize, sorghum and millet stover, and legume haulms. These feed resources have however been reported to be of low nutritional value and result in slow growth of animals (Duku *et al*., 2010).

Table 9. Sheep and goat feed sources and feeding systems adapted over wet and dry seasons in Nyando

	Kericho		Kisumu	
Season	**Dry**	**Wet**	**Dry**	**Wet**
Feed Source				
Natural grazing	98.0%	98.0%	92.2%	96.9%
Other feed sources	2.0%	2.0%	7.8%	3.1%
Feeding system				
Only grazing /tethering	98.0%	95.9%	79.7%	76.6%
Other feeding system	2.0%	4.1%	20.3%	23.4%

Other feeding systems included a combination of grazing/tethering with stall feeding

Other feed sources = crop residues, improved fodder and mineral supplements

Less than 2% of farmers provided additional feeds such as improved fodder, concentrates, and mineral blocks for their animals (Table 9). Only 2% and 3% of the farmers interviewed reported that they grew improved fodder in Kericho and Kisumu Counties respectively. Fodder species grown included; Napier grass, Rhodes grass, Leucaena, and Calliandra. Less than 5% of all the farmers supplemented their animals with minerals. These were provided in very small portions irrespective of the animals' age and reproductive stage. Minerals are very crucial nutrients in physiological processes and in maintaining good health status (Larson, 2005; Gonul *et al.,* 2009; Lengarite *et al.,* 2012; Balamurugan *et al.*, 2017).

Most of the farmers in the two counties grazed their animals in open fields (Table 9). The animals were either left to roam in the fields or tethered to restrict movement. When grazing in farmer owned land , the animals were tethered to prevent from destroying the planted crops. During the wet seasons when crops were still in the fields, fodder was provided to animals in stalls (for enclosed flocks). Once crops were harvested, animals would be left to graze in the fields. A combination of grazing with some stall feeding was mainly adopted in Kisumu by 17.7 % of the households. This type of feeding system affects selling age as animals tend to have a slow growth rate therefore take a long time to attain market weight (George & Tsiplakou, 2011). A balanced and economical feeding of livestock is important

for optimum productivity. Lower livestock productivity is often due to feed scarcity and unbalanced feeding practices (Beigh *et al.,* 2017). Young animals born under stall feeding had higher growth rates and intramuscular fat (De Brito *et al.,* 2017). Animals raised under extensive production systems tend to have slower growth rate leading to low production efficiency (Carrasco *et al.,* 2009). There is, therefore, need for supplementation for optimal growth and carcass production (Turner *et al.,* 2014).

4.4.3 Disease control

Helminth and tick control were the main sheep and goat disease control interventions adopted by 76.6% and 73.7% of the households in Kericho and Kisumu counties respectively. Control of ticks and worms in sheep and goats was initiated in the farms through the CCAFS project and supported by the livestock extension services. The farmers noted that the practices had improved the health and body condition of their animals hence the high rate of adoption. Diseases and parasites in livestock populations affect growth, result in mortality, and thus reduce productivity and profitability (Charlier *et al.,* 2014). Disease control is important in livestock production due to its role in improving productivity through lowering mortality and improving reproductive rates (Wolff *et al.,* 2019; Robertson, 2020). In relation to other diseases, the farmers indicated that they seek treatment for their animals when they fell ill.

4.4.4 Breeding practices

The sources of breeding males for the farmers in the study area are presented in Figure 8. The main source of breeding males was their own bred ram/ buck as adopted by 46.3% of the households (Figure 8).

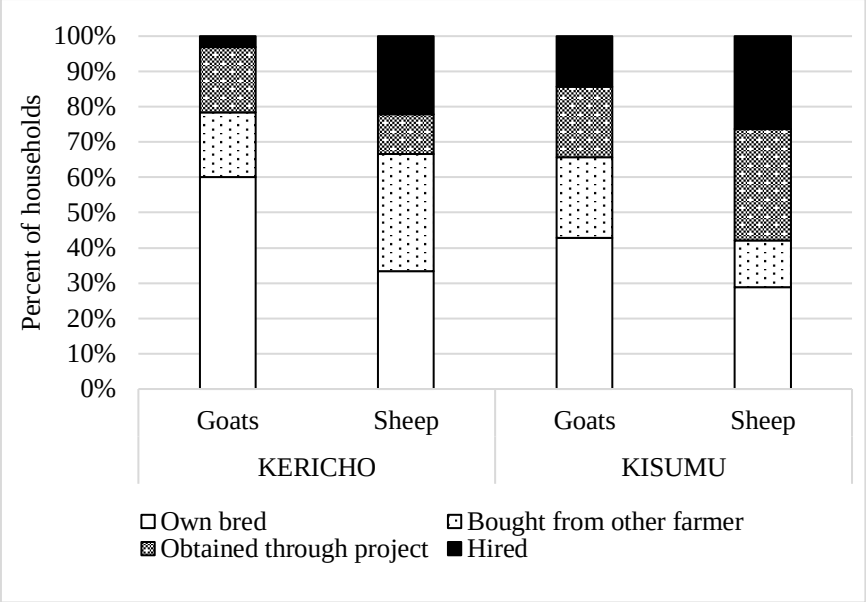


Figure 8. Sources of breeding males in Kericho and Kisumu

The farmers stated that they replaced breeding males after one year of use, and they practiced some form of animal rotation in order to prevent inbreeding. Once culled from a flock, breeding male animals would either be castrated and sold for meat or sold to other farmers for use as mating animals. Two breeding systems were practiced in this area, pure breeding, and cross breeding. Pure breeding was adopted by 9.1% and 28.6% of households, while crossbreeding was adapted by 90.9% and 71.4% of the households in Kericho and Kisumu County respectively. In both Counties, 12.9% of farmers were willing to spend extra resources on purchasing breeding male animals as this was noted to be a way of improving productivity of their animals. Previous studies on small ruminant production practices in Kenya highlight a lack of adoption of standard breeding programmes by smallholder farmers (Kosgey *et al.,* 2006; Wurzinger *et al.,* 2011). This is mainly noted to result from the failure of those introducing new practices to directly involve farmers in making critical decisions related to the breeding. In the CCAFS project areas, the farmers are key implementers of the breed improvement practices introduced (Macoloo *et al.,* 2013). Policies that facilitate farmer

involvement in breeding practices and link breeding programmes with other management practices help improve farmer participation (Kosgey & Okeyo, 2007; Wurzinger *et al.*, 2008).

4.5 Growth performance of improved small ruminant breeds introduced in "Climate Smart Villages" of Nyando

4.5.1 Factors affecting the growth performance of the sheep and goats

Results of analyses of factors affecting weights of animals at different growth stages in Kericho and Kisumu Counties are presented in Table 10 and Table 11 for sheep and goats respectively.

Table 10. Significance of different factors on birth, weaning and yearling weights of sheep in Nyando

Source of variation	df	Birth Weight	Weaning Weight	Yearling Weight
County	1	ns	ns	ns
Kericho				
Kisumu				
Breed	3	***	***	***
Indigenous breed				
Red Maasai pure				
Red Maasai*Dorper				
Red Maasai*Local				
Year of birth (2015-2019)	4	ns	ns	ns
Breed*Year of birth	12	ns	ns	ns
Sex of the animal	1	***	***	***

Table 11. Significance of different factors on birth, weaning and yearling weights of goats in Nyando

Source of variation	df	Birth Weight	Weaning Weight	Yearling Weight
County	1	ns	ns	ns
Kericho				
Kisumu				
Breed	2	***	***	***
Small East African				
Galla				
SEA*Galla				
Year of birth (2015-2019)	4	ns	ns	ns
Breed*Year of birth	8	ns	ns	ns
Sex of the animal	1	***	***	***

*** denotes the level of significance at P<0.001, ns no significance

The County and the year in which the animals were born did not significantly affect the weights of animals at different stages (Tables 10 and 11). The interaction between the year of birth and the breed-type was also not significant for all the parameters. The lack of significant differences in growth traits across the years for the different breed-types was an indication that the introduced breeds had adapted well to the climatic and environmental conditions of Nyando and were able to maintain their productivity despite the change in location.

The weights and growth rates of the introduced and local sheep and goat breeds in Kericho and Kisumu Counties from birth to one year of age are presented in Table 12 and Table 13 respectively. Within the two counties, the different breed types of both sheep and goats exhibited significantly different levels of performance for the different growth traits ($P<0.001$, Table 12 and Table 13).

Table 12. Weights from birth to one year(kg) and average daily gain (g/day) to weaning and one year of age for the sheep breeds in Kericho and Kisumu counties

Sheep Breeds	Weight kg (LSM ±SE)					Average daily gain g/day (LSM ±SE)	
Kericho (N=244)	***Birth***	***Weaning (3 months)***	***6 Months***	***9 Months***	***Yearling***	***Birth to Weaning***	***Weaning to Yearling***
Indigenous (20.5%)	2.5±0.2^{a}	10.7±1.3^{a}	13.3±1.2^{a}	14.9±1.0^{b}	19.6±1.3^{c}	91.1±12.2^{a}	33.0±0.0^{a}
Red Maasai (33.6%)	3.7±0.1^{b}	15.8±1.0^{b}	20.0±0.9^{b}	24.1±0.7^{a}	30.5±0.7^{a}	134.4±10.0^{b}	54.4±1.1^{b}
Red Maasai * Dorper (20.5%)	3.8±0.4^{b}	16.2±1.7^{b}	20.8±1.4^{b}	25.3±1.1^{a}	30.0±1.0^{a}	137.8±14.4^{b}	51.1±2.6^{b}
Red Maasai * Indigenous (25.4%)	2.7±0.1^{a}	11.1±0.9^{a}	15.0±0.9^{a}	18.9±0.8^{c}	25.3±0.9^{b}	93.3±8.9^{a}	52.6±0.0^{b}
Kisumu(N=764)							
Indigenous (17.5%)	2.5±0.3^{a}	8.6±0.4^{a}	11.8±0.1^{a}	15.0±0.7^{a}	19.4±0.5^{a}	67.8±1.1^{a}	40.0±0.4^{a}
Red Maasai (26.0%)	3.5±0.1^{b}	16.6±0.8^{c}	21.6±0.5^{c}	24.7±0.5^{b}	31.2±0.7^{d}	145.6±7.8^{d}	54.1±0.4^{b}
Red Maasai * Dorper (24.3%)	3.6±0.2^{b}	15.7±0.6^{c}	20.5±0.6^{c}	23.4±0.6^{b}	27.4±0.8^{c}	134.4±4.4^{c}	43.3±0.7^{a}
Red Maasai* Indigenous (32.2%)	2.9±0.1^{a}	11.8±0.5^{b}	16.6±0.5^{b}	19.5±0.6^{a}	23.1±0.4^{b}	98.9±4.4^{b}	41.9±0.4^{a}

^{abc} *Within column, between breeds, means without common superscripts differ significantly at P<0.01, SE=Standard Error, Kg=Kilogram, g=gram*

Table 13. Least square mean (LSM) weights from birth to one year(kg) and average daily gain (g/day) to weaning and one year of age for the goat breeds in Kericho and Kisumu counties

Goat Breeds	Weight kg (LSM ±SE)					Average daily gain g/day (LSM ±SE)	
Kericho (N=779)	***Birth***	***Weaning (3 months)***	***6 Months***	***9 Months***	***Yearling***	***Birth to Weaning***	***Weaning to Yearling***
Small East African (37.2%)	2.5±0.5^{a}	10.3±0.5^{b}	12.8±0.4^{a}	15.2±0.4^{a}	20.3±1.8^{b}	86.7±0.0^{a}	75.2±6.7^{a}
Galla Pure (20.3%)	3.9±0.1^{b}	15.9±0.8^{a}	19.5±0.6^{c}	23.0±0.8^{b}	30.1±4.5^{a}	133.3±7.8^{c}	111.5±16.7^{c}
Galla*SEA (42.5%)	3.4±0.1^{b}	11.7±0.5^{b}	14.7±0.4^{b}	17.7±0.4^{c}	24.0±2.3^{c}	92.2±4.4^{b}	88.9±8.5^{b}
Kisumu (N=444)							
Small East African (34.2%)	2.5±0.3^{a}	9.0±0.4	12.3±0.6^{a}	15.5±0.7^{a}	20.7±0.4^{a}	72.2±1.1^{a}	76.7±1.5^{a}
Galla Pure (10.6%)	3.7±0.2^{b}	10.8±1.0	17.2±1.5^{c}	23.5±2.0^{c}	**32.2±1.6^{b}**	78.9±8.9^{b}	**119.3±5.9^{c}**
Galla*SEA (55.2%)	2.8±0.1^{a}	11.8±0.4	14.8±0.5^{b}	17.8±0.7^{b}	23.2±0.4^{c}	100.0±3.3^{c}	85.9±1.5^{b}

^{abc} *Within column, between breeds, means without common superscripts differ significantly at P<0.01, SE=Standard Error, Kg=Kilogram, g=gram*

4.5.2. Growth from birth to weaning

Birth weights of lambs ranged from 2.5 kg for the local indigenous sheep to 3.8 kg for the introduced Red Maasai x Dorper animals (Table 12). Differences in lamb birth weights of were not significant between counties. In both Counties, the kids from the indigenous Small East African breed had the lowest birthweight while the introduced purebred Galla goats had the highest ($P<0.01$). The average birth weights for goat breeds in Kericho and Kisumu were 3.3±0.2Kg and 3.0±0.2Kg respectively (Table 13).

Birth weight is strongly correlated with the mature size and weight of an animal (Fasae *et al.,* 2012). It also has a strong influence on the survival of animals, as animals with low birth weights tend to have low survival rates in the early stages of their life compared to heavier ones (Morel *et al.,* 2008). Birth weights reported for lambs and kids from different sheep and goat breed types in other countries of Africa are similar to those of this study. In Tanzania, local Pare white goats are reported to have birth weights of 2.5 to 2.7 kg (Hyera *et al.,* 2018). Lower birth weights have been reported in South and West African Dwarf goat breeds (Fasae *et al.,* 2012; Birteeb *et al.,* 2015). Boer goats and their crosses with indigenous breeds are reported to have moderate birth weights when compared with pure indigenous breeds (Deribe *et al.,* 2015). The improved breeds had heavier newborns as weight at kidding/lambing have been reported to be highly correlated with kids/lambs birth weight (Asmad *et al.,* 2014; Paten *et al.,* 2017).

The pre-weaning growth of animals is greatly dependent on the animal's inherent genetic potential and the mothering ability of its dam (Yiheyis *et al.,* 2012). During growth from birth to weaning at three months of age, animals have high nutritional requirements and are also highly vulnerable to the infestation of external and internal parasites (Singh *et al.,* 2017). It is therefore important to ensure that the young animals are well-nourished. Among all the breeds of sheep in

Nyando, the indigenous animals had the lowest weight gain (P<0.01, Table 12). In Kericho, the Red Maasai x Dorper cross and pure-bred Red Maasai sheep had the highest pre-weaning growth rate, while in Kisumu, the Red Maasai x Dorper sheep had a significantly higher (P<0.01) pre-weaning growth rate than the other breeds (Table 12).

In both Kericho and Kisumu, the introduced pure-bred Galla goats and their crosses with indigenous breeds had significantly (P<0.01) higher growth rates from birth to weaning than the indigenous Small East African goats. The improved breeds were selected based on their fast rate of growth and early attainment of market weight (Ojango *et al.,* 2018).

4.5.3. Growth from weaning to one year

In both Kisumu and Kericho Counties, the local indigenous sheep had significantly lower weights at all stages of growth (P<0.01) compared to the introduced breeds and their crosses with the local indigenous breeds (Table 12). Differences in weaning weights for the Red Maasai x Dorper crosses and the pure Red Maasai breed were not significant. Among the goat breeds, the indigenous Small East African had a significantly lower weaning weight (P<0.01) than the Galla x Small East African crossbred and the purebred Galla (Table 13). In Kericho, the pure Galla goats were significantly (P<0.01) heavier than all the other breeds at weaning. The weight of animals at weaning is of high relative economic importance for livestock keepers as it indicates the adaptability of the animals (Fasae *et al.,* 2012). Both high and low weaning weights have been reported for indigenous sheep breeds in Ethiopia, Nigeria, and Tanzania (Muhammad *et al.,* 2008; Mengistie *et al.,* 2010; Lakew *et al.,* 2014). In Ethiopia, indigenous Begait goat breeds raised in semi intensive and extensive production systems were reported to have weights ranging

from 10.3 to 11.1Kg, and 20.6 to 24.1Kg at weaning and yearling stages respectively (Abraham *et al.,* 2018). Reports from studies on crossing indigenous goats in Tanzania, Uganda, and Ethiopia with Boer goats from South Africa indicate that animals that have low weaning weights also tend to have lower weights at one year of age (Ssewannyana *et al.,* 2004; Hango *et al.,* 2007; Deribe *et al.,* 2015; Girma, 2016).

It was notable that in both Kisumu and Kericho County, the pure-bred Red-Maasai sheep had the highest rates of growth post-weaning, resulting in the animals having a significantly higher ($p<0.01$) yearling weight than the Red-Maasai x Dorper animals in Kisumu county (Table 12). The growth rates in Red Maasai and Red Maasai Dorper crosses was not different from that reported for sheep raised under the semi-arid environments (König *et al.,* 2017), an indication that the breeds were adaptable to the Nyando environment.

The pure-bred Galla goats were heavier at weaning in Kericho County than in Kisumu County (Table 13), however, the animals had good potential for growth resulting in larger animals at one year of age. The pure-bred Galla goats were significantly ($p<0.01$) larger at one year of age in Kisumu county than in Kericho county (Table 13).

Breed type and sex of an animal were the most important factors influencing yearling weights in both sheep and goats. The sex of the animal had a significant effect on the yearling weight of sheep and goats and male animals were heavier than the female animals. Several studies have reported differences in the growth rate between male and female animals (Bela & Haile, 2009; Tabreze, 2018; Ampong *et al*., 2019). The growth rate in indigenous Sokoto sheep breed in Nigeria was also reported to be affected by the breed and sex of the animals (Muhammad *et al.,* 2008). The differences in growth rate between the male and female animals can be attributed to

the male sex hormones secreted from gonads and which have an anabolic effect (Joshi *et al.*, 2018).

The growth rates of the sheep and goats in Nyando from birth to yearling are presented in Figure 9 and Figure 10 respectively.

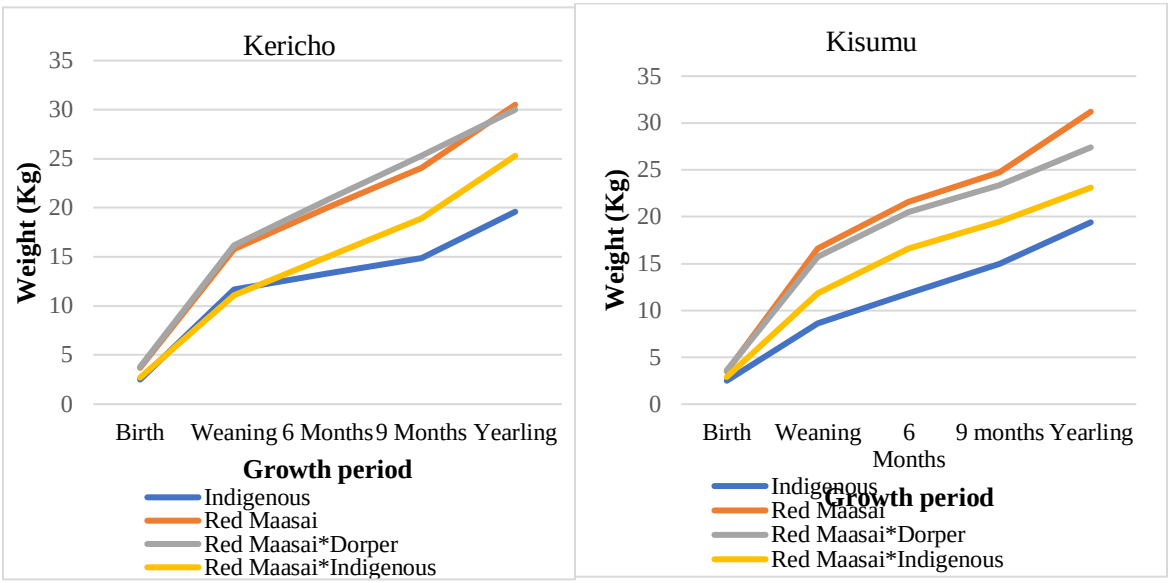


Figure 9. Growth performance of sheep breeds from birth to one year of age in Kericho and Kisumu Counties

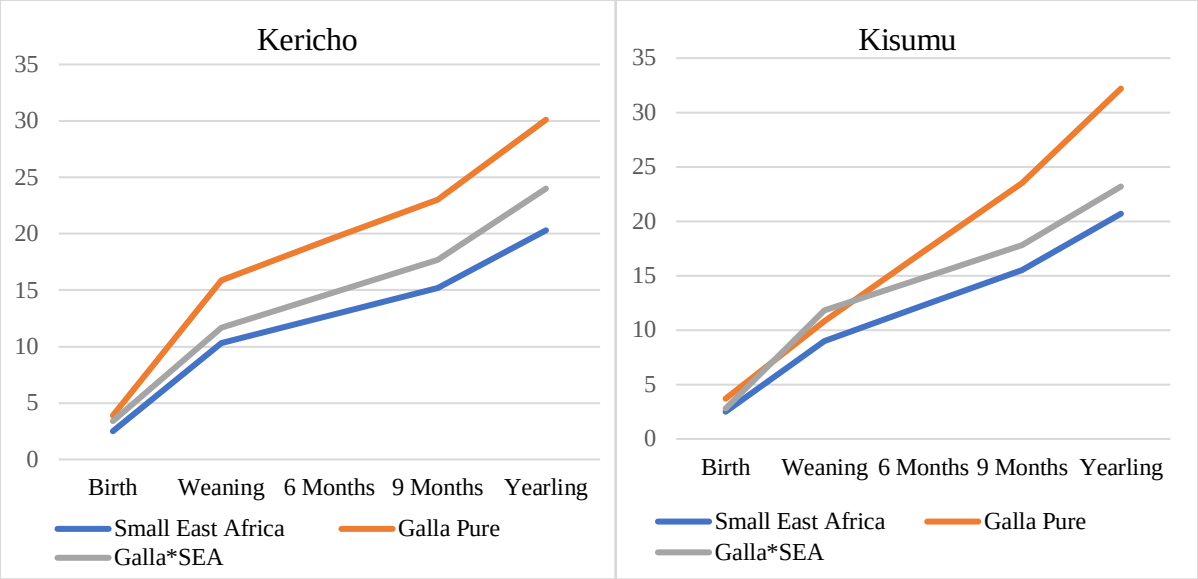


Figure 10. Growth performance of goat breeds from birth to one year of age in Kericho and Kisumu Counties

The improved sheep and goat breeds introduced in the two counties had superior growth rates compared to the indigenous breeds. Among the sheep breeds, both the pure bred Red Maasai and the Red Maasai x Dorper animals demonstrated superior growth rate (Figure 9). Crosses between the introduced animals and the indigenous animals also outperformed the indigenous breeds for both sheep and goats (Figure 9 and Figure 10). For all the animals, immediately after weaning there was a decline in the rate of growth up to 9 months of age. Between 9 and 12 months of age, the rate of growth tended to increase. The crosses between the introduced breeds and the local breeds were heavier, had a faster growth rate, a larger body size, and good body conformation compared to the local breeds. At one year of age, the introduced Red Maasai sheep were 61% heavier than the indigenous breeds, while the crosses between the Red Maasai and indigenous breeds were 55% heavier than the indigenous animals ($P<0.01$).

The yearling weight is very important in small ruminant production in Nyando as it is normally at this stage of growth that animals are sold. The weight attained by an animal at this age thus

determines the amount of income that can be obtained. The Red Maasai x Dorper breed introduced in Nyando had a large frame and was able to produce offspring with a large frame in the new environment. Studies of improved small ruminant breeds introduced in different environments have shown good adaptability of their crosses with the indigenous breeds. For instance, the Boer goats when introduced in different environments are able to maintain good growth rates (Browning & Browning, 2011; Teklebrhan, 2018). Dorper sheep have also demonstrated good adaptability in the introduced environments in the Eastern Amhara region in Ethiopia (Lakew *et al.,* 2014). Cross breeding initiative in Uganda showed that crosses between the improved and the indigenous breeds had better growth rates and weights than the indigenous breeds (Ssewannyana *et al.,* 2004). Moreover, a study by Farm Africa in Kenya showed that crossing the Toggenburg with indigenous Small East African goats resulted in offspring with a significant improvement in growth rates and meat production potential relative to pure bred Small East African goats (Murithi *et al.,* 2002). Overall, the crosses between the local breeds of sheep and goats and the improved breeds in Kericho and Kisumu has resulted in animals with large body sizes which in turn lead to better prices for animals at market points (Mtimet *et al.,* 2014).

4.6 Economics of sheep and goat production in Nyando

4.6.1 Costs in sheep and goat production

Factors contributing to the costs of sheep and goat production in Nyando, classified as either fixed or variable costs are presented in Table 14.

Table 14. Average costs of producing sheep and goats on a farm in one year in Kericho and Kisumu Counties

*A. **Costs in sheep production***

Kericho (N=77)		**Average costs per flock in Kenya shillings***					
		Management practices				**Replacing animals**	**Total Costs**
Flock Size	***% of N***	***Mating***	***Water***	***Treatment***	***Labour***		
1-4 animals	47.10%	-	100	870.71	1,906.25	950.00	**3,827.00**
5-10 animals	33.30%	-	133.33	2,388.89	4,250.00	550.00	**7,322.20**
10-30 animals	19.60%	-	200	7,600.00		165.00	**7,965.00**
Overall Average in Kericho		-	144.40	3,619.90	3078.10	551.00	**7,393.40**
Kisumu (N=85)							
1-4 animals	52.40%	50.00	1,250.00	3,050.00	2,430.56	1,633.30	**8,413.90**
5-10 animals	30.90%	200.00	1,370.59	1,359.18	2,270.83	242.50	**5,443.10**
10-30 animals	16.70%	300.00	830.77	1,412.62	1,322.37	93.00	**3,958.80**
Overall Average in Kisumu		183.30	1,150.50	1,940.60	2,007.90	656.30	**5,938.60**

B. Costs in goat production

Kericho (N=77)		**Average costs per flock in Kenya shillings***					
		Management practices				**Replacing animals**	**Total costs**
Flock Size	***% of N***	***Mating***	***Water***	***Treatment***	***Labour***		
1-4 animals	25.4%	-	138.89	1,293.78	4,739.58	1,350.00	**7,522.30**
5-10 animals	39.4%	-	246.43	2,599.29	5,638.89	398.30	**8,882.90**
10-30 animals	35.2%	416.67	626.00	3,686.00	7,777.78	215.00	**12,721.50**
Overall Average in Kericho		156.25	352.82	2,650.96	5,920.83	819.30	**9,900.20**
Kisumu (N=85)							
1-4 animals	38.9%	14.71	1,750.00	2,462.67	3,281.25	446.90	**7,955.50**
5-10 animals	44.4%	7.50	1,322.92	2,337.92	2,625.00	946.70	**7,240.00**
10-30 animals	16.7%	8.33	5,033.33	6,427.78	2,406.25	125.00	**14,000.70**
Overall Average in Kisumu		10.47	2,107.41	3,068.07	2,731.06	430.60	**8,347.60**

**1 US Dollar = 104 Kenya shillings*

The costs of production increased relative to flock size with flocks of 10-30 animals having the highest costs. Labour for herding sheep and goats was mostly provided by children and adult female household members. Children alone provided 75% of the small ruminant family labour in both Counties. During school hours the animals would be tethered then herded in the evening after school. Labour cost accounted for 49.3% and 33.2% of the overall total costs in Kericho

and Kisumu respectively (Table 14). Other studies have highlighted the role played by women and children in the provision of labour for small ruminant production (Oluwatayo & Oluwatayo, 2012). Kumar & Deoghare, (2003) reported family labour to be an important contributor to costs in livestock production.

Variable costs comprised costs for water, animal health services, flock replacement, and breeding (Table 14). These accounted for a higher share of the overall total costs in both counties, Kericho (50.7%) and Kisumu (66.8%) compared to the fixed costs. Other studies in smallholder systems have described variable costs to be the foremost contributor to production costs in sheep and goat production (Al-Khalidi *et al.,* 2013; Al-Khaza'leh *et al.,* 2015).

Costs for water differed significantly ($P<0.01$) between the two counties, accounting for 6.8% and 32.5% of the variable costs in Kericho and Kisumu respectively.In relation to the overall costs of production water accounted for 2.7% and 22.9% of the costs in Kericho and Kisumu Counties respectively (Table 14). The high costs of water in Kisumu can be attributed to the high dependance of piped water which was primarily the main source of water (Figure 3). Water availability is a great challenge in Nyando area due to increased drought occurrences resulting from climate change (Masese *et al.*, 2008).

Animal health costs did not differ significantly between the two counties but accounted for a large proportion of costs, 69% and 50% of the total variable cost and 37.7% and 34.3% of the overall total costs of production in Kericho and Kisumu respectively. Disease control rather than treatment should be emphasized as a strategy of lowering production costs. Other studies have recommended enhanced disease management strategies as a way of improving productivity as manifested in growth (Delia *et al*., 2015; Ayantunde, 2016; Gitonga *et al.,* 2016).

Flock replacement costs included costs for additional animals purchased for improving the flock performance. These accounted for 22.2% and 10.4% of the total variable costs and 9.7% and 7.6% of the overall total costs in Kericho and Kisumu respectively (Table 14). Farmers aimed at improving their flocks in terms of increased milk production in addition to increasing the number of animals owned. The farmers were also keen on replacing the indigenous small sized animals with the improved larger sized animals as this improved their potential for marketing products.

Farmers in Kericho retained few breeding males continually within their flocks compared to those in Kisumu (Table 4&5). They therefore hired supplemental animals over short periods to mate their female flock when required. Costs for mating animals were thus higher in Kericho than in Kisumu County. Mating costs accounted for 2% and 7.1% of the variable costs and 0.6% and 2.0% of the overall total costs in Kericho and Kisumu respectively. The willingness of farmers in Nyando to pay for mating services for their animals reflected their ability to implement breeding management within their populations. Earlier studies indicated little interest in the adoption of small ruminant breeding programmes especially in low income countries (FAO, 2009). However, in the recent past, community based breeding programmes have been shown to be very successful under production systems in Ethiopia and are being extended to other countries (Karnuah & Dunga, 2018; Haile *et al.,* 2019). The feasibility of a breeding programme must be assessed in partnership with the livestock keepers prior to its implementation. Adoption of rotation of breeding males among farmers could be implemented in Nyando as a strategy for improving productivity (Kosgey *et al.,* 2006; Lobo, 2019).

Evaluating of costs within an enterprise enables farmers to better plan for interventions that could enable them to achieve better returns from their investments (Al-Khalidi *et al.,* 2013).

Results from the regression analysis of socio-economic factors of households influencing the costs of production are presented in Table 15. It was evident that the costs of production did not differ significantly depending on the gender of the household head or their level of education, but mainly due to the number of animals owned.

Table 15. Influence of socio-economic factors on sheep and goat production costs in Kericho and Kisumu

Fixed effects	Kericho		Kisumu	
	df	Prob>F	df	Prob>F
Gender of the household head (hh)	1	ns	1	ns
Level of education of hh	2	ns	2	ns
Size of land holding owned	2	ns	2	ns
Flock size	3	***	3	***

4.6.2 Revenue streams from sheep and goat production

Average prices for different categories of animals in Kericho and Kisumu as reported by the farmers are presented in Table 16.

Table 16. Average prices for sheep and goats in 2018 segregated by age and sex categories in Kericho and Kisumu

	Kericho		Kisumu	
	Average price/Sheep (Ksh)	Average price/goat (Ksh)	Average price/ Sheep (Ksh)	Average price/goat (Ksh)
Mature females	4,000.0	7,000.0	5,000.0	6,000.0
Immature females	3,500.0	4,000.0	3,500.0	4,500.0
Castrates	8,000.0	15,000.0	7,000.0	5,000.0
Immature males	3,000.0	8,000.0	4,000.0	4,500.0
Mature males	7,000.0	20,000.0	7,500.0	8,000.0
Lambs/kids	2,000.0	3,000.0	2,500.0	3,000.0

**1 US Dollar = 104 Kenya shillings*

The price of animals was higher for larger mature animals than smaller and young animals (Table 16). It was noted that the animals attracted better prices (Table 16) compared to those reported for animals in the same region in 2016 by Ojango *et al.*, (2018). During the FGD, the farmers attributed the higher prices to cross breeding of the local animals with the improved breeds which yielded a larger sized animal which attracted much higher market prices.

Revenue streams from sheep and goat for farms in the two counties are presented in Table 17 and Table 18 respectively. Revenues from sale of stock were the primary contributor to the total income from both sheep and goats in Kericho and Kisumu, representing 82% and 75.1% of the incomes respectively (Table 17 and 18).

Table 17. Source of revenue from sheep production and the average number of animals contributing to income per household depending on the flock size owned in Kericho and Kisumu in 2018

Kericho (Number of households =77)		***Average number of animals per household (hh)***					
Flock size Animal category	***% of N***	***Sold***	***Consumed at home***	***Received as gifts***	**Total number of animals**	**Price/animal**	**Total revenue**
1-4 animals	**42.6%**						**11,000.00**
Mature Females	27.7%	2			2	4,000.00	8,000.00
Immature Males	14.9%	1			1	3,000.00	3,000.00
5-10 animal	**36.2%**						**38,000.00**
Mature Females	23.4%			1	1	4,000.00	4,000.00
Mature Males	4.3%	4			4	7,000.00	28,000.00
Immature Males	8.5%	1	1		2	3,000.00	6,000.00
10-30 animals	**21.2%**						**48,000.00**
Immature Females	2.1%	2			2	3,500.00	7,000.00
Mature Males	17.0%	4	1		5	7,000.00	35,000.00
Immature Males	2.1%	2			2	3,000.00	6,000.00
Kisumu (Number of households =85)							
1-4 animals	**53.9%**						**12,500.00**
Mature Females	44.3%	1			1	5,000.00	5,000.00
Mature Males	11.5%	1				7500.00	7500.00
5-10 animal	**34.6%**						**15,000.00**
Mature Males	11.5%	2			2	7,500.00	15,000.00
10-30 animals	**11.5%**						**31,500.00**
Mature Females	1.9%		1		1	5,000.00	5,000.00
Immature Females	1.9%	1			1	3,500.00	3,500.00
Mature Males	5.8%	1	1		2	7,500.00	15,000.00
Immature Males	1.9%	2			2	4,000.00	8,000.00

**1 US Dollar = 104 Kenya shillings*

Table 18. Sources of revenues in goat production and the average number of animals contributing to income per household depending on the flock size owned in Kericho and Kisumu in 2018.

Kericho (Number of households =47)		***Average number of animals per hh***					
Flock size Animal Category	***% of N***	***Sold***	***Consumed at home***	***Received as gifts***	**Total number of animals**	**Price/ animal**	**Total revenue**
1-4 animals	**11.8%**						**14,000.00**
Mature Females	11.8%	1		1	2	7,000.00	14,000.00
5-10 animals	**49.0%**						**83,000.00**
Mature Females	23.5%	1			1	7,000.00	7,000.00
Immature Females	9.8%	3	2	1	6	3,500.00	21,000.00
Castrates	7.8%	1			1	15,000.00	15,000.00
Mature Males	7.8%	1	1		2	20,000.00	40,000.00
10-30 animals	**39.2%**						**85,000.00**
Mature Females	27.5%	1	1		2	7,000.00	14,000.00
Immature Females	2.0%	4			4	4,000.00	16,000.00
Castrates	3.9%	1			1	15,000.00	15,000.00
Mature Males	5.9%	1	1		2	20,000.00	40,000.00
Kisumu (N=54)							
1-4 animals	**25.9%**						**12,000.00**
Mature Females	25.9%	1		1	2	6,000.00	12,000.00
5-10 animal	**57.4%**						**36,500.00**
Mature Females	20.4%	1			1	6,000.00	6,000.00
Immature Females	9.3%	2			2	4,500.00	9000.00
Mature Males	22.2%	1			1	8,000.00	8,000.00
Immature Males	5.6%	2	1		3	4,500.00	13,500.00
10-30 animals	**16.7%**						**67,000.00**
Mature Females	5.6%	2			2	6,000.00	12,000.00
Immature Females	1.9%	2			2	4,500.00	9,000.00
Castrates	3.7%	1			1	5,000.00	5,000.00
Mature Males	3.7%	3	1		4	8,000.00	32,000.00
Immature Males	1.9%	2			2	4,500.00	9,000.00

The sale price for animals in Nyando depended on age, sex, body weight, and the season in which animals were sold. Households owning goat flocks earned greater returns compared to those owning either only sheep or and both sheep and goat flocks. Seventy percent of the animals sold were mature (Tables 17 and 18). During the FGD farmers indicated that animals were sold to generate income for specific needs. Both male and female animals were sold depending on their availability and the anticipated sale price. Though a higher number of mature female animals (39.3%) were sold than male animals (30.5%) in both counties, the difference was not significant. The farmers indicated that they desired to retain the female animals, however, if there was no other animal ready for sale at the time of need, they would sell the female one. The farmers in both counties sold significantly ($P<0.01$) more animals of improved breeds of both sheep and goats than the indigenous breed-types. The improved breeds were reported to have faster growth rates and larger mature body size.

Though the farmers tended to sell their animals when cash was needed for specific purposes at any time of the year, peak marketing times for the small ruminants were during festive seasons: Easter (April) and the Christmas & New year (December) holidays as illustrated in Figure 6. During the FGD, farmers indicated that better prices were offered for animals during the wet season relative to the dry season. A study on marketing practices for small ruminants in Ethiopia also reported peak sale times for sheep and goats during festive seasons (Legesse *et al.,* 2008). The farmers in Nyando noted through the FGD that they sell animals in the event of need rather than for making a profit. In the study by Legesse *et al.,* (2010) it was also noted that smallholder rural farmers tend to dispose animals in times of need or climate challenges rather than to provide a regular household income or for profit.

Sheep and goats consumed at home represented 7.2% and 13.8% of the total revenues in Kericho and Kisumu respectively. In the FGD it was established that farmers tended to consume more of the local breeds at home as culled animals since they had lower mature

weights than the introduced breeds. Animals granted as gifts contributed 5.1% and 6.1% of overall total revenues in Kericho and Kisumu respectively.

It was notable that in both Kericho and Kisumu counties revenues from goats were higher compared to those from sheep (Table 17 and 18). In both counties, the higher prices for goats relative to sheep (Table 16) could have influenced the higher number of goats sold in the areas.

Revenues from milk consumption and sales are presented in Table 19. Goats were the only milk producers in the two Counties.

Table 19. Revenues from the sales and the value of goat milk consumed goat in Kericho and Kisumu Counties

Kericho Flock Size	Average number of animals milked/day	Average milk production /animal/day (litres)	Days in milk /year	Total milk production Litres /year	Total revenue from milk (Ksh)
1-4 animals	1	1.0	30	30	**3,000.00**
5-10 animals	2	1.0	22	44	**4,400.00**
10-30 animals	3	1.0	30	90	**9,000.00**
Overall Average	**2**	**1.0**	**29**	**58**	**5,800.00**
Kisumu					
1-4 animals	1	1.0	15	15	**2,250.00**
5-10 animals	1	1.0	25	25	**3,750.00**
10-30 animals	1	1.0	20	20	**3,000.00**
Overall Average	**1**	**1.0**	**20**	**20**	**3,000.00**

*The milk was sold at 100ksh per litre in Kericho and 150Ksh per litre in Kisumu, *1 US Dollar = 104 Kenya shillings*

Revenues from milk differed significantly between the Counties ($P<0.01$) and represented 5.7% and 5.0% of overall total revenues in Kericho and Kisumu respectively. Variations in milk revenues can be attributed to differences in flock size between the two Counties. The farmers indicated that though the average milk production per day for improved breeds was higher than that for indigenous animals (1.5kg vs 0.25kg), the improved breeds tended to have a shorter lactation length of 3-5 months compared to the indigenous breeds which would produce milk over 5-8 months. Investment in milk production from the goats needs to be

enhanced as the current production in the traditional extensive systems is low. Milk from small ruminants can provide a more regular source of income for rural households (Kumar *et al.,* 2010). Goat milk can contribute substantially to household income with intensification and proper husbandry and marketing strategies. Several studies have acknowledged the role played by goat milk in the economic, nutritional, and health wellbeing of the consumers (Ahuya *et al.,* 2009; Turkmen, 2017).

The impact of the household socio-economic factors on returns from sheep and goats combined reflected through the regression analyses are presented in Table 20. The goodness to fit for the model was 0.35 and 0.41 for Kericho and Kisumu respectively.

Table 20. Influence of socio-economic factors on farm revenues from small ruminants in Kericho and Kisumu Counties

Fixed effects	Kericho		Kisumu	
	df	Prob>F	df	Prob>F
Gender of the household head (hh)	1	***	1	***
Level of education of hh	2	***	2	***
Size of land holding owned	2	ns	2	ns
Species type	1	***	1	***
Flock size	3	ns	3	ns

In addition to the number of animals owned and the species kept as presented in tables 17 and 18, the gender of the household head and their level of education contributed significantly to the revenue from sheep and goat production (Table 20). Households headed by men attained higher revenues from livestock than households headed by women. Other studies have reported that men in households tend to be the key decision makers when it comes to animal sales and mostly control the incomes (Njuki et al., 2013; Wanyoike *et al.,* 2015). It was notable that in this study, farmers with non-formal education earned higher revenues from their animals compared to those with more formal of education (Table 20). Most farmers in Kericho and Kisumu Counties who had no formal education were elderly and had vast

experience in small ruminant trading. They were thus better at targeting traders and negotiating prices for their animals.

4.6.3 Net Returns form sheep and goat production

The net returns from rearing sheep and goats were calculated based on the costs and revenues from each enterprise are presented in Table 21. Returns differed within each county depending on the average flock size owned. Generally, farmers owning less than 4 animals received the lowest returns.

Table 21. Net returns from sheep and goat production in Kericho and Kisumu in 2018

Average Returns for each flock size per farmer						
Kericho	Sheep			Goat		
Flock size	Total Revenues (Ksh)	Total costs (Ksh)	Returns (Ksh)	Total Revenues (Ksh)	Total Costs (Ksh)	Returns (Ksh)
1-4 animals	11,000.00	3,827.00	7,173.00	14,000.00	7,522.30	6,477.70
5-10 animals	38,000.00	7,322.00	30,678.00	83,000.00	8,882.9	74,117.10
10-30 animals	48,000.00	7,965.00	40,035.00	85,000.00	12,721.50	72,278.50
Overall average	*32,333.30*	*6,371.30*	*25,962.00*	*60,666.70*	*9,708.90*	*50,957.80*
Kisumu						
1-4 animals	12,500.00	8,413.90	4,086.10	12,000.00	7,955.50	6,294.50
5-10 animals	15,000.00	5,443.10	9,556.90	36,500.00	7,240.00	29,260.00
10-30 animals	31,500.00	3,958.80	27,541.20	67,000.00	14,000.00	61,400.00
Overall average	*19,666.70*	*5,938.60*	*13,728.10*	*53,783.30*	*9,731.80*	*44,051.50*

In both counties, the farmers earned higher returns from goats than from sheep (Table 21). Returns from both sheep and goat enterprises were significantly ($P<0.01$) higher in Kericho than Kisumu county. This difference was attributed to higher number of animal sales in Kericho than Kisumu county (Table 17 and 18).

Studies on small ruminant production in India also reflect increasing revenues with increasing flock sizes (Kumar *et al.*, 2010). The number of animals available for sale is higher from larger flocks, hence the positive association between flock size and returns from sale of animals. In small holder farming systems, the number of animals that can be reared by a household is greatly limited by the size of land holding owned. Optimizing flock size in relation to resources available is desirable.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

Conclusion

1. The improved breeds of sheep and goats introduced in the CSV of Nyando made a significant contribution to the incomes of the smallholder farmers in the area. Most revenue (82% and 75.1% of the total revenues in Kericho and Kisumu) came from the sale of live animals. The improved breed-types for both sheep and goats introduced through CCAFS fetched better prices.
2. The improved purebred Red Maasai and the ¾ Red Maasai crossed to Dorper sheep breeds, and the Galla goats breeds and its crosses with local breeds had superior growth performance. Results obtained in the CSV demonstrate the benefit of cross breeding using improved indigenous breeds of small ruminants as an intervention to improve livestock productivity under challenging environmental conditions.

Recommendations

1. The growth rates of the introduced breeds can be improved by training of farmers on the importance of improved fodder.
2. Improved feeds should be introduced to match the genetics of the introduced breeds.
3. Value addition in goat milk should be implemented as a way of improving income.

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APPENDICES

Appendix 1: Revenues and Costs survey Questionnaire

Sustainable small ruminant breeding programs for "Climate Smart Villages in Kenya

A. Households

A1. Household identification

A1.1. Date of Survey (DD/MM/YYYY):	_____ /_____/_____				
A1.2. Enumerator Name:					
A1.3. Did the household consent to the interview? (1=NO; 2=YES)	[_____]				
A1.4. If no, why? (**Code a:**					
A1.4. Time interview started:	HH:		MM:		
A1.5. Time interview ended:	HH:		MM:		
A1.6. Household GPS Coordinates:	A1.6.1 Latitude (S):		A1.6.2 Longitude (E):		
A1.7. Site Name (Code: **1**=ENK, **2**=ILK):			A1.7.1 Site Code:		
A1.8. Village Name:			A1.8.1 Village Code:		
A1.9. Name of Survey Respondent:					
A1.10. Gender [**1**=Male, **2**= Female]					
A1.11. Relationship of survey respondent to Household Head (C**ode b**:					
A1.12. When did you join CCAFS project? (**Code c:**					
A1.13. Distance of household to an all-weather road (KM):					
A1.14. Distance of household to the nearest livestock market (KM):					

a) No Consent	**b) Respondent relationship**	**c) When joined CCAFS**
1= Respondent refuses to participate **2**= Respondent does not have the time **3**= Household head (or other knowledgeable member) is not present house **4**= Other: (specify in cell)	**1** = household head **2** = spouse **3** = other family member **4**= other non-family member	1=2014 2=2015 3=2016 4=2017 5=2018 6= Other (Specify)

A2. Household Roster

- **Start with the household head, followed by his wife or wives, children (ranked from old to young) and lastly other household members – include only members who live there at least 3 months per year**

ID	Name	A2.1 Relationship to HH head (code a:	A2.2 Gender (1 = Male 2 =Female)	A2.3 Age (years) (code b:	A2.4 Highest Level of Education (code c:	A2.5 Primary activity (code d:	A2.6 Secondary activity (Code d:
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

a) Relationship to head	b) Age group	d) Primary activity/Secondary activity
1= Head 2= Spouse 3= Child 4= Sibling (sister or brother) 5= Parent 6= Grandchild 7= Other relative 8= Non-relative (including employees who live in house) 66= Other (specify)	1=Infant (below 2 years) 2=Child below school age (2-6 years) 3=School going child (6-15 years) 4=Teenage/Youth (15-20 years) 5=Young adult (21-30 years) 6=Middle age adult (31-45 years) 7=Elder (>45 years) c) Highest level of education 1=No formal and illiterate 2=No formal but literate 3= Primary school 4= High / secondary school 5= College 6= University 66=Other (specify)	1= Crop farming 2= Livestock & poultry keeping (incl. sales) 3= Trading in livestock and livestock products (not own) 4= Trading in agricultural products (excluding livestock!) (not own produce) 5= Formal Salaried employee (e.g. civil servant, domestic work) 6= Business – trade / services (non-agric.) 7=Not working/unemployed 8= Old/Retired 9= Infant (<6 years) 10= Student/ pupil 11= Disabled 66= Other (specify)

B. Assets

B1.1 Parcel Description / Name	B1.2 Size of this parcel	B1.3 Unit of land (Code a)	B1.4 Tenure system (Code b)	B1.5 If parcel **is *owned,*** who owns (Code c**)**	B1.6 If the parcel is rented-in what is the monthly cost
Arable land					
Forest land					
Grazing land					
Un-utilized land					
Other,					
a) Unit of land	**b) Tenure system**		**c) If owned, name on title/certificate:**		
1= acre 2= ha 3= sqm2 4= other, specify conversion in metric system	1= Title deed 2= Owned but not titled 3= public land 4= Rented-in/ sharecropped 5=Other (specify)		1= Male 2= Female 3= Joint 4=Other relative 5= Other		

B1. Land

**parcel is one contiguous plot of land. One parcel can contain more than one plot.*

B2. Home

B2.1 Home ownership (Code a)	B2.2 If rented how much rent do you pay per month	B2.3 Number of rooms	B2.4 Floor material (Code b)	B2.5 Wall material (Code c)	B2.6 Roofing material (Code d)
a) Ownership			**b) Floor material**	**c) Wall material**	**d)Roofing material**
1= Owned 2=Rented 3=Borrowed 4=Other (specify)			1= earth 2= cement 3= tiles 4= other, specify	1= earth/mud 2= wood/ bamboo/ iron sheets 3= cement/ bricks 4= other, specify	1= grass 2= iron sheets/ asbestos 3= tiles 4= Clay soil 5=other, specify

B3. Water

B3 What are your main sources of water for your domestic use and your animals and do you pay for it

B3.1 Use	B3.2 Main water source (Code a)	B3.3 Distance to water point and time taken to go to the water point				B3.4 Do you pay? Yes=1; No=2.	B3.5 If yes, what is your average monthly cost?	B3.6 Do you transport water to cattle post/home? If yes, which mode of transport do you use?				B3.7 Average annual transport cost for transporting water.
		B3.3.1 Dry season		B3.3.2 Rainy season				B3.6.1 (1=Yes, 0= No)	B3.6.2 Mode of transport (code b)	B3.6.3 Who transports water (Code c)	B3.6.7 What are the main constraints to accessing water? (Code d)	
		B3.3.1.1 Distance (Kms)	B3.3.1.2 Time (hrs)	B3.3. 2.1 Distance (Kms)	B3.3.2.2 Time (hrs)							
1.Home use												
2.Livestock use												

(Code a): Source 1=borehole 2=well 3=river 4= Roof Harvested rainfall	5= Water pan 6= Water company (Piped) 7 = Other specify	(Code b): Mode of Transport 1= Own car 2=Hired car 3= Carrying	4= cart (animal drawn) 5= Bicycle 6= Motorbike 7=Other(Specify)	(Code c): Water transport 1= adult male 2= adult female 3= Young male 4= young female 5=Hired male 6=Hired female 66=Other(Specify)	(Code d): Main constraints 0= None 1= Long Distance to watering points 2= Poor quality 3= Seasonality in supply 4= Other(Specify)

B3.8 Is water always available to your animals throughout the day & throughout the year? (Yes=1, No=2)

[ ]

B3.8.1 If No, how frequently do you give your animals water in a day?

B3.8.2 [____] (number of times/ day) during rainy season

B3.8.3 [____] (number of times/ day) during dry season

B3.9 Who is responsible for watering animals (use **code c** in table above) [_____

C. Livestock and small ruminants: Flock structures and flows

C1. Does your household <u>OWN</u> any livestock (0 = No, 1 = Yes)?

If yes, indicate the numbers of animals for the different species owned by the household

C1.1 Livestock Species		C1.2 Number owned by male	C1.3 Number owned by female	C1.4 Number owned jointly	C1.5 Number owned by the household but kept elsewhere	C1.6 Number owned by the household (total)
1. Cattle	a. Local					
	b. Crossbred/ exotic*					
2. Goats	a. Local					
	b. Crossbred / exotic					
3. Sheep	a. Local					
	b. Crossbred / exotic					
4.Poultry	a. Local					
	b. Crossbred / exotic					
5. Pig	a. Local					
	b. Crossbred / exotic					
6.Donkeys/Horses						
7.Rabbits						
8.Other, specify						

**** "Crossbred" refers to an animal which is part-exotic and part indigenous***

C2. If the household has small ruminants, indicate the number owned

C2.1. Small ruminant type (Code a)	C2.2 Animal category (Code b)	C2.3. Breed (Code c)	C2.4 Number kept on the farm

a) Small ruminant type	b) Animal categories	c) Breeds
1= Sheep 2= Goat	1= Rams / buck (Adult males >1year) 2= Castrated adult male 3= Immature male (Weaned male < 1 year) 4= Ewe / doe (mature female, lambed at least once) 5= mature female, but no lambing 6 = Immature female (Post weaning, no lambing) 7= ram Lamb (pre-weaning male) 8= ewe Lamb (pre-weaning females)	**Sheep:** 1=Red Maasai pure 2=Dorper pure 3= Blackhead Persian pure 4=Red Maasai*Dorper (cross) 5=Red Maasai*Blackhead Persian (Cross) 6 =Blackhead Persian*Dorper (cross) **Goats:** 7= Galla pure 8= Galla cross 9= Small East African 10= Alpine pure 11= Alpine cross 12= Other (specify)_____

C3. Have any sheep or goats entered the household herd during the past 12 months, except from purchase?
(Yes=1, No=2) [ ]?

If yes, fill in the below table, not forgetting births! (for purchase fill Table C 5)

C3.1. Inflow types (code a)	C3.2. Main Month (code b)	C3.3. Quantity (number)	C3.4 Main animal category (code c)	C3.5 [Animal Type] [Breed] (codes d and e)
.1				**[--][--]**
.2				**[--][--]**
.3				**[--][--]**
.4				**[--][--]**
.5				**[--][--]**
.6				**[--][--]**
.7				**[--][--]**
.8				**[--][--]**

Inflows (Code a)	1=Birth, 2=Gift In, 3=Exchange In, 4= Loan In, 5= Keep on behalf of others, 6=Other
Months (Code b)	1=Jan, 2= Feb, 3= Mar, 4= Apr, 5= May, 6= Jun, 7=Jul, 8= Aug, 9= Sep, 10= Oct, 11=Nov, 12= Dec
Animal category (Code c)	1= Rams / buck (Adult males >1 year) 2= Castrated adult male 3= Immature male (Weaned male < 1 year) 4= Ewe / doe (mature female, lambed at least once) 5= mature female, but no lambing 6= Immature female (Post weaning, no lambing) 7= ram Lamb (pre-weaning male) 8= ewe Lamb (pre-weaning females)
Animal type (code d)	1= Sheep, 2= Goat
Breed (Code e)	**Sheep:** 1 =Red Maasai pure, 2 =Dorper pure, 3 = Blackhead Persian pure 4 =Red Maasai*Dorper (cross), 5= Red Maasai*Blackhead Persian (Cross) 6 =Blackhead Persian*Dorper (cross) **Goats:** 7 = Galla pure, 8 = Galla cross, 9= Small East African, 10= Alpine pure 11= Alpine cross, 12= Other (specify)_____

C4. Have you purchased any small ruminants (Sheep or Goats) in the last 12 months (0 = No, 1 = Yes)?

*If **Yes**, give **individual details** on all **small ruminants that were purchased OR obtained***

C4.1 Small Ruminant type [Use codes from 5.3.5 (code a)]	C4.2 Animal category [Use codes from 5.3.5 (code b)]	C4.3 Breed [Use codes from 5.3.5 code c]	C4.4 Reasons for purchase (code d)	C4.5 From whom (code e)	C4.6 Cost	C4.7 Purchased where (codes f)	C4.8 Which months do you purchase your sheep and/ goats animals? Use codes from C5.6 (Code e)	C4.9 Name of market/ trader	C4.10 Whose decision was it to purchase (code g)

	d) Reason for purchase	**e) From whom (Anim source)**	**f) where Purchased**	**g) Whose decision**
Codes a, b, c as in section 5.3.5	**1** = Replacement of old or culled animal **2** = Improvement of mutton production **3** = Improvement of milk production 4= To sell later 5= As a way of storing money I had available at the time 6= To guard against food shortage because the animal can be sold 7 = To guard against food shortage because the animal can be slaughtered 8= Increase social prestige 9= Replace animal that died 10= For animal draft 11= Other (specify)_____	**1**= Bought from other farmer 2= Bought from individual trader/broker/ market 3= From project/NGO 4= Gift from relatives/ others 5= Obtained as dowry 6= Other (specify)____	1= Within the village 2= Within the division/ Sector **3** = Outside the district **4** = Outside the county **5**=other, specify: _____	1= household male 2= household female 3= joint household (male & female) 4= non-household member 5= Other, specify

C5. Have any small ruminants (sheep or goats) exited the household flock during the past 12 months? (0 = No, 1 = Yes)?

Except for death, If yes, fill in the below table.

C5.1. Outflow types (code a)	C5.2 Animal Type (code b)	C5.3 Animal category (code c)	C5.4 Breed (Code d)	C5.5 Quantity (number)	CC6 Main Month (code e)
.1					
.2					
.3					
.4					
.5					
.6					
.7					
.8					

Inflows (Code a)	**1**=Sale (live animals) **2** = Slaughter for sale **3**=Slaughter - household needs **4**= Slaughter because sick **5**= Given away (e.g. dowry) **6**= Stolen **7**= Other, specify
Animal type (code b)	1= Sheep, 2= Goat
Animal category (Code c)	1= Rams / buck (Adult males >1 year) 2= Castrated adult male 3= Immature male (Weaned male < 1 year) 4= Ewe / doe (mature female, lambed at least once) 5= mature female, but no lambing 6= Immature female (Post weaning, no lambing) 7= ram Lamb (pre-weaning male) 8= ewe Lamb (pre-weaning females)
Breed (Code d)	**Sheep:** **1** =Red Maasai pure, **2** =Dorper pure, **3** = Blackhead Persian pure **4** =Red Maasai*Dorper (cross), 5= Red Maasai*Blackhead Persian (Cross) 6 =Blackhead Persian*Dorper (cross) **Goats:** 7 = Galla pure, 8 = Galla cross, 9= Small East African, 10= Alpine pure 11= Alpine cross, 12= Other (specify)_____
Months (Code e)	1=Jan, 2= Feb, 3= Mar, 4= Apr, 5= May, 6= Jun, 7=Jul, 8= Aug, 9= Sep, 10= Oct, 11=Nov, 12= Dec

C6. Please provide the following information on the animals sold.

C6.1 Category (Code a) and breed (Code b) of animal sold	C6.2 Purpose for Sale (code c)	C6.3 Number Sold in last 1 year	C6.4 Average price per unit*	C6.5 To whom sold (Code d)	C6.6 Who controls the money? (code e)	C6.7Which months do you sell your Sheep/and Goats? Use codes from C5.6 Code e
Sheep						
Goats						

Animal category (code a)	**Breed (Code b)**
1= Rams / buck (Adult males >1 year) 2= Castrated adult male 3= Immature male (Weaned male < 1 year) 4= Ewe / doe (mature female, lambed at least once) 5= mature female, but no lambing 6= Immature female (Post weaning, no lambing) 7= ram Lamb (pre-weaning male) 8= ewe Lamb (pre-weaning females)	***Sheep*:** 1=Red Maasai pure 2=Dorper pure 3= Blackhead Persian pure 4=Red Maasai*Dorper (cross) 5= Red Maasai*Blackhead Persian (Cross) 6 =Blackhead Persian*Dorper (cross) ***Goats*:** 7 = Galla pure 8 = Galla cross 9= Small East African 10= Alpine pure 11= Alpine cross 12= Other (specify)_____

Purpose of selling (code c)	**To whom sold (Code d)**	**Who controls money (Code e)**	**Credit (Code f)**
1=To meet planned household expenses **2**=To meet emergency household expenses **3**= Livestock trading as a business **4**= Culling because not productive **5**= Culling because sick **6** = Other: (specify in cell)	**1**= Other farmer 2= Local butcher **2**= Commercial slaughter house (e. g KMC) **3**= Middleman **4**= Animal market within county **5**= Animal market in different county	1= household male 2= household female 3= joint household (male & female) 4= non-household member 5= Other, specify	**1**= None **2**= Buyer provided access to feed on credit **3**= Buyer provided access to animal health services on credit **4**= Buyer provided access to breeding services on credit **5**= Buyer provided access to household goods on credit **6**= Other: (specify in cell)

**use common currency unit throughout the survey*

C7. Have any small ruminant (sheep or goats) died in the last 12 months (1 =No, 2=Yes)?

*If **Yes**, indicate, for the last 12 months, **individual details** on all **sheep that died**.*

C7.1 Small ruminant type [Use codes from 5.3.1, (code a)]	**C7.1 Animal Type [Use codes from 5.3.2, (code b]**	**C7.2 Breed [Use codes from 5.3.3, (code c]**	**C7.3 Cause of death/loss (code d)**	**C7.4 If died due to disease, what disease? (if known) (code e)**
	[Code d] Cause of death/loss		**e) Common diseases**	
Codes a, b, c as in section 5.3	1= Old age /natural death 2= Died due to disease 3= Died due to injury, accidents 4= Died due to poisoning (acaricide, snake bite) 5= Other (specify)_____		**1**= CCPP (Contagious Caprine Pleuropneumonia) **2**= Sheep and goat pox **3**= Rift Valley Fever **4**= PPR (Peste des Petits Ruminants) 5=Blue tongue 6= Lumpy skin **7**= Other, specify	

D. Practice, Access to, and use of technology, and inputs and products from sheep and goats

D1. Breeding management

Where do you get breeding rams/ bucks from and what type of mating strategy do you use with the different breed types?)?

D1.1 Breed (code a)	D1.2 Source of breeding males (codes b)	D1.3 System of mating Ram/Buck is used for (1=Pure breeding 2= Cross-breeding)	D1.4 Is there cost incurred in acquiring the breeding males? (0=No, 1=Yes) If Yes how much?
Sheep			
Goats			

Breed Sheep: 1=Red Maasai pure 2=Dorper pure 3= Blackhead Persian pure 4=Red Maasai*Dorper (cross) 5=Red Maasai*Blackhead Persian (Cross) 6=Blackhead Persian*Dorper (cross) Goats: 7= Galla pure 8= Galla cross 9= Small East African 10= Alpine pure 11= Alpine cross 12= Other (specify)_____	Source of Males (Code b) 1= Own bred 2= Bought from other farmer 3= Bought from individual trader/broker 4= Obtained through project (Specify which project) 5= Gift from relatives/ others 6= Obtained as dowry 7= Other (specify)_____

D1.5 Which month of the year do you normally aim to have lambs/kids born and why (Tick)

Month	J	F	M	A	M	J	J	A	S	O	N	D	Reason for using method
Breed type													
Indigenous/ Local													
Cross-breeds													
Exotics													

D1.6 Do you own any tools/ items that are used for in management practices of Sheep or Goats? (Yes/ No) If YES, Which ones: List (Codes). What was the cost of acquiring these tools?

D1.6.1 Equipment Codes (code a:	Cost (Ksh)
a) Equipment 1= Spraying pump 2= Burdizzo 3= Ear Tag applicators 4= Panga/ slasher 5= Hoe 66=Other Specify	

D1.7 Housing

D1.7.1Have you housed your sheep/ goats in the last 12 months? [ ] [0=No, 1=Yes]	D1.7.2 If Yes, which type of housing did you use? (Code a:	D1.7.3 What was the construction cost?
a) Type of housing		
1= No housing 2=Backyard sheds 3=Stall/shed 4=Housed in living premises e.g kitchen 5=Other (specify)		

D2. Which attributes are considered when categorizing animals for sale? How does each attribute rank in terms of importance in defining the price of an animal?

	D2.1 Age of animal	D2.2 Sex	D2.3 Conformation	D2.4 Nutritional status	D2.5 Breed
1. Is the attribute important in defining the grade category of an animal? (Y/N)	[____]	[___]	[____]	[____]	[____]
2. Rank of importance of the attribute in defining the price of animals (1=most important and 5=least important)	[____]	[___]	[____]	[____]	[____]

D2.6 Sale Price of sheep and goats

<table>
<tr><td colspan="6">D2.6.1 Are there specific times of the year when you decide /choose to sell sheep/goats?
[0=No, 1=Yes)
If Yes, which time in seasons and months?</td></tr>
<tr><td colspan="2">D2.6.2 Seasons
(code a)</td><td>[ ]</td><td colspan="2">D2.6.3 Months use codes in section C5.6 (Code e)</td><td>[ ]</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">D2.6.4 Age (code b)</td><td>D2.6.5Price:</td><td></td></tr>
<tr><td rowspan="2">At what age do you often sell your sheep/goats?</td><td>Sheep</td><td>Goats</td><td>Sheep</td><td>Goats</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="3"></td><td colspan="4">D2.6.6 Breeds use section C5.4 (code d)</td></tr>
<tr><td colspan="2">Sheep</td><td colspan="2">Goats</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Code a) Seasons
1=Dry season
2=Rainy season</td><td colspan="4">Code b) Age category
1 < 1 year
2= 1-2 years
3=2-3 years
4=3-4 years
5=4-5 years
6=Other: (specify)</td></tr>
</table>

D3. Small Ruminant products and their sales

D3.1 Do you keep Milk any of the sheep or goats? (0 = No, 1 = Yes)
If Yes fill the table below.

D3.1.1 How many sheep /goats do you milk?	D3.1.2How much milk is produced per animal per day?	D3.1.3 What is the milking period per lambing/kidding?	D3.1.4 Do you sell the fresh milk? [0=No, 1=Yes]	D3.1.5If Yes, whom do you sell the milk to? (code a)	D3.1.6 How many litres do you sell in a day?	D3.1.7 Approximately how much do sell pay/litre?	D3.1.8 Do you sell other milk products? **Y/N**. If Yes, which ones? (code b)	D3.1.8.1 If Yes, whom do you sell to? (code a)	D3.1.8.2 How much does each product cost?	D3.1.8.3 What marketing strategy do you use? (code c)	D3.1.8.4 What are the payment processes? (code d)

Code a) Who do you sell milk to	**Code b) Milk products sold**	**Code c) Marketing strategy**	**Code d) Payment processes**
1=Other farmer within the village 2=other farmer in the division 3=Non-farmer within the village 4=At market 5=Hotel/restaurant 6=Other (specify)	1= skimmed milk 2=sour milk 3=Yoghurt 4=Butter 5=Cheese 6=Other(specify)	1=Takes to the customer 2=The customer picks it from the farmer 3=Other(specify)	1=Cash on delivery daily 2=Cash on delivery weekly 3=Cash on delivery monthly 4=In kind with delay 5=In kind on delivery 6=In kind in advance 7=Other (specify)

D3.2 Manure

D3.2.1 Have you used manure in the last 12 months? [0=No, 1=Yes]	If Yes for what purpose (code a)	Did you sell any manure in the last 12 months? [0=No, 1=Yes]	Whom do you sell to? (code b)	If Yes, what quantity and cost of the manure sold? (sacks/wheelbarrow)?			
				Quantity		Cost	
				Sacks	Wheelbarrow	Sacks	Wheelbarrow
Code a) **Manure uses** 1=Direct use for crop production 2=Used to make compost manure 3=To make biogas 4=Other(specify)			**Code b) Sold to whom** 1=Neighbor 2=Farmer within the village 3=Farmer outside the village 4=Other (specify)				

D4. Animal health

D4.1 Which animal health activities do you practice and what are the costs?

D4.1. 1 Health activity (code a:	D4.1.2 Who provided the service? (code b:	D4.1.3 Against what disease was the service provided? Use codes in section C7.4 (code e)	D4.1.4 Type of control/treatment used?	D4.1.5 How many times have used this service in the last 12 months?	D4.1.6 What was your total expenditure in the last 6 months	D4.1.7 Who made the decision to use the service/ service provider? (Code c:	D4.1.8 When was the last intervention?

Code a) Animal health activity	**Code b) Service provider**	**Code c) Who made the decision**
1=Deworming 2= External parasite control 3=Vaccination 4= Prophylactic treatment 5= Other (Specify)	1= Self/Neighbour with professional advice 2= Self/Neighbour without professional advice 3=Government veterinarian 4=Project/NGO staff 5=coop/group staff 6=Community Animal health service provider 7=Community dip 8=Other, specify	1= household male 2= household female 3= joint household (male & female) 4= non-household member 5= Other, specify

E. Feeding

E1. Feeds and feeding system

E1.1 Small ruminant type (code a)	E1.2 Feeding system & feed source/ season				E1.3 Who is responsible for feeding the animals? (code d:	E1.4 Challenges in feeding code e:
	E1.2.1 Rainy season		E1.2.2 Dry season			
	E1.2.1.1Feeding system (code b:	E1.2.1.2 Feed source (code c:	E1.2.2.1 Feeding system Code b:	E1.2.2.2 Feed source Code c:		

Code a) small ruminant type	**Code b) feeding system**	**Code c) feed source**	**Code d) Responsible for feeding**	**Code e) challenges**
1 = Sheep local breed 2=Sheep cross and grade breed 3= Goat local breed 4= Goat cross and grade breed	1 = Only grazing (free-range) 2= Mainly grazing with some stall feeding 3 = Mainly stall feeding with some grazing 4=Only stall feeding 5= Other (specify)	1=Natural grazing 2=Grown fodder 3= Crop residues 4=Concentrates 5=Other (specify)	1= Child (<15 years) 2=Teenage/Youth (15-20 years) 3=Young adult (21-30 years) 4=Middle age adult (31-45 years) 5=Elder (>45 years)	1=Seasonality of feeds 2=Poor quality feeds 3=High feed costs 4=Small farming area 5=Pest and diseases in feeds 6=Other (specify)

E2. Do you grow improved fodder? (0 = No, 1 = Yes). If Yes, Enter different fodder and pasture species in different rows

E2.1 Which ones? **(code a:**	E2.2 % of land under the fodder or pasture	E2.3 What seeds/ planting material are you using? **(code b:**	E2.4 Any treatment before feeding? (**code c:**	E2.5 Who is responsible for growing the fodder? Use section E1.3 (**Code d**:	E2.6 Cost of production per year	E2.7 How do you manage your fodder? (**code e:**	E2.8 Do you sell your grown fodder? (0 = No, 1 = Yes)			
							E2.8.1 Which months in the last 1 year	E2.8.2 Quantity and prices in the last 1 year		
								E2.8.2.1Feed type (**code f**:	E2.8.2.2 Quantity	E2.8.2.3 Price

Code a) Pasture **1**= Napier grass **2**= Rhodes grass **3**=Leucaena **4**=caliandra	**5**=sweet potatoes **6**=Tithonia **7**=Other, Specify	**Code b) Seeds** **1**= recycled from own farm **2**= recycled from other farmers **3**= improved seeds **4**= Other, specify	**Code c) Treatments** **0**= no treatment **1**= chopped using panga **2**= chopped using chaff cutter **3**= prepared using a pulverisers **4**=storage	**Code e) Fodder management** 1=Fresh chopped bales 2=Bales of hay 3=Silage 4=Other(specify)	**Code f) Feed type sold** 1 =Crop residues 2 = Improved fodder 3= Other (specify)

E3. Do you feed sheep and/or goats crop residues? Y/N. If Yes

E3.1 Which ones? [code a]	**E3.2 Grown on farm or purchased? (1=grown, 2=purchased)**	**E3.3 Any treatment? [code b]**	**E3.4 Cost per year of purchase, treatment, and storage**
(a)Crop residues **1**= green/dry maize stovers and thinning **2**= cereal (wheat, barley, rice, etc.) straws **3** = Millet, sorghum stalks **4**= Legume (beans, sheep peas, soya, etc.) haulms **5**= root and tuber peelings (potato, cassava, bananas, etc.) **6**= Agro-industrial by products (vegetable wastes, brewers waste, etc.) **7**= other, specify		**b) Treatments 0**= no treatment **1**= chopped using a machete **2**= chopped using chaff cutter **3**= prepared using a pulverizers **4**=storage	

E4. Do you purchase fodder or crop residues for feeding sheep and/or goats for the last 12 months? Y/N.
If Yes fill the table below

E4.1Which ones? (code a:	E4.2 Where did you purchase (code b:	E4.3Months/year purchase is done	E4.4 What is the average monthly cost during months purchased	E4.5 % contribution to total feed fed
Code a) Fodder/Crop residue **1**= Napier grass **2**= Rhodes grass **3**= green/dry maize stovers and thinning **4**= cereal (wheat, barley, rice, etc.) straws **5** = Millet, sorghum stalks **6**= Legume (beans, sheep peas, soya, etc.) haulms **7**= root and tuber peelings (potato, cassava, bananas, etc.) **8**= Agro-industrial by products (vegetable wastes, brewers waste,etc.) **9**= other, specify			**Code b) Feed sources** 1=Agro vet shop 2=Other farmers 3= Market, trader 4= Other (specify)	

E5. Did you feed sheep and/or goats on concentrate feeds and mineral supplements in the last 12 months?

E5.1 Which ones? (Code a)	**E5.2 Cost per year of purchase and related costs**	**E5.3 Which animal types are fed with it? (Code b)**	**E5.4Kgs fed/ animal/ day (when fed)**	**E5.5 How many months of the year do you feed these?**	**E5.6 Where did you get the info? (Code c)**

a) Concentrate type	**b) Animals fed**	**c) Information sources**
1= Roughage **2**= Mineral blocks **3**= Vitamins **4**=Concentrates **5**=Others	**1**= all **2**= Rams only **3**= lactating Ewes only **4**= Lambs only **5**= other, specify	**1**= Govt extension agent **2**= Research/ training institute **3**= coop or group **4**= Private ext provider e.g agro vet shop/company **5** = NGO/Project **6**= other, specify

F. Other Services

F.1.1 Type of services	F.1.2 Is the service available? (Y/N)	F1.3 Have you used this service in the last 12 months? (Y/N)	F1.4 Who requested/received this service? (Code a)	F1.5 Who provides the service? (Use section E5.6 code c)	F1.6 How are the services (code b)	F1.7 What are the terms for the services (code c)	F1.8 Do you pay for the services? [0=No, 1= Yes] If Yes how much do you pay for the services
F1. Extension visits and Training							
Extension visits							
1. Livestock- general							
2. Sheep/ goats							
3. Crop							
4. Other, specify [ ]							
Training							
5. Livestock in general							
6. Sheep/ goats							
7. Crop							
8. Other, specify [ ]							
F2. Information (other than extension and training)							
Financial services							
9. Savings							
10. Credit/Loan							
11. Health insurance							
12. Domestic/home insurance							
13. Crop insurance							

14. Livestock insurance							
F3. Electricity							
15. National grid							
16. Solar							

a) WHO REQUESTED / USED THE SERVICE	**b) HOW ARE THE SERVICES**	**c) TERMS OF THE SERVICE**	
1= household male 2= household female 3= joint household (male & female) in HH 4= non-household member 5= other, specify	1=Rigid 2=Flexible 3= Other (specify)	1= Cash on delivery 2=Cash in advance 3=Cash with delay	4= Barter trade 5 = Credit 6 = other, specify

G. Membership of groups

G1. Name of group*	G2. Type of group [Code a]	G3. Main function that this group performs for you (up to 2) [Code b]	G4. How many men in the household belong to this group?	G5. How many women in the household belong to this group?	What are the terms

a) Type of groups

1= social/ welfare & community development groups 2= savings and credit groups 3= agricultural producer groups	**4** = livestock producer groups **5** = agricultural marketing groups **6** = livestock marketing groups **7** = Other, specify

b) Main functions

1= provides access to the milk market **2**= provides access to inputs and services for sheep **3**= provides training/ advisory for sheep **4**= provides access to the market for crops	**5**= provides access to inputs and services for crops **6**= provides training/ advisory for crops **7**= provides ways to save money and get credit **8**= social functions and networking

**Complete one row per group which the household (any person) is a member of a group*

H. Labour allocation

The table is to be filled for activities on sheep and/goats

H1. Type of Activity	H2. Labour source		H3. Wage rate per day
	H2.1 Age group (use section E1.3 code d)	H2.2. Gender (Code a:	
H1.1 Grazing			
H1.2 Feeding (+ collecting &			
preparation) H1.3 Watering			
H1.4 Cleaning of animal shed/shelter			
H1.5 Collection of Farmyard Manure (FYM)			
H1.6 Selling animals/ animal products			
H1.7 Disease control / Caring for sick animals			
H1.8 Other: [ ]			

Code b) Gender
1=Household male 2=household female
3= Non-household male 4=Non-household female

**Labour for the whole herd*

I. Other enterprises

I.1. Do you have other enterprises? Y/N

If Yes, fill the table below

I.1.1 Type of the enterprise type (Code a)	**I.1.2When do you get the produce?**		**I.1.3 Do you sell the produce? Y/N**	**I.1.4 If Yes, whom do you sell to? (Code b)**	**I.1.5How is the product sold? (Code c)**	**I.1.6 What quantity do you sell?**	**I.1.7 What is the market price/quantity sold?**
	I.1.2.1 Months (Use sectionC5.6 code e)	I.1.2.2 seasons (Use codes D2.6.2 code a)					

Code a) Enterprises			**Code b) Whom do you sell to**
Code a_i Major crops 1=Maize 2=Finger millet 3=Banana 4=Ground nuts 5=Sweet potato 6=Beans 7=Cassava 8=Coffee 9=Nakati (solanum ethiopica) 10=Dodo (amaranthus) 11=Cabbage 12=Cow pea 13=Green grams 14=Pigeon pea 15=Rice 16=Sorghum 17=Forages 18=Sukuma wiki (Kales) 19=Tomatoes 20=Onions 21=Water melon 22=Pumpkins 23=Butternut 24=Other crop (specify)	**Code a_{ii} Other livestock** 1=Cattle 2=Poultry 3=Donkey 4=Rabbits 5=Other (specify)	**Code a_{iii} Other enterprises** 1=Forestry 2=Fishing 3=Trading 4=Sand/ stone mining 5=Brick making 6=Bee keeping 7=Mat making 8=Pottery 9=Carpentry 10=Pension 11=Remittances e.g. Mpesa 12=Other (specify)	1=Neighbor 2=hotel/restaurant 3=market 4=Other (specify) **Code c) How the product is sold** 1=Daily 2=weekly 3=Monthly 4=Seasonly 5=Other (specify)

To be answered privately by the enumerator immediately following the interview

1. In your opinion, how did you establish rapport with this respondent [____]
   1 = with ease
   2 = with some persuasion
   3 = with difficulty
   4 = it was impossible

2. Overall, how did the respondent give answers to your questions? [____]
   1 = willingly
   2 = reluctantly
   3 = with persuasion
   4 = it was hard to get answers

3. How often do you think the respondent was telling the truth? [____]
   1 = rarely
   2 = sometimes
   3 = most of the times
   4 = all the time

DATE OF QUESTIONNAIRE INSPECTION BY SUPERVISOR (dd/mm/yyyy):	_____/_____ /_____
Reviewing of the questionnaire:	
ENUMERATOR: Enter your comments here AFTER you have administered the questionnaire	
SUPERVISOR: Enter your comments here AFTER you have inspected the WHOLE questionnaire	

I certify that I have checked the questionnaire two times to be sure that all the questions have been answered and that the answers are legible.

Enumerators' Signature:_____ **Date** _____/_____/_____

Appendix 2: Growth Performance Questionnaire

CCAFS Nyando: Sustainable small ruminant breeding programs for "Climate Smart Villages" in Kenya

Household Monitoring Tool – Animal Growth

Farmer Name:_____ Respondent Name:_____ Respondent Gender:_____

Relationship to HH head:_____ County:_____ Village: _____

Date: _____ Site Coordinator: _____

Date	Species SH/GT	Breed Name	Ear Tag	Weight (Kgs)	Period	Remarks

Period: (Time of sampling):1=At Birth, 2=At Weaning (3-4 months), 3=9 months, 4=12 months,5=Weight at the sale, 6=Other (specify)
Sheep Breeds:1=BHP pure, 2=BHP*RM, 3=RM*Dorper, 4=RM Pure **Goat Breeds**: 1=SEA Pure, 2=Galla Pure, 3=Galla*SEA