ANALYSIS OF STRATIFIED LIVESTOCK PRODUCTION AS AN OPTION FOR ENHANCING COMMERCIAL OFF-TAKE OF PASTORAL CATTLE IN KENYA'S DRYLANDS

BULLE HALLO DABASSO

BSC. (EGERTON UNIVERSITY, KENYA), MSC. (NORWEGIN UNIVERSITY OF LIFE SCIENCES, NORWAY)

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN RANGE MANAGEMENT

DEPARTMENT OF LAND RESOURCE MANAGEMENT AND AGRICULTURAL TECHNOLOGY

FACULTY OF AGRICULTURE

COLLEGE OF AGRICULTURE AND VETERINARY SCIENCES

UNIVERSITY OF NAIROBI

2020

DECLARATION

This thesis is my original work and has not been presented for degree award in any other university.

Signature: _____ Date: 08/11/2020

Bulle Hallo Dabasso

Supervisors:

This thesis has been submitted with our approval as University supervisors.

Signature: _____ Date: 09/11/2020

Dr. Oliver Vivian Wasonga

Department of Land Resource Management and Agricultural Technology, Faculty of Agriculture, College of Agricultural and Veterinary Services, University of Nairobi, Kenya

Signature: _____ Date: 10/11/2020

Dr. Patrick Irungu

Department of Agricultural Economics, Faculty of Agriculture, College of Agricultural and Veterinary Services, University of Nairobi, Kenya

Signature: _____ Date: 11/11/2020

Prof. Brigitte Kaufmann

German Institute for Tropical and Subtropical Agriculture, and Institute for Agricultural Sciences in the Tropics, University of Hohenheim, Germany

DEDICATION

In memory of my late mother, Ware Hallo (1945-2018)

ACKNOWLEDGEMENTS

First, I thank the Almighty God for His love, protection, and grace that enabled me to complete this thesis. Several individuals and institutions supported me, to whom I express my utmost gratitude. I sincerely thank my supervisors; Drs. Oliver Wasonga and Patrick Irungu, and Prof. Brigitte Kaufmann, for their insightful and professional guidance. I also thank the German Federal Ministry of Education and Research (BMBF) for the generous scholarship that covered my stipend, tuition, and research expenses through the Reduction of Post-harvest Losses and Value Addition in East African Food Value Chains (RELOAD) project. Through the RELOAD project, the BMBF facilitated my visits to the Germany Institute of Tropical and Subtropical Agriculture in Witzenhausen, Germany, where I accessed sufficient literature and received guidance from Prof. Brigitte Kaufmann during the initial stages of this study.

I am grateful to the University of Nairobi (UoN) for admission to pursue a doctorate program and to the Kenya Agricultural and Livestock Research Organization for granting me a study leave. The International Livestock Research Institute (ILRI) provided me with working space at its InfoCentre in Nairobi. My interaction with Dr. Harun Gitari at the ILRI InfoCentre was instrumental in writing of the thesis, particularly in accessing the relevant literature. I thank my fellow Ph.D. students in the RELOAD project (Drs. Raphael Lotira, Guyo Malicha, Josephant Njenga, and Buke Galma,) and friends (Drs. Hassan Roba, Hussein Wario, and Margareta Lelea) for the experiences and joyful moments we shared. Mr. Peter Mwangi of the African Drylands Institute for Sustainability of the UoN helped in mapping my study areas. I appreciate Mr. Charles Ikutwa of the UoN for the logistical support that ensured my stipend and research funds were released on time. I thank all those who assisted in data collection; Messrs Stanley Mollo of Narok County, Ismail Guyyolle of Tana River County, and Joseph Nanyoi of Laikipia County.

Finally, I am indebted to my wife, Kule Dida, daughters (Darmi Bulle, Ware Bulle, and Tume Bulle), and son (Waqo Bulle) for love and enduring my long absence from home. My wife diligently handled family chores and issues and gave me a peaceful mind to complete the thesis. My late mother, Ware Hallo, always inquired about my progress and wished me blessings. Her passing on 20th August 2018, before the epic of my academic life, was a great sorrow to me and to all those who knew her. I drew the inspiration and motivation to complete this thesis from her struggle in life to single-handedly secure education and livelihood for my siblings and me. I forever cherish the sacrifices and the hard work she made in life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AFDB	African Development Bank
ALMO	African Livestock Marketing Organization
ANOVA	Analysis of Variance
ASALS	Arid and Semi-Arid Lands
AU-IBAR	African Union Inter-African Bureau for Animal Resources
BMBF	German Federal Ministry of Education and Research
CBPP	Contagious Bovine Pleuropneumonia
CSIRO	Commonwealth Scientific and Industrial Research Organization
DFZS	Disease-Free Zones
DWG	Daily Weight Gain
ESRI	Environmental System Research Institute
GDP	Gross Domestic Product
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
GoK	Government of Kenya
IGAD	Intergovernmental Authority for Development
ILRI	International Livestock Research Institute
KIIs	Key Informant Interviews
KMC	Kenya Meat Commission
LMD	Livestock Marketing Division
LSD	Lumpy-Skin Disease
NEPDP	North Eastern Pastoral Development Program
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
OWG	Overall Weight Gain
RELOAD	Post-Harvest Losses and Value Addition in East African Food Value Chains
SCP	Stratified Cattle Production
SD	Standard Deviation
SEZ	Small East African Zebu
SPSS	Statistical Package for Social Sciences
UoN	University of Nairobi
USAID	United States Agency for International Development
USD	US Dollar

GENERAL ABSTRACT

Livestock production in Kenya accounts for 10–15 % of the country's gross domestic product (GDP) and about 42% of the agricultural GDP. The production mainly occurs in pastoral areas, where approximately 70% of the national large ruminant herd is reared, and predominantly inhabited by pastoralist and agro-pastoralist communities. The pastoral areas of Kenya are characterized by high seasonal and inter-annual rainfall variability that influences pasture availability−during the dry season, the pasture is scarce and limited in nutrient concentrations. Consequently, animals become lean in the dry season and fall short of terminal markets' quality requirements. On the other hand, pastoralists are under duress to sell many animals in the dry season, either to purchase cereals (given the reduced milk supply during such periods) or to avoid drought-related livestock mortalities. However, terminal markets' quality requirements, constrain the effort by pastoralists to commercially off-take lean animals during the dry season. This situation contributes to the high and widespread drought-related livestock losses often reported in Kenya's pastoral areas.

A system that geographically stratifies livestock production so that breeding takes place in pastoral areas followed by fattening in areas with better eco-climatic conditions and more grazing and water resources is a potential option for ensuring lean animals from drylands meet the quality requirements of terminal markets, and thus, facilitates commercial off-take from pastoral systems. This approach is known as the stratified livestock production (SLP) system and is practised many in countries in Africa and elsewhere to fulfil terminal markets' requirements, especially in terms of animal carcass specifications. From the early 1960s to 1970s, the government of Kenya (GoK) implemented a SLP program in which immature cattle produced in country's pastoral areas were transferred to ranches and feedlots for fattening before selling in terminal markets. The program was discontinued when the existing livestock

marketing infrastructure became dilapidated. This notwithstanding, the SLP has currently re-emerged in response to socio-economic and ecological changes in the country. Although, the re-emerged production could provide an opportunity for pastoralists in Kenya's drylands to commercially off-take lean animals during the dry season, its potential for the same has not been comprehensively analysed.

Against the foregoing background, this thesis sought to analyse the SLP as an option for improving the sale of pastoral cattle in Kenya's drylands. The existing forms of stratified cattle production (SCP) were identified, characterized, and the cattle fattening performance and profitability under each form evaluated. The characterization exercise was conducted using narrative interviews with thirty-four (34) purposively selected respondents, and the data was qualitatively analysed. The results revealed three forms of SCP practised by ranchers, by traders, and by agro-pastoralists, which differed with respect to access to grazing resources, herd size, and fattening period.

The evaluation of cattle fattening performance and profitability was done by collecting data on animal weights at purchase and at sale points, costs of purchase and fattening, as well as cattle sale prices. Fattened animals had average daily weight gain of 0.24 ± 0.07kg (n = 601), 0.39 ± 0.13kg (n = 240), 0.24 ± 0.08kg (n = 140) under the SCP by ranchers, traders and agro-pastoralists, respectively. On average, the practitioners earned USD 61.7 ± 34.2 (ranchers), USD 81.3 ± 44.0 (traders), and USD 55.9 ± 36.6 (agro-pastoralists) as net revenues after selling the animals.

The study further investigated whether there were requirements in the use of SLP as an avenue for selling pastoral cattle from Kenya's drylands and strategies used by pastoralists to fulfil the requirements. To do these, twenty-four (24) key informant interviews (KIIs) and two (2) focus group discussions (FGDs) were conducted. The results revealed that under the SCP systems practiced by traders and ranchers, pastoralists were required to sell 3-4 year bulls or

steers of Borana or Sahiwal breed in secondary markets or near urban centres, use sale agents to ensure the traceability of the animals whenever necessary, and comply with unpredictable supply orders. The results further revealed that in response to these requirements, the pastoralists were slowly changing their animal husbandry practices to produce the required type of animals, keeping "emergency" animals in the home-based herds to target the unpredictable market demands, arranging with sale agents to sell in the secondary markets, and establishing buyer-seller trust.

The study concludes that different forms of SCP, with varying management practices, exist in Kenya's drylands. The forms of SCP are economically attractive to the practitioners, and appealing to the pastoralists as they are integrating their production and marketing practices to meet the requirements of using the system as a marketing channel. However, the SCP systems operate against the backdrop of poor livestock marketing infrastructure, limited availability of grazing resources and other production inputs, outbreaks of notifiable cattle diseases, and informal and non-binding resource lease agreements. The study recommends promoting and strengthening SLP in Kenya's drylands by addressing the existing challenges. This study did not determine the type of cattle (in terms of genetic make-up, age, sex, and body condition) that had the highest weight gain and returns under the SCP systems, and therefore, further research that fills this gap is recommended.

Keywords: cattle fattening, drought-related livestock losses, grazing resource variability, livestock market demands, pastoral livestock marketing challenges, two-tier livestock production system.

CHAPTER ONE

1.0 General Introduction

1.1 Background information

Livestock production is the primary livelihood activity that provides food and income for pastoralist and agro-pastoralist communities living in the arid and semi-arid lands (ASALs) of Eastern Africa. The communities keep mostly the indigenous species of cattle, camels, sheep, and goats for milk, meat, and for defining social and cultural identities (Dioli, 2018). Additionally, they engage in livestock trade–involving mostly male and unproductive female animals–to generate income for household needs. Pastoral livestock trade in Africa contributes largely to the local, national, and international demand for meat in the continent, and thus immensely helps in the national economic growth of many countries (Galaty, 2008). Pastoral livestock production and trade accounts for 10−40% of the agricultural GDPs for Algeria, Mali, Chad, Sudan, Namibia, Ethiopia, Somalia, and Kenya (African Union, 2010). Despite the importance of pastoral livestock production and trade, pastoralism in Africa had been undervalued (Hesse and MacGregor, 2006), yet it is one of the most suitable land use options in drylands that produces higher economic return per hectare of land than crop farming and commercial ranching (Angassa and Oba, 2007; Behnke and Kerven, 2013).

Livestock production under the pastoral system relies on strategic access and utilization of grazing resources in drylands. This is because climatic conditions in drylands are highly dynamic and cause ephemeral concentrations of vegetation and water resources (Krätli et al., 2013). Pastoralists strategically move herds across landscapes to intelligently utilize vegetation at its appropriate growth stages when the nutrient concentrations are high, making the seasonal variability of vegetation an asset for improving livestock production (Krätli and Schareika, 2010). This strategic mobility helps in the opportunistic utilization of variable grazing

resources and important in accessing markets and in creating symbiotic relations with non-pastoral communities (Niamir-Fuller, 2005). Despite the importance of herd mobility for sustainable pastoral livestock production in drylands, pastoralism in Eastern Africa faces encroachment of other land uses such as crop farming, wildlife conservancies, and other land use options (Fratkin, 2001; Lamprey and Reid, 2004; Galvin, 2009). This implies that the remaining communal grazing lands will be overgrazed, as herd mobility to access other areas is limited, leading to degradation of the rangelands. The result is the declined in the productivity of the rangelands, causing pasture shortage, especially during the dry season. Consequently, during the dry season, animals become lean and hardly meet terminal market requirements, and thus fetch low prices for the producers (Aklilu, 2008). On the other hand, during the dry season, pastoralists sell many animals under duress either to buy cereals or to avoid drought-related livestock mortalities, a condition known as "stress-sale syndrome" (Mcpeak, 2004). However, the market demand for the lean animals is limited, and pastoralists often struggle to sell them. The high drought-related livestock losses often reported in pastoral areas (Oba, 2001; Catley et al., 2014) that even outweigh net sales made by pastoralists (Desta and Coppock, 2002) can be reduced if there are sufficient marketing avenues available to pastoralists. Despite this opportunity, the herd growth in pastoral production systems continues to follow a "boom and bust" cycle, in which there are years of gradual herd growth, followed by sudden and widespread drought-related livestock mortalities (ibid.).

Although droughts are a frequent phenomenon in drylands, they are becoming more distressful in the context of changing land use that restricts herd mobility in accessing critical grazing resources in pastoral areas. For example, in northern Kenya, the 1991/2 drought was more disastrous compared to the 1984/5 drought (Oba, 2001). This has been attributed to the changing land use that limits livestock mobility across landscapes, undermining the adaptive capacity of pastoralists to the climate variability. In a study conducted in the southern

rangelands of Kenya, Nkedianye et al. (2011) concluded that the areas that have undergone land fragmentation experienced high livestock mortality than others during the 2005/2006 drought.

The response by both government and development actors in Kenya for minimizing drought-related livestock losses has been the provision of emergency destocking and restocking programs, support for supplementary livestock feeding, peace-building (to facilitate migrations), and delivery of water and veterinary services as well as early warning information (Zwaagstra et al. 2010). Though these interventions are necessary for salvaging livelihoods, they are usually expensive, donor-driven with unsatisfactory performance in achieving the desired objective, and therefore, have little basis for sustainability (Aklilu and Wekesa, 2001). Evaluating the effectiveness of an emergency livestock off-take program implemented by the Veterinaires Sans Frontieres in Turkana County during the 2005/2006 drought, Watson and Binsbergen (2008) noted some limitations. The authors reported that, in addition to the flawed destocking approach done on "first-come-first-served" basis, the prices offered were too low (ranging from USD 3.45 to 7.89 per goat) and had little financial help to the pastoralists. Aklilu and Wekesa (2002) found that the supplementary livestock-feeding program implemented by development agencies in northern Kenya during the 1999/2000 drought was costly, labour intensive, and had other challenges associated with feed spoilage. Drawing on experiences of the Arid Lands Resource Project, Sinange (2007) observed that the drought early warning system implemented in 11 arid districts of Kenya had challenges of unreliable data and delayed in releasing results, and thus had little prospects in providing future climate predictions for timely action. An alternative option for reducing drought-related livestock moralities is the provision of a sustainable marketing approach that facilitates commercial off-take of lean animals during extended dry seasons.

One of the potential options to sustainably market lean pastoral animals is through SLP which involves breeding in pastoral areas and fattening in areas with better eco-climatic conditions (Jahnke, 1982). The aim is to fetch better prices by meeting the requirements for a certain niche markets. In Kenya, livestock production is practiced in two ecological zones, the semi- arid zone that is used for ranching activities and the integrated crop-livestock production, and the arid zone mainly used for pastoralism (Kabubo-Mariara, 2008). The semi-arid zone is suitable for fattening or finishing immature animals from the arid zone (Nyariki,1990). The GoK realized this opportunity to practice SLP in Kenya drylands, and in 1960-1970, established stock routes, quarantine centres, and livestock holding grounds, to facilitate purchase of immature cattle from pastoral areas for fattening in ranches and feedlots before slaughtering at the Kenya Meat Commission (KMC) (Raikes, 1981). In doing this, the government managed to utilize the 4,000 metric tons of beef quota allocation by the European Union (Irungu et al., 2014). Although the beef exports ceased following government failure to maintain disease free zones (DFZs), studies (Mahmoud, 2006; Farmer and Mbwika, 2012) have reported increasing adoption of SCP systems in which private business entrepreneurs source pastoral cattle for fattening in the semi-arid zone before selling in terminal markets.

1.2 Problem statement

Despite its economic contribution, pastoralism in Kenya has continued to face several challenges, including deplorable marketing infrastructure (AU-IBAR and NEPDP, 2006), low and fluctuating livestock prices (Barrett et al., 2003), weak market access, and poorly organized market information (Roba et al., 2018). These challenges have been found to constrain commercial off-take rates of pastoral livestock and therefore, undermining effective market participation by pastoralists (Negassa and Jabbar, 2007; Kyeyamwa et al., 2008; Musemwa et al., 2010).

Improving commercial off-take of pastoral livestock from Kenya's drylands has been the subject and objective of various government policies and programs implemented over the years. During the colonial period, the government introduced the concept of grazing schemes in which pastoralists were grouped and provided with extension services that mainly advocated for increased sales (Ngethe, 1992). The idea of grazing schemes was based on the assumption that pastoralists keep many animals, which are destructive to the environment and economically inefficient, and therefore, there was a need to do destocking (Anderson, 2010). The assumption was primarily reinforced by the influential Hardin's (1968) 'tragedy of the commons' theory, which suggests that rangelands are open access, and therefore, every herder seeks to maximize the utility by adding more animals. The grazing schemes concept was not successful as the pastoralists moved out of the schemes in search for better pasture, particularly during the dry season or droughts (Veit, 2011). As an alternative incentive to encourage the pastoralists to sell livestock, the government tried to provide land tenure security by introducing group ranches, particularly in the southern rangelands (Mwangi, 2007). Amidst the need for livestock mobility across the ranch boundaries, the concept was accepted for protecting the land tenure security (Mwangi, 2005). However, it had negative implications as the accessibility of pasture outside the ranches became increasingly limited, exposing the pastoralists to climate-related shocks, particularly during the dry season (Nkedianye et al., 2011).

1.3 Justification

In the context of eroding traditional drought coping strategies (Ouma et al., 2011), as well as increasing climate variability that compromises pastoralists' post-drought recovering efforts (Ahmed et al., 2002), facilitating pastoralists to sustainably sell their animals is increasingly becoming important (Nyariki et al., 2005). This is because providing avenues for pastoralists to commercially off-take their animals helps to minimize the drought-related losses and hence

increased food and income security among pastoral households, and also matches the available pasture with the livestock population, thus contributing to sustainable pastoralism.

In the wake of increasing drought impacts in pastoral areas, the SLP is being promoted to facilitate the sale of pastoral animals in countries such as Botswana (Engelen et al., 2013), Ethiopia (Little et al., 2014), and Argentina (Ruiz et al., 2000). In Kenya, the existence of semi-arid and arid ecological zones with varied availability of grazing resources, provides an opportunity to practice a SLP system and fatten lean animals available in Kenya's drylands during extended dry periods. In a bid to capture this opportunity, there is increasing adoption of a SLP system, especially in the country's coastal region (Mahmoud, 2006; Farmer and Mbwika, 2012). However, the emerging SLP in Kenya has not been comprehensively analysed as a pastoral livestock-marketing channel. Farmer and Mbwika (2012) acknowledged that there is a need for an in-depth analysis of the SLP to guide and develop robust rancher-pastoralist linkages under the production system. A similar recommendation was made by Aklilu et al. (2013) who observed that the remerging SLP in Kenya's drylands in which pastoral animals are fattened on ranches could be one of the best practices in pastoral livestock value chains, but the production system need to be understood well to identify supportive measures. This study was conducted in light of these research gaps to generate the required information necessary for guiding the development and out-scaling of the SLP as an avenue for improving commercial off-take of pastoral cattle in Kenya's drylands.

1.3 Broad objective

This study was conducted to gain an in-depth understanding of the SLP system in Kenya's drylands for the purpose of informing its development and out-scaling as an option for selling pastoral cattle.

1.4 Specific objectives

(i) Characterize forms of stratified cattle production systems in the drylands of Kenya.

(ii) Analyse changes in live-weights of animals fattened under the stratified cattle production systems.

(iii) Determine costs and revenues in purchasing and fattening animals under the stratified cattle production systems.

(iv) Analyse marketing requirements under stratified cattle production systems and pastoralists' strategies and practices for fulfilling them.

1.5 Research questions

(i) What are the characteristics of stratified cattle production systems that currently exist in Kenya's drylands?

(ii) How much live-weight do animals gain under stratified cattle production systems in Kenya?

(iii) What are the costs and revenues associated with purchasing and fattening of animals under various stratified cattle production systems?

(iv) What are the requirements for pastoralists to sell animals under stratified cattle production systems in Kenya's drylands?

(v) What strategies and practices do pastoralists in Kenya's drylands put in place in responding to market requirements under different stratified cattle production systems?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Economic importance of pastoral livestock production in Africa

In Africa's drylands, pastoral livestock production has been hailed as the most viable and sustainable land use option compared to crop farming (Behnke and Kerven, 2013) and ranching (Angassa and Oba, 2007). It supplies a substantial amount of meat for domestic, regional and international markets, contributing 10 – 40% of the GDPs of most African countries (African Union, 2010). The economic contribution would even be higher if the household milk consumption, livestock sales in informal markets, inputs to crop farming, and animal transport services were incorporated (Hesse and MacGregor, 2006). In Kenya, the contribution of livestock production accounts for 10–15 % of the national GDP (Behnke and Muthami, 2011) and approximately 42% of the agricultural GDP (GoK, 2008). Approximately, 70% of the total large ruminant herd in the country is reared in pastoral areas (GoK, 2012), implying substantial contribution of the pastoral livestock production to the national economic growth. Under the Vision 2030 Economic Blueprint, the GoK had recognised the economic contribution of the pastoral livestock production in the realization of the country's 10% annual GDP growth and envisaged establishing flagship projects such disease-free zones (GoK, 2012). Cattle production forms an important component of the pastoral livestock production, contributing 70% of the amount of beef consumed in Kenya (GoK, 2008)−the remaining amount of beef comes through cross border trade with neighbouring countries (Little, 2009), and also from cull cows and non-breeding bulls in the dairy sector (Kosgey et al., 2011). In one of its economic survey reports, the GoK indicated that the value of cattle trade in Kenya worths about US $ 0.9 in 2018 and US $ 1.0 in 2019 (Kenya National Bureau of Statistics, 2020).

2.2 Variability of grazing resources in pastoral production systems

The economic value of pastoral livestock is realized despite the production systems operating mainly in arid or semi-arid climatic zones where variability and ephemeral concentrations of vegetation and water resources are an inherent phenomenon (Krätli et al., 2013). Rainfall and temperatures are highly dynamic in drylands, making the resources for livestock production not only low but also short-lived. The variability of pasture production and distribution can range from 276,500 to 140kg of biomass per hectare, depending on season and type of landscape (woodland, grassland or shrubland) (Egeru et al., 2014). The variation is also in terms of the nutrient concentrations required for livestock production−during the dry season, the available pasture is deficient in nutrient concentrations (Gwelo et al., 2015), and has high fibre content, that limits animal intake (Sampaio et al., 2010).

The decline in the quantity and quality of pastures causes adverse changes in the body condition of animals− animals gain weight during the wet season or when there is more availability of grazing resources and lose weight in the dry season or when the grazing resources are less (Nyamukanza et al., 2009). Additionally, the variability of grazing resources adversely influences the reproductive performance of animals. Kanuya et al. (2006) found that the animal body condition, calving, and conception rates of the Tanzania Shorthorn Zebu cattle reared under an agro-pastoral production system were influenced by the dynamics of pasture of quality and quantity. In the pastoral areas of northern Kenya, the variability of pasture affects the reproductive traits of animals (Hary et al., 2003).

The main determinants of pasture dynamics in ASALs has been the subject of debate over the years. Controversies exist as to whether livestock grazing or abiotic factors (such as rainfall) cause substantial fluctuations in pasture availability. The proponents of the view that livestock grazing negatively impacts vegetation dynamics presume that the rangeland carrying capacity has to be maintained below a certain threshold to avoid land degradation (Wessels et

al., 2007). Growing literature (Ho, 2001; Sullivan and Rohde, 2002; Oba et al., 2003; Miehe et al., 2010; Wehrden et al., 2012) dissipate this view for failing to comprehend that rainfall is the key determinant of vegetation change in drylands and that livestock population crashes before reaching a level that can cause environmental damage. These studies acknowledge the variability of grazing resources as an inherent phenomenon in drylands and that an opportunistic use of resources through herd mobility across landscapes is critical to livestock survival in uncertain environmental conditions.

Pastoralists use livestock mobility as a key tool for strategic utilization of variable grazing resources and for coping with uncertain environmental conditions in drylands (Niamir-Fuller, 2005). In fact, the economic viability of pastoralism depends primarily on the ability of pastoralists to strategically move their livestock and utilize vegetation at their appropriate growth stages when the nutrient concentrations are high (Krätli et al., 2013). In this regard, the unpredictability of pastures is not avoided but harnessed intelligently, thus making it an asset for improving livestock production (Krätli and Schareika, 2010). The herd mobility in pastoral production systems is also important for accessing markets as well as creating symbiotic relations with other communities (Niamir-Fuller, 2005). Nevertheless, herd mobility is increasingly being restricted by rising encroachment of other land uses into pastoral production areas (Fratkin, 2001; Lamprey and Reid, 2004; Galvin, 2009).

2.3 Implications of restricted herd mobility on pastoral livestock marketing

Limited herd mobility in pastoral production systems results in restricted access to critical pastures, especially during the dry season, causing deterioration of livestock body condition. The result is increased availability of lean animals that fall short of market requirements and therefore, fetch low prices for the producers. Despite being under duress to generate income to meet the increased demand for cereals during the dry season (Orindi et al., 2007), pastoralists do not wish to sell livestock at low prices, particularly when they are uncertain how long the

season could last as they always hope for better productivity in future. As observed by Campbell et al. (2006), it is less costly for pastoralists to keep animals through the dry season than to destock and later restock when the condition improves. However, when the condition deteriorates into a drought, pastoralists usually resort to a "stress-sale syndrome" and supply many poor quality animals despite limited market demands for such animals (Mcpeak, 2004). Although, the intention is to reduce economic losses associated with droughts, more often than not, pastoralists are unable to sell such animals promptly since the animals hardly meet market requirements and specifications in terms of live-weights or carcass fat cover (Mummed and Webb, 2014). The consequence is high drought-related livestock mortality in pastoral production systems (Oba, 2001; Catley et al., 2014), which might even exceed the net sales (Desta and Coppock, 2002).

Many drought episodes have been reported in African drylands, including 1921-1930, 1946-47, 1965-66, 1972-73, 1982-83, 1986-87, and 1991-92 droughts (Garanganga, 2007), and the trend is likely to change in response to climate change. Except a few studies (Choc et., 2009; Johnson and Xie, 2010) indicating that increasing sea surface warming and air circulation in the Intertropical Convergence Zone would make some parts wetter, literature (Sheffield and Wood, 2008; Dai, 2011; Dai, 2013) generally project that the drought frequencies in tropics and subtropics would intensify in response to climate change. An analysis of a time series data collected daily by the Kenya Meteorological Department over 50 years in northern Kenya, showed an increasing yearly number of dry days (no or less 1mm of rainfall) (Dabasso and Okoti, 2015). As pastoralists focus on building herds in post-drought periods (Ahmed et al., 2002), increasing drought frequencies imply that this post-drought recovery strategy is compromised. The fragmentation of grazing lands observed in pastoral areas (Galvin 2009; Hobbs et al., 2008), would further weaken pastoralists drought coping strategies and intensify drought-related losses. Analysing the impacts of the 2005/2006 drought in terms of livestock

losses in Kenya's southern rangelands, Nkedianye et al. (2011) observed that the losses were high in highly fragmented areas. This was despite adequate rainfall in those locations before the drought onset. His findings corroborate with a study by Oba (2001) which compared the effect of the 1984/1985 drought with that of 1991/1992 in northern Kenya. Oba (2001) observed that the severity and impacts varied from one location to another, but at the regional level, there were more livestock mortalities in 1991/1992 than 1984/1985, possibly because of decreasing herd mobility and range condition in the region.

Common interventions for minimizing the drought-related livestock losses in pastoral production systems include supplementary livestock feeding (Bekele and Abera, 2008), emergency destocking programs (Abebe et al., 2008), and provision of early warning information to trigger timely sales (Ericksen et al., 2010), and provision of transport subsidies to traders (Morton and Barton 2002). These interventions are either expensive or inadequate in achieving the required objective (Morton et al., 2005). Based on the experiences of development agencies in northern Kenya in their response to the 1999/2000 drought, Aklilu and Wekesa (2002) observed that supplementary livestock feeding is costly, labour intensive, and has other challenges associated with feed spoilage. Supplementary feeding also alters the vegetation-livestock dynamics as it reduces the risk of livestock loss, thereby increasing herd sizes in the long-run, which results in rangeland degradation (Muller et al., 2015). In addition, studies (FAO, 2009; Erb et al., 2012) have indicated that when supplementary feeds are cultivated alongside food crops, there is a possibility of compromising households' food security. As observed by Morton and Barton (2002), emergency livestock destocking is also expensive and donor-driven, although important in saving livelihoods. Analysing stakeholders' experiences in undertaking drought mitigation measures in pastoral areas of Kenya, Nyariki et al. (2005) observed that most of the stakeholders had budgetary limitations to undertake sufficient emergency pastoral livestock off-take programs. Furthermore, emergency destocking

programs often offer low prices for the supplied animals and hence have little financial help to the sellers (Watson and Binsbergen, 2008). The use of the early-warning information in predicting future climatic conditions and timely action by development agencies is undermined by data unreliability and delays in releasing results (Sinange, 2007). Considering the limitations of these drought interventions, need to explore alternative options that facilitate commercially off-take drought-stricken pastoral animals is necessary.

2.4 Use of stratified livestock production to commercially off-take pastoral animals

A stratified livestock production (SLP) system involves "the arrangement of the process of meat production into separate stages−breeding cow/calf herds, growing out, fattening, processing−with each stage located geographically to make use of the comparative advantage in each eco-climatic zone" (Jahnke, 1982, p. 91). Generally, it entails a two-tier livestock production approach−breeding in the drier parts of ASALs, followed by fattening in higher potential rangelands having better grazing resources (ibid.), a three-tier SLP system in which there is an intermediate production phase between breeding and fattening to condition the animals for muscles and skeletal development has also been reported (Kumar et al., 2012). The two-tier SLP system is widely practised in African countries and elsewhere. For instance, in the Entente States of West Africa (Mauritania, Chad, Liberia, Cameroon, and Niger), cattle breeding and raising until they are two years old has been traditionally done in the arid northern zone after which the animals are transferred to the semi-arid southern zone for fattening on pasture and agricultural by-products before selling (Shapiro, 1979). In the arid areas of Niger and Central Mali, herders sell lean cattle at the beginning of the dry season to agriculturalists, who eventually fatten them on crop residues before the sale (Amano, 1995). In Botswana, farmers in semi-arid areas purchase beef cattle from pastoral areas and feed them on sorghum residues that are supplemented with maize bran (Farrington et al., 1989), while large scale feed-lot entrepreneurs fatten cattle in ranches before selling to the Botswana Meat Commission

(Malope et al., 2007). In Argentina, extensive pastoral areas are used mostly for cattle reproduction and raising of steers until they are 5−8 months, while other areas with better climatic conditions are used for fattening the steers until they reach 15 months and weigh 380−500kg depending on the breed (Ruiz et al., 2000).

In the Horn of Africa, SLP systems are often considered as some of the best practices in pastoral livestock value chains that facilitate market access particularly during droughts (Aklilu et al., 2013). The systems have the potential to create win-win economic benefits for traders and pastoralists. For instance, during the 2006 drought in southern Ethiopia, the United States Agency for International Development (USAID) piloted a commercial destocking program in which traders purchased emaciated cattle from pastoralists and transported them to holding grounds from where the animals were provided with fodder until when they were healthy to travel to feedlots for fattening (Abebe et al., 2008). Assessing the program's impacts, Abebe and Catley (2013) observed the pastoralists received substantial income to buy feeds for their remaining animals and meet household expenses. Stratified livestock production systems benefit fattening entrepreneurs as well. For example, Little et al. (2014) noted profits made by traders after fattening the drought-stricken animals that were purchased from herders in southern Ethiopia during the drought of 2011. Malole et al. (2014) also reported that fattening pastoral cattle on natural pasture and supplementing with cottonseed hulls is profitable in northwestern Tanzania. However, livestock traders' profits under SLP systems depend on access to high-end domestic or international markets. Abebe et al. (2008) indicated that the USAID-supported commercial livestock destocking in southern Ethiopia during the drought of 2006 was successful mainly because the livestock exports from the Horn of Africa to Arab markets were robust and well established by then, a situation that enticed the traders to buy lean cattle from pastoralists for fattening before selling to the exporters. This means that although SLP is considered one of the innovations in pastoral livestock value chains

(Mahmoud, 2006), that does not only help in commercial off-take of pastoral animals but also encourage pastoralists to keep productive breeding stock (Jahnke, 1982), the production approach works well if access to terminal markets is facilitated and other constraining factors addressed.

2.5 Factors influencing the use of stratified livestock production to commercially off-take pastoral cattle

Use of SLP models as options to sell pastoral cattle depends on several factors, including pastoralists' participation and integration in livestock value chains as well as the expected animal weight gain in the areas targeted for cattle fattening. The latter is a function of many factors, including management practices such as feeding approach, breeds, classes of cattle kept, and the duration of fattening. There are various animal feeding approaches, including grazing on natural pastures, grazing combined with supplementary feeding, and feedlotting where animals are fed *ad libitum* on concentrates. For instance, in the sub-tropics of South Africa, weaner cattle of approximately 12 months are fattened on natural pasture, known as "sweetveld", before selling at 18-30 months (Plessis and Hoffman, 2004). In northern Nigeria, small-scale farmers fatten bulls for 6-8 weeks on locally available hay and crop residues (maize and sorghum stovers) while giving supplementary feeds during the dry season on maize bran and cottonseed cake as energy and protein supplements, respectively (Lamidi et al., 2008). In Shinyanga and Mwanza regions of Tanzania, Mlote et al. (2012) noted that traders buy cattle from pastoralists and agro-pastoralists for supplementary feeding on cottonseed cake, cotton husks or maize bran, for 3-4 months before selling. In the eastern Shoa region of Ethiopia, traders purchase Borana, Bale, and Arsi cattle breeds from pastoralists and smallholder farmers and fatten them under a feedlot system where roughages and concentrates are fed for 3-4 months before marketing (Teklebrhan and Urge, 2013).

The animals that depend on grazing alone (without supplementation) may not gain weight faster than those given supplementary feeds or fed *ad libitum*. In the semi-arid areas of Uganda, Asizua et al. (2009) compared the fattening performance of Ankole cattle under three different feeding regimes−grazing alone, grazing combined with supplementary feeding on concentrates, and a feedlot feeding system. They recorded average daily weight gain of 0.85kg, 0.55kg, and 0.27kg under the feedlot, supplementary feeding, and grazing alone feeding regimes, respectively. Farrington et al. (1988) also conducted feeding trials involving 32 steers in the semi-arid areas of Botswana and concluded that the best fattening results (both in terms of animal weight gain and net financial returns) were achieved when the steers are fed *ad libitum* on sorghum stovers and supplemented with high level of maize or sorghum bran.

Moreover, the expected animal weight gain in livestock fattening programs may also be influenced by the breed, age, and the body condition of the animals. Ozluturk et al. (2004) observed that the Charolais breed had better weight gain and meat quality than Simmental or the Eastern Anatolian Red breed among cattle calves of different breeds fed on dry alfalfa and concentrates. Osuji and Capper (1992) evaluated the effects of animal age on fattening performance of draught oxen in the Ethiopian highlands and observed average daily weight gain of 0.62kg, 0.54kg, and 0.41kg for the animals in 4−5, 7−8, and 10−11year categories, respectively. In the Iowa State of America, Koknaroglu et al. (2005) found that cattle having initial live weights of less than 273kg, 273–364kg, and more than 364kg, had an average daily weight gain of 1.14kg, 1.20kg and 1.25kg, respectively. This suggests that initial animal body condition is also one of the factors influencing livestock fattening performance.

The use of SLPs as avenues for increasingly off-taking pastoral cattle also depends on the existing socio-economic factors affecting pastoral livestock value chains. For example, Tiki (2012) indicated that despite the importance of Ethiopian feedlot operators in facilitating livestock exports to Egypt, United Arab Emirates, and Oman, the high costs of feeds and

limited access to finance compromised their operations. Other factors that affect the use of SLP systems in enhancing commercial off-take of pastoral cattle include pastoralists' marketing practices in terms of supplying animals required by the markets. Whether pastoralists are willing to supplying animals demanded by the markets has been the subject of scientific discourse. However, only a few studies (Negassa and Jabbar, 2008; Ng'eno et al., 2010) postulate that pastoralists rarely participate in livestock marketing and often sell poor quality animals (aged or culls). Other literature (Kerven, 1992; Galaty, 2008; Mahmoud, 2013; Little et al., 2014) generally agree that pastoralists are responsive to market demands.

2.6 History of stratified cattle production in Kenya and factors influencing its performance

Stratified cattle production (SCP) in Kenya was initially started in the 1960s and lasted for about 10 years, during which the government purchased immature cattle from pastoral areas for fattening in ranches and feedlots before slaughtering at the Kenya Meat Commission (Raikes, 1981). The program arose out of the need to increase the sale of pastoral animals as a strategy to control overgrazing in the rangelands (Anderson, 2010). There was a general assumption that pastoralists make limited livestock sales, resulting in accumulation of stock and eventually degradation in the rangelands (Lamprey, 1983). This assumption was rooted in the old theories of "cattle complex" by Herskovits (1926) and the "tragedy of the commons" by Hardin (1968). Herskovits's theory suggests that pastoralists keep large livestock herds off the markets as a store of wealth and as a cultural prestige. Hardin's theory, on the other hand, posits that rangelands are open access resources and therefore, it makes sense for every herder to maximize personal gain by adding more and more animals to his/her herds, which eventually leads to a 'tragedy of the commons'(over-grazing). Although, these notions have been largely dismissed for failing to understand important aspects of pastoralism, including the land tenure arrangements that have rules and regulations for resource use and access (Lane, 2014), they

still form part of the mainstream view about pastoral livestock production and continue to influence the government policies and programmes in Kenya.

The limited livestock sales by pastoralists and overgrazing in pastoral areas are caused by inappropriateness of government policies and programmes rather than by pastoralists' practices. For example, in Kenya, the Cattle Cleaning Act that was enacted in 1927 to prohibit movement of the pastoralists' herds from the ASALs to the humid and sub-humid areas (Conelly, 1998) had negative repercussions on livestock sales and the condition of the rangelands. The humid and sub-humid areas had exotic cattle breeds such as Ayrshire, Guernsey, Holstein-Friesian, Jersey, and their crosses that were introduced by European settlers for commercial dairy production (Muriuki, 2003) and therefore, the quarantine regulation was aimed at protecting the dairy sector from common contagious diseases such as rinderpest, East Coast Fever and bovine pleuro-pneumonia (Waller, 2004). Raikes (1981) revealed that the quarantine resulted in overgrazing and limited livestock sales by the pastoralists, prompting the colonial government to put up a meat-canning factory in the late 1930s to off-take lean and emaciated animals from the rangelands and produce corn-beef for exports. However, the pastoralists were offered low prices that did not motivate them to sell, making the government resort to a compulsory culling campaign, which was later stopped following political protests (Anderson, 2010).

As Raikes (1981) observed, the colonial government then explored an alternative strategy to supply the livestock to the meat-canning factory and established the African Livestock Marketing Organization (ALMO) that built field abattoirs and created stock routes in pastoral areas. After Kenya's independence in 1963, the ALMO was replaced with the Livestock Marketing Division (LMD), which shifted its focus from corn-beef to producing quality carcasses for export and high-end domestic markets (ibid.). The strategy for achieving this was by buying immature animals from the pastoralists for fattening in commercial ranches and

finishing in feedlots before slaughtering. However, livestock marketing infrastructure, including stock routes, quarantine centres and livestock holding grounds, established by the LMD in 1960s, became dilapidated and affected the operation of the livestock fattening programme (AU-IBAR and NEPDP, 2006). The collapse of livestock marketing infrastructure might have been a ramification of the Sessional Paper No. 10 of 1965, in which the government was advised to invest more national resources to develop 'high potential' areas. The areas were perceived to yield better economic returns relative to the ASALs where pastoral livestock production was the dominant livelihood activity (GoK, 2017). The meat canning factory (renamed the Kenya Meat Commission in 1950) also had an insufficient supply of cattle for slaughter after the government decontrolled beef pricing and trade in 1986/1987, following the adoption of neoliberal structural adjustment policies propagated in developing countries by the Bretton Woods Institutions (Kahi et al., 2006). The price decontrol caused stiff competition from private butchers and slaughterhouses, crippling the KMC (van der Valk, 2008). Consequently, the SCP was halted, and Kenya lost 4,000 metric tons of beef quota in the European Union market (Irungu et al., 2014). However, as indicated by Mahmoud (2006), in the last few decades, private sector-led models of SCP have emerged in Kenya.

The current forms of SLP are being adopted in the background of emerging social-economic factors that affect livestock fattening programs in the country. These factors include high cost of feeds for livestock finishing (Kahi et al., 2006), land subdivision and mismanagement, and limited market outlets (Aklilu et al., 2002), leadership struggles, illegal mining activities, and lack of sufficient water in some ranches, in particular, those at the Kenyan coast (Njogu and Dietz, 2006). Other issues include the dilapidated stock routes that connect Kenya's pastoral areas with either ranches or terminal markets, and lack of adequate water sources, quarantine centres and holding grounds (AU-IBAR and NEPDP, 2006). Additionally, most of the Kenyan ranches host a diverse array of large mammals, and therefore,

wildlife conservation is being promoted as a supplementary activity (Sundaresan and Riginos, 2010). This implies that there could be high costs relating to the control of zoonotic diseases in such ranches. Wild animals, including buffaloes and antelopes, host pathogens that cause and spread common livestock diseases such as foot-and-mouth disease (Vosloo et al., 2009), making the control of diseases in a livestock-wildlife production system costly. Despite the challenges, there are also emerging opportunities such as the rising demand for meat and the existing technological innovations in market access and business transactions (Irungu et al., 2014), which may have positive implications for the use of the SCP systems in the country.

The demand for meat in Kenya is rapidly growing, especially in the urban centres where population growth is high (Alarcon et al., 2017). As such, beef consumption in the country accounts for about two-thirds of the total quantity of red meat consumed in the country (Chantylew and Belete, 1997; Bergevoet and Engelen, 2014). The increasing demand for meat has generally been observed in developing countries and attributed to population, income, and urbanization growth (Delgado, 2003). The demand presents livestock producers with an opportunity for intensified production in the tropical and sub-tropical areas of Africa (McDermott et al., 2010) and Asia (Millar and Photakoun, 2011; Stür et al., 2013). However, livestock intensification is associated with environmental pollution and emission of greenhouse gases (FAO, 2006), and therefore, low external input livestock production systems seem to be the most suitable for meeting increasing global demands for livestock products. Exploiting the low-input production systems, through SLP systems, provides pastoralists with an opportunity to participate in global livestock value chains for better incomes and enhanced resilience against emerging external shocks.

Considering the several aforementioned factors that influence the performance of livestock fattening programs and the debate on pastoralists' participation in livestock marketing, it is crucial to analyse SLP systems before promoting or up-scaling them as

approaches for strengthening pastoral livestock value chains. However, the SLP in Kenya drylands has been scantly analysed, therefore, lack basis for development and promotion, despite its importance in enhancing commercial off-take of pastoral herds, and increase the integration of pastoralists into the market economy.

CHAPTER THREE

3.0 STRATIFIED CATTLE PRODUCTION IN PASTORAL AREAS OF KENYA: EXISTING FORMS, DRIVING FACTORS, AND MANAGEMENT PRACTICES

Abstract

The seasonal fluctuation in forage availability considerably affects the body condition of livestock kept in Africa's drylands. In dry pastoral areas of Kenya, animals become lean during pasture shortage, and fall short of meeting market requirements, fetching low prices for producers. However, a stratified cattle production (SCP) system in which animals are transferred from arid to semi-arid areas with better production advantage is emerging as an option to improve animal body condition to target lucrative terminal markets. This practice is gaining popularity against the backdrop of scanty information to guide both the development and up-scaling of the system. Using qualitative data, collected through face-to-face interviews, this study characterizes the existing forms of SCP, their driving factors and management practices for coping with production and market challenges. Results revealed three forms of SCP in which Borana cattle breed, East Africa Zebu and their crosses were fattened. Each form was run by different practitioners–ranchers, traders and agro-pastoralists, who exhibit differences with respect to access grazing resources, herd size and the fattening period. Ranchers owned grazing resources and fatten 100-120 cattle for 6-12 months whereas traders leased grazing resources to fatten 80-100 cattle for 6-8 months. Agro-pastoralists supplemented pastures with crop residues to fatten 20-30 cattle for 3-4 months. The adoption of the SCP systems was driven by changes in socio-economic and ecological conditions in the drylands of Kenya, including an occurrence of drought and demand in terminal markets. However, the practitioners experience some challenges such as high animal purchase and production costs, disease outbreaks and high marketing costs. In order to minimize costs associated with these

challenges and maximize profits, management strategies were put in place. The strategies include purchasing animals during the dry season when prices are low, using sale agents to source animals and bargain for prices, buying mature animals that take a shorter fattening period, making grazing lease arrangements flexible, and shorting the fattening period when there is an impending drought. These findings could guide the development and promotion of SCP in Kenya and other drylands of Africa.

Keywords: drylands, dry season, fattening, lean animals, pasture availability

3.1 Introduction

Pastoral livestock production is practised under marginal climatic conditions, with highly variable rainfall, yet contributes substantially to national economies (Davies and Hatfield, 2007). About 10 – 40 percent of the gross agricultural domestic product of various African countries such as Kenya, Algeria, Mali, Niger, Sudan, Ethiopia, Chad, and Somalia come from pastoral livestock production (African Union, 2010). Pastoral livestock production, therefore, remains one of the most sustainable land use options in the African drylands compared to other land uses such as crop farming (Behnke and Kerven, 2013) and ranching (Angassa and Oba, 2007).

Despite the potential of pastoral livestock production in Africa's drylands, the temporal variability of rainfall that characterizes these areas greatly influence pasture availability for livestock production (Muir and Alage, 2009). During the dry season, natural pasture is scarce, deficient in nutrient concentrations (Gwelo et al., 2015), and has high fibre content, limiting animal intake (Sampaio et al., 2010). Accordingly, animal body condition fluctuates in response to seasonal changes in pasture production and quality. For example, Nyamukanza et al. (2009) observed that in the semi-arid areas of South Africa, the body weight difference between rainy and dry seasons ranges from 220 to 450kg, 290 to 420kg, and 280 to 330kg for oxen, bulls, and cows, respectively, in 2005/2006. Leloup et al. (1996) also attributed the low annual weight gain of 35-45kg per head of Zebu cattle in southern Mali to the seasonal change in the quantity and quality of the pasture. The seasonal dynamics in pasture availability and quality also influences animal reproductive performance (Kanuya et al., 2006), capacity to provide draught services (Bartholomew et al., 1993), and animal market prices (Barrett et al., 2003) in Africa's rangelands.

Stratified livestock production in which livestock are transferred from arid regions where rainfall is low and highly variable to semi-arid areas with better production conditions, is one

of the options for addressing the challenges related to the seasonal pasture shortage in drylands. More often than not, it improves animals' body condition, price, and by extension, increased income for producers and traders. For example, Ankole cattle and their crosses of Borana and Friesian kept under a traditional grazing system in Uganda's semi-arid region showed a daily weight gain from 0.27kg/day to 0.55kg/day when supplemented with concentrates (Asizua et al., 2009). In South Africa, local cattle breeds bought from farmers and put in feedlots were reported to have a better carcass quality that meets terminal market specifications (Strydom et al., 2008). In Nigeria, supplementation of White Fulani steers with crop residues during the dry season helped in maintaining the animals' body weight attained during the previous rainy season (Aregheore, 2009). In addition, Little et al. (2014) reported enhanced market prices and profit made by traders from fattening the drought-stricken cattle purchased from pastoral areas of southern Ethiopia during the 2010/2011 drought. These authors observed that the traders made a substantial profit despite losing 10 percent of the herd during transit to feedlots. According to Nowers et al. (2013), cattle sourced from communal areas of South Africa showed increased growth rate when management practices such as feeding, dipping and vaccination were improved.

In Kenya, stratified cattle production (SCP) was pioneered by the government in the early 1960s to improve the quality of animals brought from the pastoral areas so that they meet the standards demanded in international markets (Raikes, 1981). Livestock holding grounds, stock routes and quarantine areas were established with the support of the Livestock Marketing Division (AU-IBAR and NEPDP, 2006). Cattle from arid northern Kenya were bought and fattened in ranches and slaughtered at the KMC for export and domestic markets. Under this arrangement, the government controlled beef prices, especially in urban markets (Raikes, 1981). After the liberation of the beef market in 1986/87, there was an insufficient supply of cattle for slaughter at the KMC, which led to the collapse of the government-supported beef

marketing operations (van der Valk, 2008). However, since the 1999/2000 drought in Kenya, SCP has increasingly been adopted in its original or modified forms (Mahmoud, 2006; Farmer and Mbwika, 2012). This practice is gaining popularity against the backdrop of scarce information to guide both the development and up-scaling of the system. The objectives of this study were, therefore, to identify and characterize the existing forms of SCP, and document factors underpinning their adoption, challenges experienced by practitioners and coping mechanisms they have developed. This information is important for guiding lean cattle marketing through a stratified production system, especially during the dry season, when pasture availability in pastoral areas is limited.

3.2 Materials and Methods

3.2.1 Study areas

The study was conducted in Taita Taveta, Laikipia and Narok Counties located in the semi-arid areas of Kenya (Figure 3.1). These areas were purposively selected based on some form of SCP established from literature review and interactions with stakeholders. Taita Taveta County has an annual rainfall of about 200 mm to 587 mm in the lowland areas where livestock production is the dominant livelihood activity (Pellikka et al. 2009), while Laikipia County receives an annual average rainfall of 500 mm – 550 mm (Okello et al., 2001). The average annual rainfall for Narok County is about 508 mm in the savannah plains, where livestock production and wildlife conservation are the main economic activities (Ogutu, 1999). The three counties' rainfall is bi-modally distributed with the short rainy season occurring in March – May, and the long rainy season in November – December.

Cattle ranching and wildlife-based tourism are among the main economic activities in all the study areas. Taita Taveta County has several private and cooperative livestock ranches established by the government in the 1960s and early 1970s with the support of World Bank to boost national livestock production (Aklilu et al., 2002). The initial intention of these ranches

was livestock breeding, but they are now mainly used for pastoral cattle fattening (Mahmoud, 2006). Similarly, several ranchers in Laikipia fatten pastoral cattle or lease out grazing resources to livestock keepers during droughts (Heath, 2001). In Narok County, local livestock traders are also increasingly fattening pastoral cattle maximize revenues from the ranches (Personal communication with Manager of Ramat Livestock Marketing Group in Suswa, Narok County, 2015).

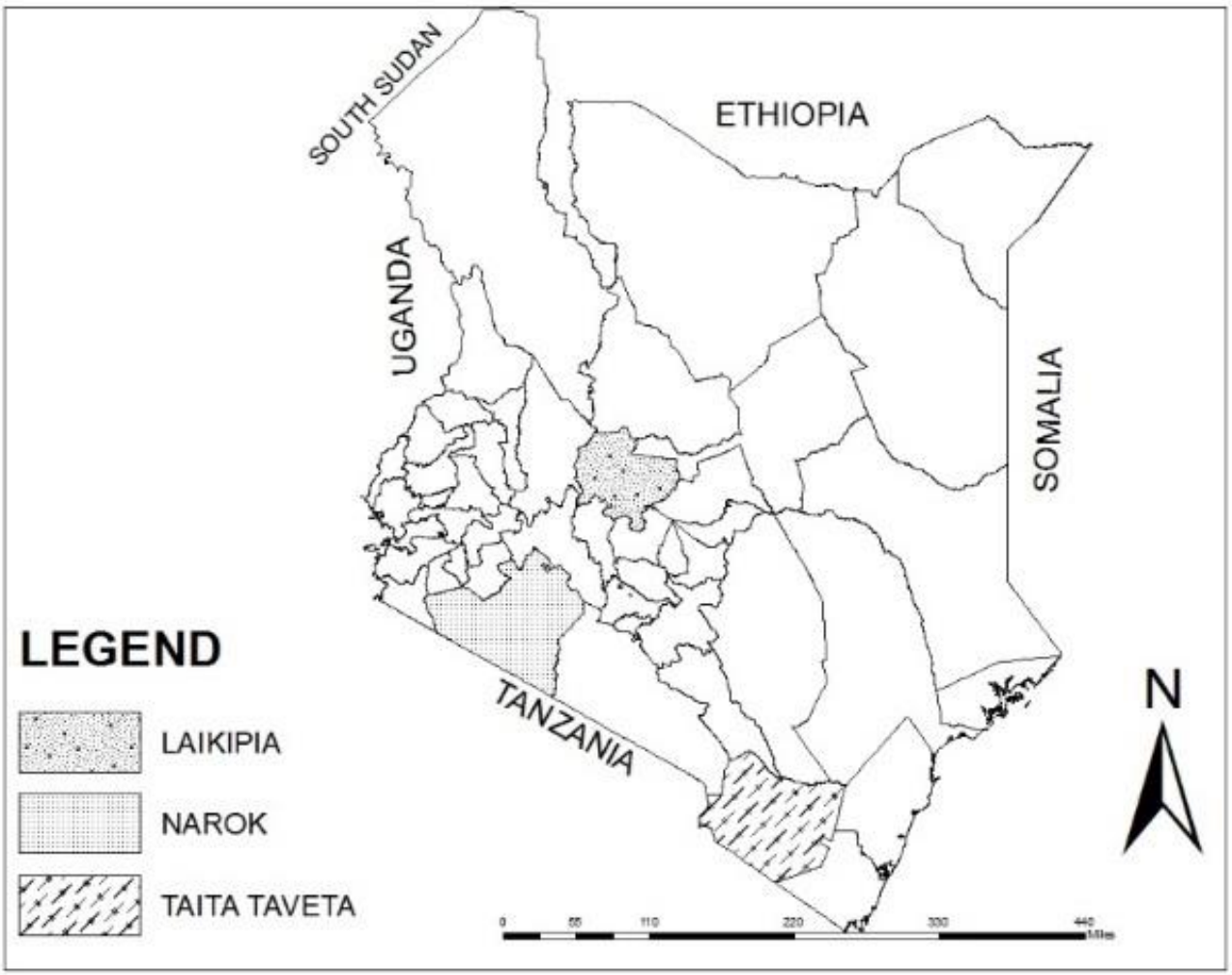


Figure 3. 1: Location of the study areas

(Source: Generated using ArcGIS 10.2, ESRI 2011)

3.2.2 Data collection

Taita Taveta, Laikipia, and Narok counties were purposefully s*el*ected as areas where pastoral cattle were being fattened. The cattle fattening entrepreneurs in each county were purposively identified and selected for narrative interviews. The attached question guide (Appendix 1) was used in conducting the interviews. The interviews focused on the characteristics of the production systems, including animal husbandry practices and other operational activities from the purchase until the finished animals were sold. The collected data include sources of the animals, classes (steers, bulls, cows, and steers), breeds, age at purchase, vaccination against

the common notified diseases, watering regimes, salt provision, deworming, spraying against ectoparasites, access to grazing resources, and the available market outlets. The interviews were conducted according to the procedure by Jovchelovitch & Bauer (2000), which suggests that the interviewee gives uninterrupted narration following by probing, where details were not provided. Thirty-four cattle fattening entrepreneurs were interviewed across the counties (Taita Taveta, n = 12; Laikipia, n = 12; Narok n =10). The sample size for each county was based on the concept of saturation as described by Mason (2010), which indicates that the researcher may not need additional interviewees if the subsequent ones do not provide any new information about the subject under investigation. A checklist of management practices among the entrepreneurs was generated from the analysis of the narrative interviews and used to interview seventy-three additional respondents across the counties (Taita Taveta, n = 29; Laikipia, n = 24; Narok n =20). The sample size for the additional interviewees in each county was determined using the formula developed by Krejcie and Morgan (1970) as follows:

$s = X^2NP\ (1 - P)/d^2\ (N - 1) + X^2\ P\ (1 – P)$

Where;

s = the required sample size

X^2 = the chi-square table value for 1 degree of freedom at 95% confidence level, usually 3.841

N = the population size

P = the proportion of target the population estimated to have characteristics being measured, usually assumed to be 50%

d = the level statistical significance set (5%)

Using the formula, the calculations for the required sample sizes were done as follows;

For Taita Taveta County,

N = 30;

X^2 =3.841;

P = 0.5;

d = 0.05;

$$s = \frac{(3.841 * 3.841)(30 * 0.5)(1 - 0.5)}{(0.05x0.05) * (30 - 1) + (3.841 * 3.841)(0.5)(1 - 0.5)}$$

$$s = \frac{110.649}{3.760}$$

s = 29

For Laikipia County,

N = 25;

X^2 =3.841;

P = 0.5;

d = 0.05;

$$s = \frac{(3.841 * 3.841)(25 * 0.5)(1 - 0.5)}{(0.05x0.05) * (25 - 1) + (3.841 * 3.841)(0.5)(1 - 0.5)}$$

$$s = \frac{92.208}{3.748}$$

s = 24

For Narok County,

N = 21;

X^2 =3.841;

P = 0.5;

d = 0.05;

$$s = \frac{(3.841 * 3.841)(21 * 0.5)(1 - 0.5)}{(0.05x0.05) * (21 - 1) + (3.841 * 3.841)(0.5)(1 - 0.5)}$$

$$s = \frac{77.455}{3.738}$$

s = 20

3.2.3 Data analysis

The data from the narrative interviews was coded for qualitative content-analysis where information relevant to answering the research objectives was sorted and organized into clusters as described by Mayring (2014). A systematic coding process was followed in which codes were defined, followed by revision, final coding and lastly interpretation as shown in Figure 3.2. This method has the advantage of providing in-depth analysis from respondents' narration (Hsieh and Shannon, 2005). The narration's data helped in identifying three categories of SCP based on the different operational activities and animal husbandry practices. Chi-square test (IBM Corp. SPSS, 2011) was used to test associations between management practices/driving factors with the different categories of SCP at 5% significance level.

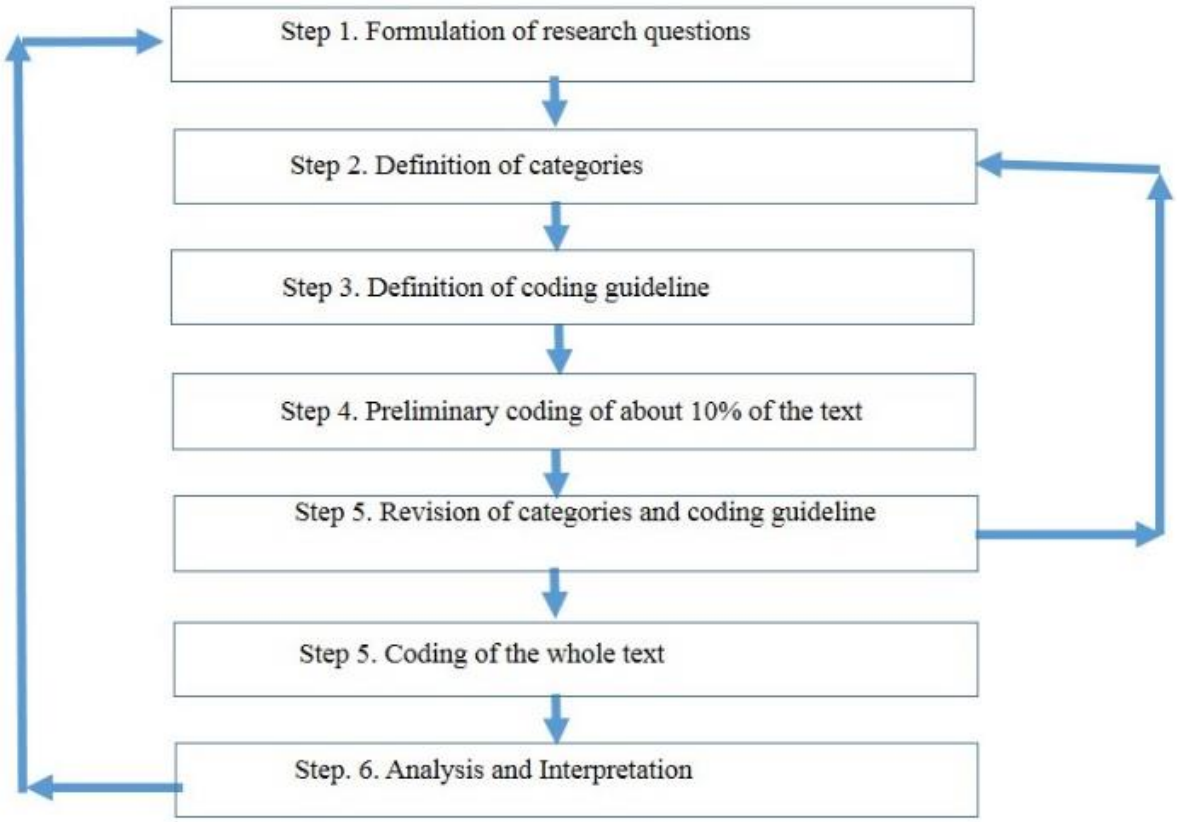


Figure 3. 2: A systematic procedure for the content analysis

(Source: Adopted from Mayring, 2014)

3.3 Results

Three forms of SCP that involve fattening of Borana cattle, small East African Zebu and their crosses were identified. The forms differed in terms of access to grazing resources, herd sizes, class of cattle targeted, animal husbandry practices, duration of fattening, and livestock market outlets (Table 3.1). One form of SCP was practised by private ranchers, who owned large tracts of land mainly used for livestock production in Laikipia, and Taita Taveta counties. Ranchers kept two types of cattle herds; ranch raised herds for breeding and purchased herds for fattening. The latter were mainly 3 to 4 year-old steers and bulls bought from pastoral areas for fattening before sale. The ranchers quarantined their animals after purchase, at strategic places and vaccinated them against notifiable diseases such as foot-and-mouth disease (FMD), anthrax, lumpy-skin disease (LSD), and contagious bovine pleuropneumonia (CBPP) before allowing them into the ranches. Vaccination against FMD and anthrax was repeated every 6 to 7 months, while vaccination against lumpy-skin and CBPP was done once in a year. Animals were watered every day during the rainy season but after every two days in the dry season. Salts of various brands were provided *ad libitum* either in mixtures (salts of different brands) or separately. The ranchers sprayed the animals against external parasites and dewormed them a few days after purchase, and thereafter the animals were sprayed every week and dewormed every three months. No withdrawal period prior to slaughter was suggested, either in the use of pesticides or de-wormers, but it is unlikely that the animals were de-wormed less than a month before selling or sprayed a few days prior to marketing, as it increases production costs.

The second form of SCP was practised by traders, who leased grazing resources from ranchers. Under this model, a short-term (30 days or less) or a long-term (usually for 12 months or more) lease was followed. The cost of the short-term lease ranged from $0.98 to $1.47 per head of cattle per month while for the long-term was from $24.32 to $72.99 per hectare year. The traders' management practices were similar to those of the ranchers. The third form of SCP

was practised on smallholder farms by agro-pastoralists who kept both breeding and purchased cattle herds in an integrated crop-livestock production system in Laikipia and Narok counties. These agro-pastoralists grazed their animals on natural pastures and moved them to cultivated parts of the farms to use crop residues from harvested maize, wheat, and beans. They were no disease preventive measures taken when animals enter or leave farms but quarantine was imposed, and market access restricted whenever there was a disease outbreak.

Table 3. 1: Forms of SCP in Taita Taveta, Laikipia and Narok counties of Kenya

Form of SCP	Type of Practitioner	Where practiced (County)	Characteristics					
			Source of grazing resources	Herd size (Head)	Class of cattle	Animal husbandry practice	Period of fattening (months)	**Market**
SCP on private ranches	Ranchers (n = 10)	Taita Taveta, Laikipia	Own ranches either as companies or cooperatives	100-120	Steers and bulls	Regular vaccination, daily watering, *ad-libitum* salt provision, weekly spraying and deworming every three months.	6-12	Abattoirs and slaughterhouses in Nairobi and other major towns.
SCP on leased ranch pastures	Traders (n = 12)	Taita Taveta, Laikipia	pastures leased from ranchers	80-100	Steers and bulls	Regular vaccination, daily watering, *ad-libitum* salt provision, weekly spraying and deworming every three months.	6-8	Abattoirs and slaughterhouses in Nairobi and other major towns. Occasional export to Mauritius.
SCP on smallholder farms	Agro-pastoralists (n = 12)	Narok, Laikipia	Supplement natural pastures with crop residues	20-30	Steers, bulls, cows, heifers	Occasional vaccination, daily watering, spraying after every two weeks and deworming every four months.	3-4	Local markets.

Several factors were cited as reasons for the adoption of SCP in Kenya's pastoral areas. These include droughts, market demand, and financial gains associated with the production system (Table 3.2). These factors did not differ with the type of practitioners ($P > 0.05$). Drought as one of the factors that motivated the adoption of SCP was mentioned by majority of the ranchers, traders, and agro-pastoralists. Ranchers indicated that droughts annihilated a large proportion of ranch-raised herds, and led to underutilization of the ranch carrying capacities in the post-drought periods, necessitating adoption of SCP. At the same time, there was a rising market demand for quality animals, e.g., disease-free animals with high live-weights and fat-content. Demand for ranch leasing arose from the traders' need to capture financial gains associated with the production system. However, the proportion of ranchers, traders, or agro-pastoralists who cited terminal market demand or financial gain as the motivational factor for the adoption of SCP was low. For the agro-pastoralists, SCP also provided an opportunity to cope with the limited grazing resources on communal grazing areas by keeping cattle for a shorter period and selling them just before grazing conditions deteriorated.

Table 3. 2: Drivers of SCP in Taita Taveta, Laikipia and Narok counties of Kenya

Driving factors	SCP practitioner	Practitioners citing the driving factor	Degree of freedom	Chi-square	*P*-value
Drought occurrences	Ranchers	11	2	1.044	0.593
	Traders	11			
	Agro- pastoralists	15			
Terminal market demands	Ranchers	5	1	0.579	0.447
	Traders	9			
Financial gains	Ranchers	6	2	1.275	0.529
	Traders	9			
	Agro-pastoralists	8			

n = 18 for ranchers, 23 for traders, and 32 for agro-pastoralists

The respondents mentioned several production and market challenges, namely: high animal purchase cost, high production cost, disease outbreaks, high marketing cost and fluctuation in livestock market prices. The high purchase cost often arose from the exorbitant transportation charges during rainy periods when existing roads become less accessible. In addition, animals purchased at the end of a prolonged dry season usually had poor health, leading to mortalities while on transit to fattening areas. Weak animals on transit could not withstand transportation stress or injuries related to the loading or offloading activities. The high production cost was associated with the increased use of production inputs such as feeds, water, and drugs, especially where fattening periods were extended. In circumstances where cattle were not vaccinated against FMD, anthrax, LSD, and CBPP, the disease outbreaks increased the cost of treatment, delayed off-take and enhanced mortality rates. The high marketing cost was also associated with delayed payments by buyers and the possibility of a notifiable disease in herds destined for exports, leading to a rejection of all herds. When the targeted period for selling animals coincides with the period of low cattle prices, the producers' revenues may be reduced.

To minimize the losses associated with the aforementioned challenges, various management practices were adopted (Table 3.3). For example, to reduce purchase cost, animals were either bought towards the end of a dry spell or during a drought, when cattle prices were relatively low. The majority of ranchers, traders, and agro-pastoralists purchased animals during the dry season. However, those with insufficient grazing resources purchased cattle during the rainy season to ensure availability of adequate pasture and water. Prior arrangements were made with the agents or primary traders to source the required animals and negotiate for favourable prices. About half of the ranchers or traders and a quarter of the agro-pastoralists used agents in sourcing animals for SCP. The decision on when to truck or trek the animals in order to minimizing transportation costs

was carefully considered. Trucking was reported to be cheaper during a drought, when trucks that transport relief food to pastoral areas are available to transport cattle on return-trips at relatively low costs. Trekking was deemed convenient during rainy seasons when roads are impassable and surface water is available along the stock routes.

A long fattening period, especially when extended into a dry season or a drought was reported to take more resources and increase the production costs. In response to this challenge, mature animals of approximately three to four years old or more were purchased, as they require a shorter fattening period. The percentage of the traders or agro-pastoralists that purchased mature animals of 3 to 4-year-old was more than that of the ranchers. In addition, practitioners shortened fattening periods when they expected a prolonged dry or drought period, to minimize the production costs, which were often high during such times. The proportion of the traders or agro-pastoralists that shortened animal fattening periods when a prolonged dry season was imminent was higher than that of the ranchers ($P < 0.05$). For the ranchers, they may engage in non-livestock income generating activities such as carbon trading and eco-tourism, and used part of that the revenue to support cattle fattening activities such as development of water sources and firebreaks in the ranches. This helps in compensating for the high production costs incurred. For the traders, other strategies for minimizing the production costs include sharing the costs of development and maintenance of water sources in the leased ranches with the ranch owners and also seek a short-term and flexible lease arrangement. The agro-pastoralists practised the integrated crop-livestock production system and used the crop residues as supplementary feed at times of pasture scarcity to reduce the production costs.

A few ranchers in Taita Taveta were reported to have taken an animal insurance cover, valued at the cost of 3% of the animal's market price, to guard against financial losses related to

cattle mortalities. Traders had no animal insurance covers, but in the stances of deteriorating livestock body condition, they were paying premium fees ($4.8−5.0 per cattle per month) to their ranch owners who in return provided specialized animal management (herding, daily watering, weekly spraying, deworming, and vaccination against notifiable diseases). The premium fees were payable as soon as the traders sold the finished animals.

To reduce the marketing costs, the practitioners could request the buyers to pay the market taxes or reimburse them part of the marketing cost. The proportion of the traders or agro-pastoralists that shared the marketing cost with buyers was significantly higher than that of the ranchers ($P > 0.05$). For the traders, the marketing costs were reduced by getting back the firth quarter (offals, heads, and hides) of the animals from the buyers−a deal negotiated based on the animals' selling prices. To cope with the fluctuation of animal market prices, a small percentage of ranchers or traders sought supply agreements with slaughterhouses or supermarkets. Animal sales were also planned to coincide with the October to December period when livestock prices in the market were better due to high demands associated with the end of year festivities. This further helps in coping with the fluctuation of animal selling prices.

Table 3. 3: Management practices for reducing costs among ranchers, traders and agro-pastoralists involved in SCP in Taita Taveta, Laikipia and Narok counties of Kenya

Management practice	Type of SCP practitioner	Practitioners citing the management practice	Degree of freedom	Chi-square	*P*-value
Purchasing animals during the dry season when livestock prices are low	Ranchers	12	2	0.736	0.692
	Traders	18			
	Agro-pastoralists	24			
Using agents or primary traders in sourcing animals and bargaining for better prices	Ranchers	10	2	4.681	0.095
	Traders	9			
	Agro-pastoralists	8			
Reducing transport cost by choosing to truck or trek the animals from supply source when appropriate	Ranchers	6	2	2.178	0.337
	Traders	12			
	Agro-pastoralists	11			
Purchasing mature animals (3 – 4 years old) that take shorter period to fatten	Ranchers	7	2	3.955	0.138
	Traders	15			
	Agro-pastoralists	21			
Shortening fattening period when there is impending drought	Ranchers	4	2	15.378	0.010*
	Traders	15			
	Agro-pastoralists	25			
Negotiating for short-term and flexible ranch lease arrangements	Traders	4	1	0.889	0.348
	Agro-pastoralists	7			
Sharing of marketing costs with the buyers of fattened animals	Ranchers	2	2	9.560	0.008*
	Traders	8			
	Agro-pastoralists	13			
Having supply agreements with slaughterhouses or supermarkets	Ranchers	2	1	0.078	0.781
	Traders	6			
Planning the sale of fattened animals to coincide with the period of high livestock demand	Ranchers	6	2	0.268	0.875
	Traders	9			
	Agro-pastoralists	13			

n = 18 for ranchers, 23 for traders, and 32 Agro-pastoralists. *significant at 5% level

3.4 Discussion

Forms of SCP reported in this study differed with regard to access to grazing resources, number and classes of animals purchased, animal husbandry practices, the fattening period and the market outlet. Ranchers who practised SCP on private ranches, fattened larger herds for a longer period compared to the traders and agro-pastoralists who practiced SCP on leased grazing resources and on smallholder farms, respectively. The difference in herd size and the fattening period was most likely influenced by the availability of and access to grazing resources. Traders and agro-pastoralists had less access to grazing resources, which might have prevented them from sustaining large herds for a long period, contrary to ranchers. In a study conducted in Mieso Woreda in Ethiopia, Tegegne et al. (2011) reported that when grazing resources for cattle fattening are limited, the fattening period is either shortened or planned to coincide with a period of feed availability. They further observed that the agro-pastoralists of the study area undertook cattle fattening from June to November, when feed resources were relatively sufficient.

This study found that while the ranchers and the traders mainly targeted bulls and steers for SCP, the agro-pastoralists fattened herds of mixed classes. This relates to the fact that the agro-pastoralists also own breeding herds, which are herded together with the fattening animals, particularly when they were few or there was no enough labour to herd them separately. The agro-pastoralists who herd the purchased animals together with their own breeding herds may choose to purchase cows, heifers, and steers as a way to control breeding, while those who can afford herding labour herd bulls and other classes of cattle separately. Controlled breeding is essential to maintain breeding herds that are adapted to local ecological conditions and to meet the multiple objectives of livestock keepers (Ayantunde et al., 2007). Animal husbandry practices were different in the identified forms of SCP, principally in terms of vaccination frequencies. Ranchers

and traders were found to undertake regular vaccination, while agro-pastoralists only vaccinated occasionally, especially when an outbreak of a notifiable disease is looming. The difference in vaccination frequencies may not reflect variation in disease incidences across the study areas, but possibly relates to the affordability of or access to vaccines. As reported by Onono et al. (2013), in a study conducted in Kajiado County of Kenya, agro-pastoralists occasionally vaccinate their herds, despite high incidences of notifiable diseases, and they attributed it to the access and affordability of drugs. In Mairowa area of Tanzania, Homewood et al. (2006) investigated the association between uptake of veterinary intervention and the ability of livestock keepers to pay for the same. They concluded that herd size and wealth status play a role in the use of livestock vaccines and that wealthier households tend to vaccinate a larger percentage of their herds than their poorer counterparts do.

Variation in the market outlets among the actors was observed in this study. Whereas the ranchers and traders were found to target major abattoirs and slaughterhouses in urban towns, the agro-pastoralists sold the finished animals at local markets. This suggests that cattle sold by the ranchers and traders, as opposed to those offered for sale by the agro-pastoralists, meet the characteristics (e.g., animal body weight and fat-content) required in the terminal markets. On the other hand, the observed difference in the market outlet can also mean that the agro-pastoralists do not have access to different terminal markets. According to a synthesis report by the AU-IBAR and NEPDP (2006), the choice of livestock market outlets in Kenya depends on market infrastructure, including stock routes that connect livestock production areas to terminal markets. In all the identified forms of SCP, fattened animals were sold directly, without feedlot finishing, unlike in other cattle fattening systems in countries like Botswana (Farrington et al., 1989), Ethiopia (Teklebrhan and Urge, 2013). This is despite the potential of feedlots to improve carcass

quality of indigenous cattle in Kenya (Creek, 1973) and other areas with similar ecological conditions (Asizua et al., 2009). However, the high costs of feed and infrastructure for feedlots establishment and operation (Kahi et al., 2006), may have constrained the practitioners to finish the animals on feedlots.

Most of the ranchers, traders, and agro-pastoralists in the current study cited droughts as the main driver for the adoption of SCP. The SCP, therefore, simply exemplifies one of the adaptation pathways to increasingly unpredictable and adverse climatic conditions such as droughts in Kenya's drylands. By fattening animals for short periods, when pasture is available, and selling them before the pasture deteriorates, the practitioners were able to cope with pasture scarcity associated with extended dry seasons and periods of drought. The adoption of SCP in response to droughts, also indicates that livestock producers in African drylands are dynamic and constantly innovate new approaches to cope with emerging challenges. In a study conducted among the Maasai in Tanzania, Goldman and Riosmena (2013) showed how households with large herds coped with droughts by selling some of their cattle and pay for private access to pasture outside their communal grazing lands. In southern Ethiopia, Taye and Lemma (2009) reported value addition of supplementary feeds such as crop residues and dry grasses by chopping, soaking in water and sprinkling with salts to enhance cattle fattening. Such innovative approaches are critical, given that the drought-induced herd die-off has become more pronounced in recent years with increase in frequency and severity of drought events (Oba, 2001) and with the weakening of traditional coping mechanisms occasioned several factors, including changes in land use (Fratkin, 2001; Lamprey and Reid 2004; Galvin, 2009). These challenges necessitate innovative ideas for minimizing the drought impacts. The SCP reported in this study was hence one of the emerging approaches and practices by livestock producers for coping with droughts. Other approaches for

coping with droughts include the use of environmentally adapted breeding stock, production and storage of quality hay, and improved access to water (Scholtz et al. 2016).

The demand for quality animals from the terminal markets was reported as another motivational factor for the adoption of SCP. The rising demand for quality animals could be a result of the growing population and income growth in developing countries (Delgado, 2003). However, access to terminal markets is dependent on other marketing requirements, including sanitary and phytosanitary standards of livestock products (Hall et al., 2004), as well as pre-slaughter animal welfare and conditions such as hunger and fatigue when the animals were transported over long distances to slaughterhouses (Chulayo et al., 2012). Such conditions are hardly met in Kenya, where livestock are directly supplied from remote pastoral areas for slaughter in urban markets. In order to meet the terminal market requirements and promote livestock trade, especially export, the Kenyan government has plans to implement disease-free livestock production zones under the Kenya Vision 2030 project (GoK, 2007). The project's implementation may resolve the challenge of disease outbreaks experienced by the practitioners and enhance the adoption of SCP in Kenya.

Despite the adoption of SCP in response to the socio-economic and ecological changes, there were challenges such as high purchase and production costs, disease outbreaks and high marketing costs. These challenges were similar to those reported in other studies (Desta et al., 2006; Rufael et al., 2008; Onono et al., 2015) and found to influence livestock production and marketing in the pastoral areas of eastern Africa. However, the SCP practitioners were found to have management strategies to cope with the challenges and to maximize profits. Most of the management practices for cost reduction did not differ with the forms of SCP, suggesting that the practices were equally important to the ranchers, traders, and to the agro-pastoralists. Nonetheless, a few of the

management practices, including shortening of the fattening period, and sharing of marketing costs with the buyers, differed among the actors. The shortening of the fattening period was largely practised by the agro-pastoralists, given that they are more constrained by grazing resources as compared to the ranchers and traders. The sharing of marketing cost with buyers was mostly practiced by the traders and agro-pastoralists. The difference in the sharing of marketing costs with buyers as a management practice may be explained by the variation in marketing strategies between the two groups of practitioners. The ranchers rarely shared their marketing costs with buyers, because they sold their finished animals on the ranches, meaning the buyers would transport the animals to slaughterhouses or other terminal markets at their own cost. On the other hand, traders sold the purchased animals as soon as they are finished to minimize costs associated with grazing fees, and they would prefer transporting them to the markets by themselves. This situation made the traders to negotiate cost-sharing arrangements with buyers.

3.5 Conclusions

Different forms of SCP that vary with respect to access to grazing resources, herd size, classes of animals purchased, animal husbandry practices, and the fattening period, exist in Kenya's drylands. They involve fattening of mostly steers and bulls of Borana cattle, small East African Zebu, and their crosses on natural pasture for 3−12 months, depending mainly on the availability of grazing resources and the health of the animals at purchase. The various SCP were adopted in response to droughts, and market demand, but face challenges, including high production costs, high marketing costs, disease outbreaks, and the fluctuation in animal market prices. To cope with these challenges, the SCP practitioners undertake management practices that aim to minimize purchasing and production costs, and in the process maximize profits. These practices comprise purchasing animals during the dry season when prices are low, using agents to source animals, and

bargain for better prices prior to market visits, purchasing mature animals that take a shorter period to fatten, choosing flexible lease arrangements for grazing lands, and shortening the fattening period to evade droughts. The study's results are expected to guide interventions aimed at enhancing commercial off-take of lean animals from pastoral areas using stratified production systems.

CHAPTER FOUR

4.0 STRATIFIED LIVESTOCK PRODUCTION ADDS VALUE TO PASTORAL CATTLE: EVIDENCE FROM THE DRYLANDS OF KENYA

Abstract

In Africa's pastoral production systems, the body condition of livestock declines during the dry seasons when grazing resources become scarce, resulting in lean animals that fail to meet terminal market requirements and, therefore, fetch low prices. In Kenya, SCP systems in which cattle are purchased from pastoral areas and fattened in other areas where the conditions are more favourable for their growth, are increasingly being adopted. This study evaluated the existing SCP systems practised by ranchers, by traders, and by agro-pastoralists as options for improving the body condition and market prices of cattle produced in the arid and semi-arid pastoral areas. Data on the cattle's live weights at the time of purchase and sale, their costs of purchase and fattening, and the selling prices were collected for the period of January 2010 to June 2016. Cattle fattened by the ranchers, traders, and agro-pastoralists had average daily weight gains (± SD per animal) of 0.24 ± 0.07kg (n = 601), 0.39 ± 0.13kg (n = 240), 0.24 ± 0.08kg (n = 140), respectively. In addition, the average net revenues (± SD per animal) for ranchers, traders and agro-pastoralists were USD61.7 ± 34.2, USD81.3 ± 44.0, and USD55.9 ± 36.6, respectively. The results show that SCP is effective in improving body condition and market prices of lean cattle from pastoral areas. These findings are expected to inform the development of the pastoral cattle value chain in Kenya and other areas with similar ecological conditions.

Keywords: Livestock fattening, weight gain, net revenue, pastoral production, marketing

4.1 Introduction

Pastoral livestock production defines the social and cultural identity of pastoralists (Dioli, 2018), and it is also an important source of food and income for both pastoralist and agro-pastoralist communities inhabiting the drylands of Africa. The sector contributes 10−40% of the agricultural gross domestic product for several African countries, including Algeria, Mali, Chad, Sudan, Namibia, Ethiopia, Somalia, and Kenya (African Union, 2010). Pastoralism's potential to realize more social and economic values is constrained by the seasonal fluctuation of grazing resources. Pastoralism in Africa largely operates in drylands, where biomass production is highly variable, both within and across seasons (Nori, 2006; Egeru et al., 2014). During the dry season, both the quantity and quality of available pasture are low, and therefore, the body condition of livestock declines (Kanuya et al., 2006; Nyamukanza et al., 2009). This implies that the livestock fall short of meeting market requirements and thus fetch low prices (Fatchamps and Gavian, 1997; Barrett, 2001; Barrett et al., 2003; Ayele et al., 2006).

Improving the body condition and the market price of livestock that become lean in the course of the dry season is important in enhancing the socio-economic contribution of pastoral livestock production to both local and national economies. However, a viable option for improving the body condition of the livestock produced in pastoral production systems hardly exists. The most common option is supplementary feeding of livestock (Bekele and Abera, 2008; Oddoye et al., 2008), which is costly, labour intensive (Aklilu and Wekesa, 2001), and has the possibility of compromising food security when livestock feeds are cultivated alongside with crops (FAO, 2009; Erb et al., 2012).

This study evaluated SCP systems as options for improving body condition and the market price of cattle produced in pastoral areas. Stratified livestock production has been practised widely

in Africa and elsewhere. For example, in Niger and Central Mali, herders often sell weak animals at the beginning of the dry season to agriculturalists who fatten them for market (Amano, 1995). In Botswana, farmers in semi-arid areas purchase beef cattle from pastoral areas and feed them on sorghum residues supplemented with maize bran (Farrington et al., 1989), while large scale feed-lot entrepreneurs fatten cattle in ranches before selling them to the Botswana Meat Commission (Malope et al., 2007).

In Kenya, SCP was started in the early 1960s, when the government initiated the screening of cattle produced in the pastoral areas, followed by fattening, before slaughtering them at the Kenya Meat Commission (Raikes, 1981). However, the government failed to maintain the livestock marketing infrastructure, including holding grounds, quarantine centres, and stock routes, which led to the discontinuation of the system in 1982 (AU-IBAR and NEPDP, 2006). Despite the poor marketing infrastructure, the SCP re-merged over the last two decades (Mahmoud, 2006; Farmer and Mbwika, 2012). The adoption is driven by the terminal market demands for well-finished cattle (Dabasso et al., 2018) and possibly relate to the liberalisation of the Kenyan beef market in the mid-1980s (Nyariki, 2008).

Nonetheless, there are production and marketing challenges that could hinder the performance of the various forms of SCP practiced in Kenya. For instance, some ranches located in the coastal region of Kenya, are experiencing leadership struggles, illegal mining activities, lack of sufficient water (Njogu and Dietz, 2006), land subdivision, mismanagement, and limited market outlets (Aklilu et al., 2002). These challenges could compromise the sustainable operation of livestock fattening programs in those ranches. Moreover, the stock routes that connect the pastoral areas to the ranches are dilapidated (AU-IBAR and NEPDP, 2006). However, there also emerging opportunities, which could make the SCP, attractive to investors. These opportunities include the

growing market demand for meat (Alarcon et al., 2017) and the increasing use of mobile money transfer and phone communication systems that can enhance market access and reduce transaction costs (Rutten and Mwangi, 2012). Given the background of the aforementioned constraints and opportunities, this study evaluated various forms of SCP as options for adding value to cattle produced in Kenya's pastoral areas to enhance their competitiveness in niche markets. The findings are useful in guiding the development of the production system for better returns and improved livelihoods.

4.2 Materials and Methods

4.3.1 Study areas

The study was conducted in Taita Taveta, Laikipia, and Narok counties, located in the semi-arid region of Kenya (Figure 4.1). Environmental conditions of these counties, including rainfall, relative humidity, and temperature, are presented in Table 4.1. The rainfall for these areas has a bimodal distribution, with the short-rains season occurring in March to May and the long-rains season in October to December (Figure 4.2). The type of vegetation ranged from wooded savannah to open grassland, where perennial grasses, including *Pennisetum mezianum*, *Digitaria* sp., *Themeda triandra*, *Cenchrus ciliaris*, *Chloris roxburghiana* and *Enteropogon* sp. are the dominant species (field notes).

The main economic activity in the areas is cattle ranching, which initially started with the aim of producing breeding herds. Nonetheless, many ranches are now used for fattening lean cattle that were purchased from pastoral areas (Mahmoud, 2006). In addition, to maximize revenues from those ranches, the cattle fattening also helps in controlling bush encroachment whilst boosting market outlet for pastoralists during droughts (Bell and Pramer, 2012).

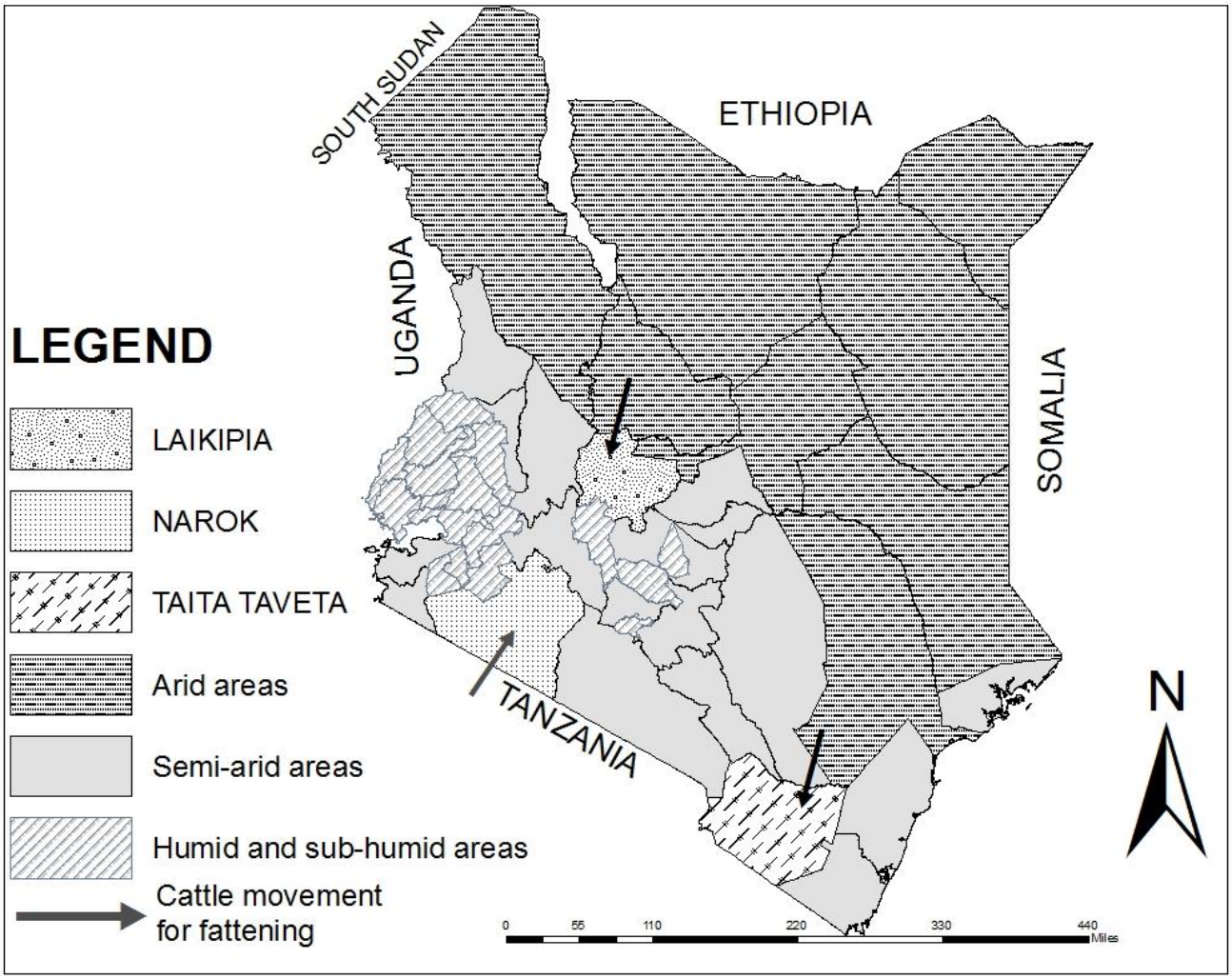


Figure 4. 1: Location of the study areas

Source: Generated using ArcGIS 10.2, ESRI 2011

Table 4. 1: Geographical location and environmental conditions of the study areas

Study area	Geographical location		Climate			Reference
	Latitude	longitude	Temperature (°C)	Average relative humidity (%)	Annual rainfall (mm)	
Narok	0°50'−1°50' S	35°28'−36°25' E	10−20	61.0	463−1642	GoK, 2013b
Taita Taveta	0°46− 4°10 S	37°36'−30°14 E	18.2−25	74.0	341−1,200	GoK, 2013c
Laikipia	0°18''S−051' N	36°11''−37° 24' E	16−26	60.0	400−750	GoK, 2013a

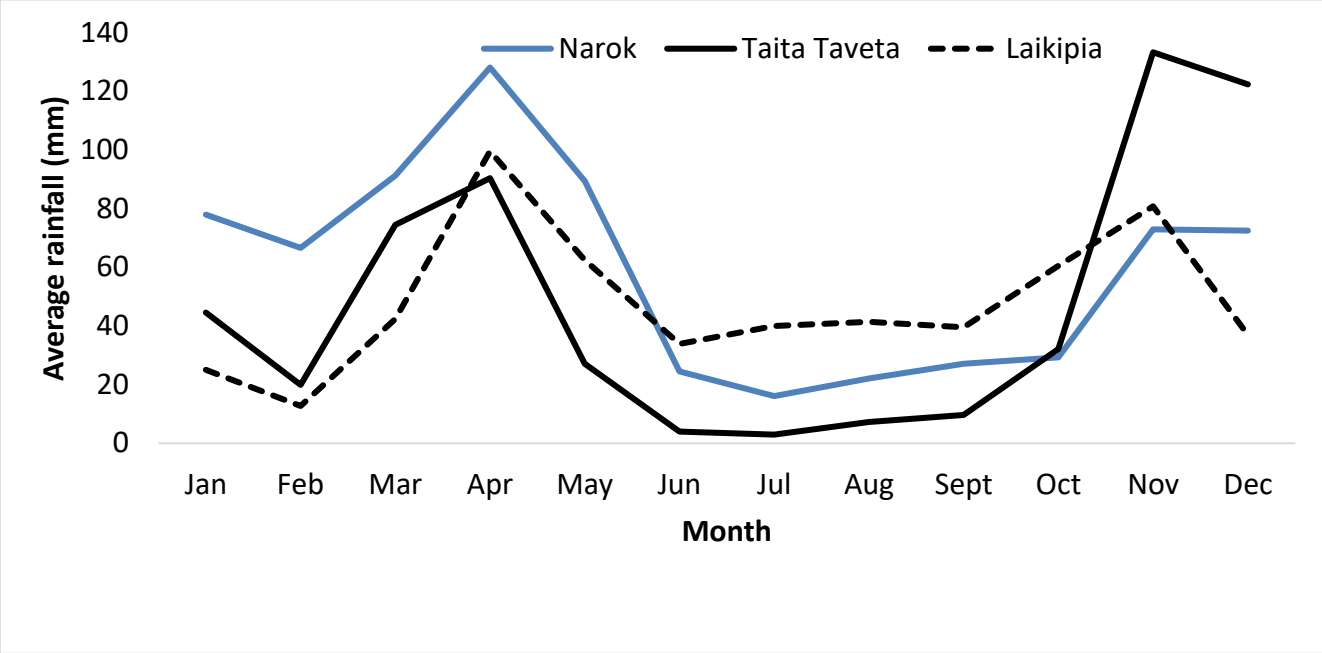


Figure 4. 2: Monthly average rainfall from 1980 to 2016 for Taita Taveta, Laikipia and Narok Counties

Source: Authors analysis of rainfall data obtained from the Kenya Meteorological Department in Nairobi, Kenya

4.3.2 Data collection

Ranchers, traders, and agro-pastoralists having records of the required data were purposively selected across Taita Taveta, Laikipia, and Narok counties of Kenya. The required data included weights of cattle at the time of purchase and at the time of sale, buying and selling prices, market levies (county fees, sale brokerage charges), transportation costs, charges for veterinary permits, and overhead costs (travel expenditures, administrative costs). Other required data were herding labour (salaries, bonuses, food, and medicine), feed and water charges, costs of deworming, spraying/dipping, veterinary drugs, salts/minerals, vaccination, repairs, and wages for night guards.

In Taita Taveta County, there were two traders (n[1] = 231) and three ranchers (n = 273) who previously collected data or collecting at time of the study and agreed to share their records. In Laikipia, there were two ranchers (n = 328) who agreed to share their data. None of the agro-pastoralists had records of required data, and therefore, those who purchased animals during the start of the fieldwork (July 2015) were chosen purposively and issued with sheets (Appendix 2). Nine agro-pastoralists (n = 140) were purposively selected only across Laikipia and Narok counties (as there were no agro-pastoralists fattening pastoral cattle in Taita Taveta at the time of the study). The selected agro-pastoralists were also issued with weighing tapes (made by Dalton Supplies Ltd., England) (with printed weight measurement on them) to estimate the animals' weights from the heart-girth measurements. The tape has about 95% accuracy in estimating live weights of East African zebu cattle from the heart-girth measurements (Goe et al., 2001; Lesosky et al., 2013). Two trained field assistants were recruited (one in Laikipia and other in Narok) to help the agro-pastoralists to accurately use the weighing tapes and collect the required data.

4.3.3 Sources, general characteristics, and the management of sample animals

The ranchers and traders sourced the animals from Kenya's northern areas while the agro-pastoralists sourced them from the southern part of the country. The cattle were of different classes, breeds, and ages and included steers, bulls, cows, and heifers of the Borana breed, the Small East African zebu or their crosses, aged 3−4 years. Both the ranchers and traders regularly vaccinated the cattle against foot-and-mouth disease, anthrax, lumpy-skin disease, and contagious bovine pleuropneumonia. The agro-pastoralists did occasional vaccination whenever there was an expected outbreak of a notifiable disease. All the practitioners watered the cattle daily during the

[1] Heads of cattle fattened and used as sample animals.

wet season and once in two days during the dry season. The cattle were given *ad-libitum* access to salts of locally available brands, either in mixtures or separately. The ranchers and traders provided anthelmintics every three months, sprayed the cattle with acaricides weekly, while the agro-pastoralists gave anthelmintics every four months, and sprayed acaricides on every fortnightly.

The ranchers had their own ranches while the traders had to lease grazing resources from ranchers. The agro-pastoralists fattened their stock in smallholder farms and supplemented them with crop residues (wheat/sorghum straws, maize stovers, and legume haulms). The cattle fattened by the ranchers and traders were sold to abattoirs and slaughterhouses in Nairobi and other major towns in the country while those by the agro-pastoralists were sold in local markets.

4.3.4 Data analysis

Cattle weight gains, costs of purchase and fattening, financial losses, and the net revenues for individual animals were calculated using the Microsoft Excel Spreadsheet (Version, 2013). The weight gains were calculated using equation 1 (Dunn et al., 2010):

$$DWGi = \frac{FWi - IWi}{Di} \quad (1)$$

where; DWGi = Daily weight gain for the ith animal.

FWi = Final weight for the ith animal at the time of sale.

IWi = Initial weight for the ith animal at the time of purchase.

Di = Fattening period (in days) for the ith animal.

The purchase costs were calculated using equation 2, as described by Blanco et al. (2011):

$$PUi = \sum (BPi + MLi + TCi + OVi) \quad (2)$$

where; PUi = Total purchase cost for the ith animal.

BPi = Buying price for the ith animal.

MLi = Market levy for the ith animal.

TCi = Transport cost for the ith animal.

OVi = Overhead cost for the ith animal.

The fattening costs were calculated using equation 3 (Ramsey et al., 2005):

$$FCi = \sum (HLi + FWi + DWi + SPi + VDi + STi + VCi + OTi) \quad (3)$$

where; FCi = Total fattening costs for the ith animal.

HLi = Herding labour for the ith animal.

FWi = Cost of feeds and water for the ith animal.

DWi = Cost of deworming for the ith animal.

SPi = Cost of spraying/dipping for the ith animal.

VDi = Cost of veterinary drugs for the ith animal.

VCi = Cost of vaccination for the ith animal.

OTi = Other costs for the ith animal (repairs, wages for night guards).

Where the costs were applicable to the entire herd, costs related to individual cattle were determined by dividing the overall costs by the number of cattle in the herd. To facilitate this, cattle deaths and transfers at the end of every month were recorded.

Financial losses relating to individual cattle were calculated by dividing the total purchasing and fattening costs incurred for the dead or lost cattle divided by the total number of cattle purchased for fattening as suggested by Ott et al. (1999) (equation 4).

$$LS = \frac{\sum_{n}^{i} PU + \sum_{n}^{i} FC}{n} \quad (4)$$

where; LS = Losses per animal.

$\sum_{n}^{i} PU$ = Summation of purchase costs (buying prices, market levies, transportation, and overhead costs) incurred for the dead or lost animals.

$\sum_{n}^{i} FC$ = Summation of fattening costs (herding labour, costs of feeds and water, deworming, spraying/dipping, veterinary drugs, vaccination, repairs, night guards) incurred for the nth number of the dead animals.

n = Total number of cattle purchased for fattening

The net revenues were determined by subtracting the total costs of purchase and fattening from the cattle's selling prices (Belasco et al. 2009). The cattle were sold on-farm, and therefore, no marketing costs were incurred.

In each of the SCP system, the cattle were grouped depending on the location, year of purchase, duration of fattening and the individual practitioner involved in their management. The duration of fattening was categorized as short, medium or long, depending on whether it was below, within or above the general average for the SCP system in consideration, respectively. One-way analysis of variance (ANOVA) (IBM Corp. SPSS, 2011) was used to test whether the weight gains, costs incurred, and the revenues obtained, varied with the location, year of purchase, duration of fattening, and with individual practitioners. The values were considered significant at $P<0.05$.

4.4 Results

4.4.1 Cattle weight gains, costs, selling prices and net revenues under the stratified cattle production by ranchers

The cattle (n = 601) fattened by the ranchers had an average initial weight of 232.1 ± 24kg at the time of purchase and after 376.9 ±139.5 days, attained an average weight of 315.5 ± 33.1kg, which translated into per animal overall weight gain (OWG) and daily weight gain (DWG) of 83.4 ± 19.2kg and 0.24 ± 0.07kg, respectively. The average purchase cost per animal was USD 286.1 ± 70, which encompassed the animal buying price (95.6%), the costs of transport (3.4%), overheads (0.5%), market levy (0.4%), and veterinary permit (0.1%). The fattening cost per head of cattle was USD 47.6 ± 28.1, which included the costs of herding (37.1%), feeds and water (2.4%), deworming (11.1%), spraying/dipping (12.2%), veterinary drugs (3.7%), salts/minerals (12.7%), vaccination (6.6%) and others including repairs, wages for night guards (14.2%). The ranchers sold the animals at an average price of USD 406.77 ± 67.96 and obtained net revenue of USD 61.7 ± 34.2 per head of cattle.

The weight gains, costs, selling prices, and revenues varied with the location, year of purchase, duration of fattening, and with the individual practitioners (Table 4.2). The cattle fattened in Laikipia County had 29.6% higher OWG and 33.3% higher DWG than those fattened in Taita Taveta County.

Table 4. 2: Cattle weight gains (average ± SD kg per animal), costs, selling prices and net revenues (USD) (average ± SD per animal) under the SCP by ranchers, and their variations with location, year of purchase, duration of fattening and with individual ranchers

Source of variation	Overall weight gain (Kg)	Daily weight gain (kg)	Cost of Purchase (USD)	Cost of fattening (USD)	Selling price (USD)	Net revenue (USD)
Location						
Taita Taveta (n = 273)	71.8 ± 17.7^{b}	0.21 ± 0.04^{b}	313.5 ± 37.8^{a}	54.5 ± 5.4^{b}	376.7 ± 71.4^{b}	60.3 ± 27.5^{b}
Laikipia (n = 328)	93.1± 14.6^{a}	0.28 ± 0.08^{a}	261.4 ± 81.3^{b}	66.8 ± 24.7^{a}	431.7 ± 53.4^{a}	80.2 ± 30.4^{a}
Year of purchase						
2010 (n= 122)	93.2 ± 14.9^{a}	0.16 ± 0.02^{c}	155.9 ± 0.0^{c}	36.8 ± 7.7^{b}	363.6 ± 16.3^{b}	87.4 ± 10.5^{a}
2012 (n=302)	87.5 ± 14.8^{b}	0.27 ± 0.08^{a}	304.7 ± 28.2^{b}	66.2 ± 27.9^{a}	420.2 ± 76.3^{a}	68.7 ± 18.4^{b}
2014 (n= 177)	69.7 ± 18.3^{c}	0.24 ± 0.05^{b}	340.8 ± 9.4^{a}	23.2 ± 6.0^{c}	413.6 ± 62.8^{a}	65.1 ± 60.6^{b}
Period of fattening (days)						
Short (< 237) (n = 53)	78.7 ± 15.2^{b}	0.39 ± 0.07^{a}	263.4 ± 0^{b}	24.8 ± 1.4^{a}	310.4 ± 10.0^{c}	37.5 ±12.7^{b}
Average (238−516) (n = 469)	81.2 ± 19.0^{b}	0.24 ± 0.05^{b}	309.3 ± 53.0^{a}	51.2 ± 30.5a	423.9 ± 65.5^{a}	48.8 ± 14.1^{b}
Long (>516) (n = 79)	99.9 ± 13.7^{a}	0.15 ± 0.01^{c}	155.9 ± 0.0^{b}	41.6 ± 4.7^{b}	369.8 ± 17.3^{b}	68.3 ± 12.9^{a}
Rancher						
Rancher 1 (n = 96)	75.8 ± 15.9^{b}	0.35 ± 0.08^{a}	263.4 ± 0.0^{c}	26.9 ± 2.6^{c}	308.9 ± 10.0^{e}	13.5 ± 11.1^{d}
Rancher 2 (n = 100)	64.0 ± 7.9^{c}	0.23 ± 0.03^{c}	332.5 ± 0.0^{b}	28.3 ± 1.2^{c}	381.8 ± 24.4^{c}	5.0 ± 24.5^{e}
Rancher 3 (n = 122)	93.2 ± 14.9^{a}	0.16 ± 0.02^{d}	155.8 ± 0.0^{d}	36.8 ± 7.6^{b}	363.7 ± 16.3^{d}	167.3 ± 10.4^{a}
Rancher 4 (n = 77)	77.0 ± 24.5^{b}	0.24 ± 0.07^{b}	351.5 ± 0.0^{a}	16.5 ± 1.5^{d}	454.8 ± 72.9^{b}	74.1 ± 70.6^{b}
Rancher 5 (n= 206)	93.0 ± 14.4^{a}	0.23 ± 0.03^{c}	323.9 ± 0.0^{b}	84.5 ± 9.2^{a}	472.1 ± 0.0^{a}	44.6 ± 11.4^{c}

Average values in the same row with different superscripts are significantly different at $P < 0.05$, n = the number of cattle

4.4.2 Cattle weight gains, costs, selling prices and net revenues under the stratified cattle production by traders

The cattle (n = 240) fattened by the traders had an average initial weight of 308.9 ± 20kg and attained weight of 402.2 ± 24.6kg at the time of sale, after 256.8 ± 80.2 days. The average OWG and DWG per animal were 93.1 ± 11.3kg and 0.39 ± 0.13kg, respectively. The average cost of purchase, cost of fattening, selling price, and net revenue per animal were USD 452.0 ± 26.0, USD 46.3 ± 11.9, 593.6 ± 35.6, and USD 81.3 ± 44.0, respectively. The costs and revenues were influenced by duration of fattening, and differed across the traders (Table 4.3). The cost of purchase included the cattle buying price (96.0%), cost of transport (2.9%), market levy (0.2%), veterinary permit (0.2%), and overheads (0.7%), while the cost of fattening included the costs of herding (36.4%), feeds and water (35.6%), deworming (4.5%), spaying or dipping (7.1%), veterinary drugs (0.9%), salts (6.2%), vaccination (3.3%) and others (repairs, wages for night guards) (6.0%).

Table 4. 3: Cattle weight gains (average ± SD kg per animal), costs, selling prices and net revenues (USD) (average ± SD per cattle) under the SCP by traders, and their variations with duration of fattening and with individual traders

Source of variation	Overall weight gain (Kg)	Daily weight gain (Kg)	Cost of Purchase (USD)	Cost of fattening (USD)	Selling price (USD)	Net revenue (USD)
Duration of cattle fattening (days)						
Short (< 177) (n = 56)	89.2 ± 11.7^{a}	0.58 ± 0.07^{a}	465.02 ± 0.0^{a}	29.9 ± 0.0^{c}	613.2 ± 48.3^{a}	109.4 ± 48.3^{a}
Average (177.1−337.5) (n = 126)	94.2 ± 12.2^{a}	0.37 ± 0.06^{b}	456.4 ± 22.1^{b}	47.7 ± 6.7^{b}	583.5 ± 32.1^{c}	64.9 ± 38.3^{a}
Long (> 337) (n = 49)	94.6 ± 6.6^{a}	0.27 ± 0.02c	425.6 ± 31.8^{c}	51.3 ± 3.0^{a}	596.9 ± 0^{b}	91.1 ± 32.3^{a}
Trader						
Trader 1 (n = 116)	98.2 ± 9.3^{a}	0.30 ± 0.04^{b}	438.9 ± 31.8^{b}	56.9 ± 4.8^{a}	596.9 ± 0^{a}	83.5 ± 31.1^{a}
Trader 2 (n = 115)	87.9 ± 10.8^{b}	0.49 ± 0.10^{a}	465.0 ± 0.0^{a}	35.6 ± 5.5^{b}	590.2 ± 50.4^{a}	79.1 ± 53.9^{a}

Average values in the same row with different superscripts are significantly different at $P < 0.05$, n = the number of cattle

4.4.3 Cattle weight gains, costs, selling prices and net revenues under the stratified cattle production by agro-pastoralists

The cattle (n = 140) fattened by the agro-pastoralists had an average initial weight of 225.3 ± 28.8kg, and after 183.0 ± 49.8 days, they attained a final weight of 268.7 ± 33.3kg, which translated to OWG of 43.4 ± 18kg and DWG of 0.24 ± 0.08kg per animal. The average purchase and fattening costs per animal were USD 173.5 ± 44.1 and USD 43.4 ± 18, respectively. The cost of purchase comprised of the animal buying price (95.7%), cost of transport (2.9%), market levy (0.6%), veterinary permit (0.1%), and overheads (0.7%), while that of fattening included costs of herding (42.5%), feeds and water (26.4%), deworming (5.5%), spraying (7.5%), veterinary drugs (3.8%), salts (10.5%), vaccination (2.4%) and others (1.3%). The agro-pastoralists sold the fattened herd at an average price of USD 245.3 ± 54.0 and obtained net revenue of USD 55.9 ± 36.6 per animal. Weight gains, costs, and revenues differed with the location, fattening duration, and with the individual agro-pastoralists (Table 4.4).

Table 4. 4: Cattle weight gains (average ± SD kg per animal), costs, selling prices and net revenues (USD) (average ± SD per animal) under the SCP by agro-pastoralists, and their variations with location, duration of fattening and with individual agro-pastoralists

Source of variation	Overall weight gain (Kg)	Daily weight gain (Kg)	Cost of Purchase (USD)	Cost of fattening (USD)	Selling price (USD)	Net revenue (USD)
Location						
Laikipia (n = 50)	48.8 ± 16.7[a]	0.25 ± 0.04[a]	197.6 ± 41.1[a]	16.3 ± 9.2[a]	261.5 ± 52.4	47.5 ± 33.4[b]
Narok (n = 90)	40.4 ± 18.3[b]	0.23 ± 0.09[a]	160.1 ± 40.0[b]	13.0 ± 3.5[b]	236.4 ± 53.1	60.5 ± 37.6[a]
Period of fattening (days)						
Short (< 133) (n =17)	23.5 ± 6.7c	0.19 ± 0.05a	211.7 ± 33.2[a]	9.9 ± 1.2[c]	268.6 ± 35.6[a]	37.5 ± 12.8[b]
Average (133−232) (n = 100)	42.1 ± 16.3b	0.24 ± 0.09a	160.5 ± 35.2b	12.1 ± 3.4[b]	230.2 ± 49.3[b]	57.2 ± 38.6a
Long (> 232) (n = 23)	63.9 ± 10.0a	0.23 ± 0.04a	202.1 ± 56.4a	26.4 ± 3.8[a]	294.1 ± 50.9[a]	63.7 ± 35.6a
Agro-pastoralist						
Agro-pastoralist1 (n = 10)	22.2 ± 4.1[f]	0.18 ± 0.03[c]	206.2 ± 32.3[ab]	10.7 ± 0.1[e]	277.5 ± 35.4[a]	44.7 ± 5.9[c]
Agro-pastoralist2 (n = 14)	51.4 ± 4.1[b]	0.24 ± 0.06[b]	119.9 ± 33.4[e]	16.1 ± 3.6[c]	205.4 ± 62.3[c]	63.7 ± 49.1b[c]
Agro-pastoralist3 (n = 10)	53.5 ± 10.1[b]	0.29 ± 0.05[a]	157.8 ± 33.9[d]	11.0 ± 0.3d[e]	243.7 ± 95.9[b]	74.8 ± 65.1b[c]
Agro-pastoralist4 (n = 7)	54.0 ± 13.8[b]	0.33 ± 0.09[a]	133.5 ± 20.5[de]	19.5 ± 1.6[b]	204.4 ± 19.3[c]	51.4 ± 8.7[c]
Agro-pastoralist5 (n = 15)	53.7 ± 8.4[b]	0.25 ± 0.04[b]	135.8 ± 12.8[d]	16.2 ± 0.3[c]	251.3 ± 20.4[b]	99.3 ± 28.9[a]
Agro-pastoralist6 (n = 34)	28.8 ± 17.8[e]	0.19 ± 0.12[c]	180.1 ± 31.2[c]	10.4 ± 0.3[e]	234.9 ± 41.4[b]	44.5 ± 14.6[c]
Agro-pastoralist7 (n = 17)	68.5 ± 4.9[a]	0.24 ± 0.02[b]	228.7 ± 37.2[a]	28.7 ± 0.4[a]	309.6 ± 38.6[a]	52.3 ± 4.9[c]
Agro-pastoralist8 (n = 17)	37.2 ± 12.4[d]	0.24 ± 0.04[b]	203.8 ± 31.1[b]	12.0 ± 2.9[d]	230.1 ± 35.3[b]	14.3 ± 15.1[d]
Agro-pastoralist9 (n = 16)	40.2 ± 7.3[c]	0.25 ± 0.04[b]	157.9 ± 14.4[d]	7.7 ± 0.4[f]	243.5 ± 44.2[b]	77.8 ± 33.3[b]

Average values in the same row with different superscripts are significantly different at $P < 0.05$, n = the number of cattle

4.5 Discussion

The results on weight gain provide an understanding of animal productivity following fattening, which are consistent with those of Asizua et al. (2009), who evaluated weight gain for Ankole cattle and their crosses with Borana and Friesian that were fattened on natural pastures in the semi-arid region of Uganda. The net revenues recorded in the current study depict that fattening of lean cattle from pastoral areas is a profitable undertaking. Other studies (Little et al. 2014; Malole et al., 2014) also reported similar results regarding the profitability of fattening pastoral cattle through SCP systems. A study by Little et al. (2014) showed that fattening of drought-stricken cattle, purchased from herders in southern Ethiopia during the drought of 2011 was profitable. Analysed of costs and revenues by Malole et al. (2014) for the indigenous beef cattle fattening systems in northwest Tanzania also indicated the system was profitable, although, this was reported to vary with the production system. In the current study, the SCP by traders in which access to grazing resources was through lease arrangements had the highest net revenue per head of cattle and therefore, the most profitable. This may be attributable to the practice of pasture leasing, which guaranteed access to pasture, especially during dry periods. The importance of pasture leasing for livestock production in Kenya, especially during the dry season has been highlighted by Lengoiboni et al. (2011), who recommended that the government should recognize and formalize pasture lease agreements to enhance pastoralists' access to dry season grazing resources.

The cattle weight gains and net revenues were found to vary with the location, duration of fattening, and with the individual practitioners. This is attributable to the spatio-temporal variability of grazing resources coupled with possible differences in the management practices among the practitioners. Additionally, there is a high genotypic diversity among the East African zebu cattle (Rege et al., 2001), which might have also contributed to the observed differences in

the weight gains and net revenues. Also, a study that compares the profits earned by the practitioners under the SCP systems and under a non-SCP in which herds are reared for breeding, is essential in guiding the practitioners to choose the most economically viable production system. Although a few studies (Muhuyi, 1997; Nyariki, 1990), had earlier established revenues achievable in a production system in which breeding herds of cattle were reared in Laikipia areas of Kenya, data collected concurrently with that for the SCP systems would provide an accurate comparison of the profitability between the two production systems.

This study has shown that the transportation expenses took a larger proportion of the total purchase cost in all the SCP systems. This reflects weak market access in the pastoral livestock value chain, similar to the observations made in other studies (Aklilu, 2008; Onono et al., 2015). The current study further found that, a significant proportion of the total fattening cost was spent on grazing resources (feeds and water) in all three forms of SCP. This observation corroborates with the findings of Okoruwa et al. (2005) that showed that feeds' expenses formed a significant percentage of the total variable cost incurred by the cattle-fattening farms located in the Ibadan region of Nigeria.

4.6 Conclusions and recommendations

The findings in this study reveal that SCP systems effectively improve the body condition and market price of pastoral in Kenya's drylands, although, this depends on the location, duration of fattening, and the management practices. Therefore, strengthening and promoting the emerging forms of SCP is recommended to enhance the sale of drought-stricken pastoral cattle.

CHAPTER FIVE

5.0 EMERGING PASTORALISTS' PRACTICES FOR MARKET INTEGRATION THROUGH STRATIFIED CATTLE PRODUCTION SYSTEMS IN KENYA'S DRYLANDS

Abstract

Stratified cattle production (SCP) systems, which involve buying lean animals from pastoral areas and fatten them in locations having better production conditions, are re-emerging in Kenya's drylands. This study investigated how pastoralists in the drylands of Kenya fulfil cattle marketing requirements under the SCP systems. Purposefully identified cattle fattening entrepreneurs in Tana River (n = 10) and Narok (n = 12) counties were interviewed on requirements they demand in buying animals from pastoralists. Using the information generated from the entrepreneurs, pastoralists (Tana River, n = 10; Narok, n = 12) were interviewed on how they respond to the entrepreneurs' requirements and make sales. The information was triangulated with a focus group discussion in each county whose members were knowledgeable traders and pastoralists. Using a semi-structured questionnaire, randomly selected pastoral households (Tana River, n = 86; Narok, n = 69) were interviewed on cattle sales made through SCP systems. Pastoralists in the two counties were required to sell cattle of particular qualities, comply with unpredictable supply orders, sell in secondary markets or near urban centres as buyers were avoiding bush markets because of insecurity, use sale agents in order to negotiate for favourable prices, and supply large number of animals if the demand arose. To meet these requirements, the pastoralists devised a number of strategies and practices including changing the animal husbandry practices, keeping "emergency" animals in the home-based herds to comply with unpredictable demands, arranging

with market intermediaries to sell in secondary markets, and building buyer-seller trust to facilitate sales through agents. In adopting these practices, pastoralists in both counties managed to sell about 1-2 animals per household through the SCP systems over a period of 12 months, which translates into 28% of the average annual off-take rate by the households. These results imply that pastoral production system is dynamic and that pastoralists are responsive to market demands, and therefore, SCP is crucial in enhancing their integration into market economy for improved livelihoods. The information could guide stakeholders to formulate strategies for improving pastoralists' involvement in cattle marketing through SCP systems.

Keywords: Drylands, livestock fattening, market demands, market outlet, pastoral practices

5.1 Introduction

Pastoralists' livelihoods entirely depend on livestock, kept not only for milk, meat, and blood, but also for paying dowries, compensation for damages, and for performing spiritual obligations (Marshall et al., 2014). Therefore, keeping as many animals as possible is an important strategy for meeting economic and social responsibilities, and for insuring against risks and uncertainties (Yonten, 2014). Herskovits (1926) misunderstood this strategy and labelled pastoralists as those who are obsessed with livestock and keep large herds off the market for prestige. Similar to the Herskovits' notion was the theory by Hardin (1968), which states that rangelands in pastoral areas are open access resources and that every herder tend to maximize personal gains by adding more animals and share the loss (over-grazing) with other herdsmen. According to Hardin (1968), this will eventually leads to the tragedy of the commons. These theories shaped the mainstream thinking about pastoralism and thus, pastoralists were assumed to keep many animals that are economically inefficient and destructive to the environment and therefore, policies for off-taking the 'excess' animals from the rangelands were found suitable and promoted (Anderson, 2010). However, the theories were later considered myths rather than the realities and that pastoralists understood as those who fully engage the market economy (Mtetwa, 1978; Yonten, 2014). Pastoral livestock trade has also been found to contribute substantially to the agricultural gross domestic products (GDPs) of many countries in Africa, including Algeria, Mali, Chad, Sudan, Namibia (African Union, 2010), Ethiopia (Behnke, 2010), and Kenya (GoK, 2008). In northern Somalia (where pastoral livestock production is the dominant livelihood), live animal (sheep, goats, cattle, and camels) exports to the Saudi Arabian markets have been estimated to worth annual value of US $200 million (Majid, 2010), though influenced by many factors including religious festivities, livestock export regulations, and the number of export traders (Musa et al., 2020). In 2009, pastoral

livestock and livestock product exports from Kenya, Ethiopia, and Somalia had an economic value of US $1.09 billion (Catley et al., 2016).

Despite its economic contribution, pastoralism in Africa is rarely supported with appropriate policy frameworks (Pavanello, 2009; Behnke and Kerven, 2013). This is despite several challenges facing the production system, including fragmentation of formerly intact grazing lands (Galvin, 2009), growing imbalance between humans, livestock and environment (Sandford, 2006), land degradation, poverty and inappropriate land-use plans (Homann et al., 2008). These challenges exert pressure on pastoralism, forcing pastoralists in East Africa to settle around trading centres and water points in anticipation for donor aids (Niamir-Fuller, 2005). In this way, pastoralists can also diversify their livelihoods (by engaging in non-pastoral activities) and use social amenities such as schools and hospitals (Fratkin and Roth, 2005). However, the use of these services requires cash, and therefore, increasing pastoralists' integration into the market economy is an important undertaking more than ever before. To do this, existing pastoralists' practices for increasing their involvement in livestock marketing could provide important lessons and insights. Previously documented pastoralists' practices for increasing their participation in livestock marketing include shifting from rearing certain livestock species to another (Osterle, 2008), increasing sales of livestock and livestock products (Amano, 1995; Levine, 1999), seeking linkages with traders (Gautier et al., 2016), and use of bank services (Marin, 2008).

Pastoralists' practices and strategies for enhancing market integration through stratified livestock production (SLP) systems are rarely documented. A SLP system entails buying lean animals from pastoral areas for fattening in locations with relatively high and less dynamic forage productivity (Jahnke, 1982). The system is commonly practiced in the Horn of Africa, and is considered as some of the best practices in pastoral livestock value chains that facilitate market

access, particularly during droughts (Aklilu et al., 2013). For instance, during the 2006 drought in southern Ethiopia, the United States Agency for International Development (USAID) piloted a commercial destocking program in which traders purchase emaciated cattle from pastoralists and transported them to holding grounds from where the animals were provided with fodder until when they were healthy to travel to feedlots for fattening (Abebe et al., 2008). Assessing the program's impacts, Abebe and Catley (2013) observed that the pastoralists received substantial income to buy feeds for their remaining animals and meet household expenses.

Pastoralists have to fulfil certain market requirements to market livestock through SLP systems and integrate into the cash economy. This is because the livestock buyers under SLP systems have certain market specifications. For example, in Ethiopia's Shoa region, feedlot operators prefer Borana cattle breed because the breed has relatively heavier and has better feed conversion efficiency than other local breeds (Teklebrhan and Urge, 2013). In Botswana, the government feedlots demand weaner cattle of 6 – 12 months, which they finish at 18 – 24 months (Engelen et al., 2013) whilst traders in southern Ethiopia make substantial profits from feedlots fattening by buying drought-stricken cattle (Little et al., 2014). In addition to these requirements, pastoralists' integration into SLP systems could be influence by the existing market challenges in pastoral livestock value chains. For the Greater Horn of Africa, the challenges include poor infrastructure (AfDB, 2010), poorly organized market information (Roba et al., 2018), risks of losing livestock while on transit (due to transportation fatigue or theft) (Mahmoud, 2008). Other challenges are; unpredictable closures of livestock markets (whenever there is an outbreak of a notifiable disease) (Rufael et al., 2008), and the numerous market charges or fees that cut on the producers' income (Onono et al., 2015).

Focusing on Kenya's drylands, this study explored how pastoralists fulfil the market requirements, and circumvent market challenges, and integrate into the country's emerging stratified cattle production (SCP) systems. Kenya's drylands are predominately arid and semi-arid areas where pasture productivity has both temporal (seasonal or intra/inter annual) and spatial variability (Ngugi and Conant, 2008). The areas are largely used for pastoral livestock production, contributing about 10–15 % of the national GDP (Behnke and Muthami, 2011). Cattle rearing constitutes an essential component of the production system, accounting for about 70% of the beef consumed in the country (GoK, 2008)−the remaining amount of beef comes from ranches and the dairy sector (Kosgey et al., 2011) and from the cross border livestock trade (Little, 2009). In spite of its economic importance, the production system has poor marketing infrastructure, and traders generally struggle to connect with terminal markets (Roba et al., 2017). This scenario implies that animals that become lean in the dry season hardly get market. The high and widespread drought-related livestock mortalities in Kenya's drylands (Oba, 2001; 2010; Nkedianye et al., 2011) may partly relate to inadequate marketing infrastructure that limits the selling of lean animals before they succumb to a drought.

Kenya's drylands have the potential for SLP systems because of the existence of two main ecological zones for livestock production−the arid zone which is mostly used by pastoralists for breeding and rearing, and the semi-arid zone mainly used by commercial ranches to keep high yielding animals or fatten lean pastoral animals (Nyariki, 1990). The government realized this potential and as early as 1960s, and set up stock routes, holding grounds, and quarantine centres to facilitate the movement of immature cattle from the arid zone to commercial ranches and feedlots for fattening prior to selling (Raikes, 1981). Through the Agricultural Finance Corporation of Kenya, ranchers were given loans to purchase and fatten cattle from the pastoral production

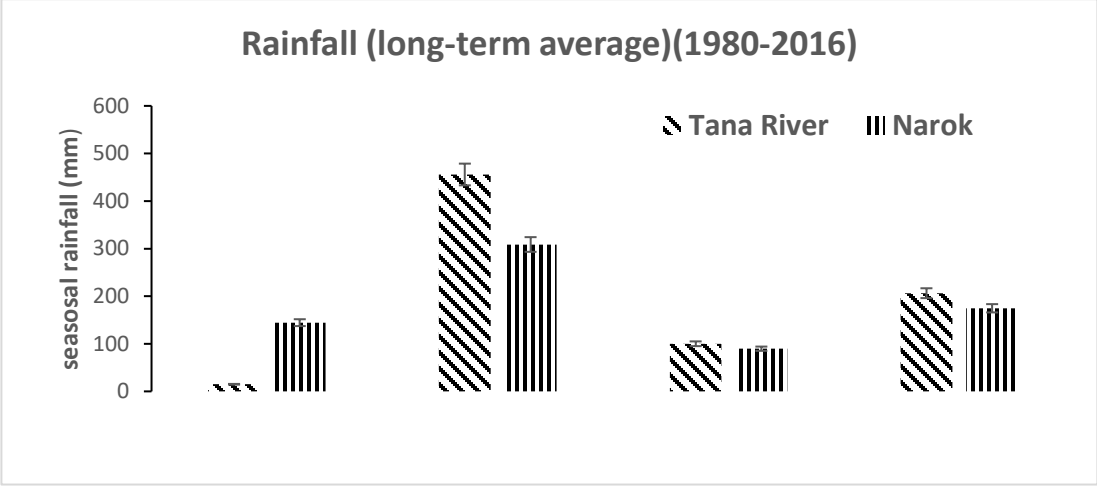
system (AU-IBAR and NEPDP, 2006). However, in the 1990s, the government support for the SCP system dwindled (van der Valk, 2008), and most of the ranches were left under-utilized (Heath, 2001). Nevertheless, other forms of SCP are have been increasingly adopted since 1999/2000, especially in the country's coastal region where traders lease ranches to fatten pastoral cattle (Mahmoud, 2006; Farmer and Mbwika, 2012). The adoption was triggered by attractive returns from fattening pastoral cattle, which is about USD 55−81 per animal (Dabasso et al., 2019). Three forms of SCP were being adopted, that practiced by ranchers, by traders, and by agro-pastoralists− they differ with respect to grazing access, herd size, and fattening period (Dabasso et al., 2018). Under the SCP systems practiced by ranchers and traders, 80−120 animals are purchased per individual practitioner and fattened in ranches for 6−12 months, while under the SCP by agro-pastoralists, an individual could buy 20−30 animals and fattened for 3−4 months in smallholder farms where crop residues were used as supplementary feeds (ibid.). Nevertheless, how the producers/pastoralists interact with the practitioners in marketing cattle through the SCP systems is hardly understood. This study assessed and analysed how pastoralists Kenya's drylands evade challenges and market cattle through the SCP systems in which ranchers and traders were the buyers. Findings are essential in improving pastoral cattle marketing through SCP systems, and enhance socio-economic development of pastoral communities.

5.3.0 Materials and methods

5.3.1 Study areas

The study was conducted in Narok and Tana River counties located in the drylands of Kenya. The average annual rainfall (mean ± SD) is about 717.6 ± 207.2 mm and 442.2 ± 219.3 mm in Narok and Tana River, respectively (data sourced from the Kenya Meteorological Department in Nairobi). In both counties, rainfall distribution is bi-modal, with the long-rains season extending

from March to May and short-rains season from October to December−some rains can also be received during other seasons (Figure 5.1).



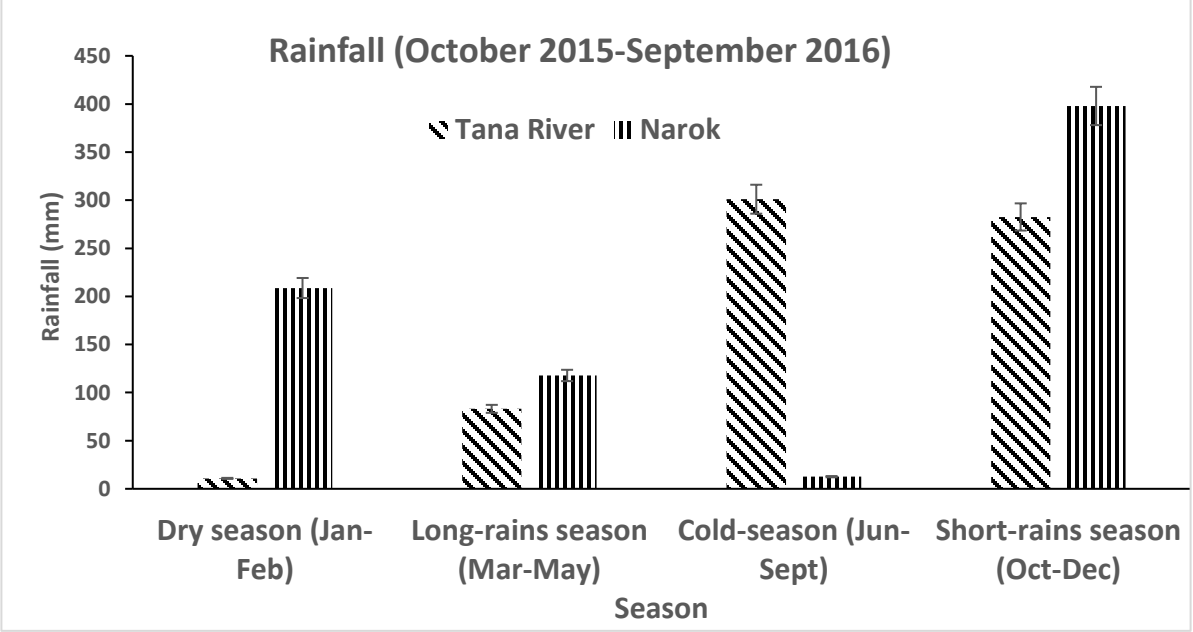


Figure 5. 1: Rainfall in Tana River and Narok counties (source: Kenya Meteorological Department in Nairobi)

Narok County is predominantly inhabited by the Maasai ethnic community, while the Orma, Wardei, and Pokomo communities are the common inhabitants in Tana River. Except the Pokomo community, whose livelihood largely depends on crop production along the Tana River, all the other communities are pastoralists and predominantly depend on livestock production for food and income sources. Livestock species that included cattle, sheep, and goats are kept for food and for performing social and cultural obligations. The animals are kept in communal grazing lands under the common property tenure arrangement that allows herds movements across landscapes, to utilize patchy and variable grazing resources. However, mobility has been limited by the recent changes in the land tenure arrangement. The communal grazing lands in Narok County have been divided into group ranches (Galaty, 1994), thereby limiting the utilization of grazing resources outside the ranch boundaries. In Tana River, the communal grazing lands have been continuously converted into state or private-owned irrigation schemes for rice, cotton, maize, and biofuel production (Smalley and Corbera, 2012). The irrigated fields are mostly the floodplains of Tana River, which were traditionally used as the fall-back grazing areas during the dry season (Oba, 2012). The land use changes limited access to the dry season pastures and therefore, exacerbated the deterioration of livestock body condition during the dry season or drought.

5.3.2 Data collection

Pastoral areas from where the cattle fattening entrepreneurs source their animals were selected using the multistage sampling technique as described by Mugenda and Mugenda (2003). The selected areas were Tarasaa location in Tana River County and Maji Moto location in Narok County (Figure 5.2).

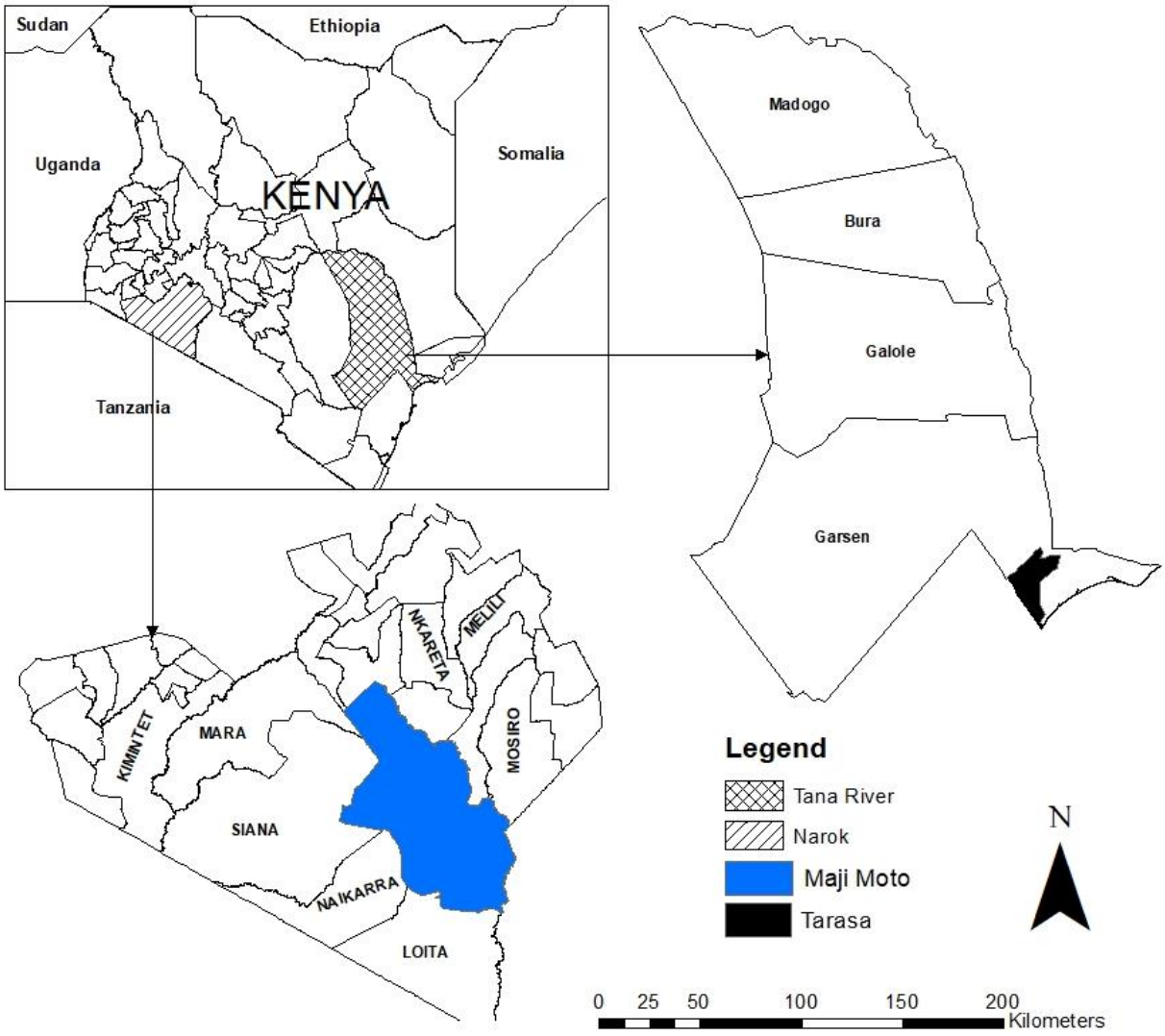


Figure 5. 2: Location of Maji Moto and Tarasaa in Narok and Tana River counties respectively (source: Generated using ArcGIS 10.2, ESRI, 2011)

The nearest livestock market centres for the two locations (Ngoswani market for Maji Moto, Garsen market for Tarasaa) were identified with the help of livestock officers in those counties. Cattle fattening entrepreneurs who frequently buy cattle from Ngoswani (n = 12) and Garsen (n = 10) markets and fatten them in ranches (located in the country's semi-arid zone), were purposively identified with the assistance of local market committees and livestock officers, and interviewed as key informants. The interviews focused on their requirements or conditions as buyers of animals

from pastoralists (Appendix 3). Using the information generated from the cattle fattening entrepreneurs, pastoralists in Tarasaa (n = 10) and Maji Moto (n = 12) were also interviewed on how they respond to the entrepreneurs' requirements and make sales. The criteria for selecting the respondents of the key informant interviews (KIIs) were knowledge and insights about the subject under discussion (based on prior interactions and the opinion of other people). The sample size for the KIIs was based on the concept of saturation, as described by Mason (2010) and Onwuegbuzie (2007), which indicates that the researcher may not need additional interviewees if they do not provide any new information about the subject under investigation.

Two focus group discussions (FGDs) (each with 9-11 participants that consisted of pastoralists, sale agents, and cattle fattening entrepreneurs) were conducted (one in Maji Moto and another in Tarasaa) to triangulate the information from the KIIs. The number of participants for each FGD was within the range of 8-12 as recommended by Wooten (2000) and allowed effective interactions. The FGD in Maji Moto had two sales brokers, three cattle fattening entrepreneurs, and four pastoralists, whereas the one in Tarasaa had three sales brokers, three cattle fattening entrepreneurs, and five pastoralists. When conducting the FGDs, research rationale was explained to the participants and the confidentiality of their responses assured, and every participant voluntarily expressed his/her view(s) without any interruption. The FGDs lasted for 2-3 hours and the members exhaustively discussed cattle fattening entrepreneurs' demands for purchasing animals from the pastoral areas, and how pastoralists were responding to those demands.

A survey of the pastoral households in Maji Moto and Tarasaa locations was conducted to establish the number of cattle sold for fattening by the individual households. Using a semi-structured questionnaire (Appendix 4), pastoral households in Maji Moto (n = 86) and Maji Moto (n = 69) were randomly selected and interviewed. The sample size in each location was calculated

based on the formulae developed by Krejcie and Morgan (1970). Based on mental recalls, the interviewees provided names of cattle sold, their classes (bulls, steers, cows, heifers, or weaners), prices, the purpose for sale, and whether the animals were bought for fattening. As pointed out by Iles (1994) and Wario et al. (2017), pastoralists' mental recall is robust and therefore, useful in capturing long-term pastoral herd dynamics. The recall period covered the last 3 months that preceded interviews, and the exercise was repeated with the same respondents after every four months from October 2015 to September 2016. Each 3-month recall period was deliberately planned to coincide with a specific season to facilitate the respondents to relate their responses to a particular season. The respondents were also encouraged to consult their spouses or any other household members to assist in recalling and arrive at a consensus. Based on their social interactions with the buyers and (or) their agents, the respondents easily recalled if the cattle they sold were taken for fattening or for other purposes.

5.3.4 Data analysis

Qualitative data on the requirements for marketing through the SCP systems and the pastoralists' responses to those requirements was analysed according to the procedure described by Mayring (2014) and Patton (2015) in which themes that were relevant in answering the research objective were identified and grouped. Calculations for the quantitative data were done in Microsoft Excel Spreadsheet (version 2013) and statistical differences were tested at 5% level of significance using analysis of variance (IBM Corp. SPSS, 2011).

5.4.0 Results

5.4.1 Emerging management practices for increasing off-take rates under the stratified cattle production systems

The practices for increasing off-take rates under the SCP systems are summarized in Table 5.1.

Table 5. 1: Emerging management practices among pastoralists in Kenya's drylands for increasing off-take rates under stratified cattle production systems

Requirement for off-take	Emerging management practice among the pastoralists
Comply with unpredictable supply order	• Changing the composition of home-based herds to include 'emergency' animals, which are easily accessed and sold whenever the demand arose.
Sell in secondary markets or near urban centres	• Exploring innovative arrangements to access and keep animals around secondary markets.
Sell through sale agents	• Building buyer-seller trust to increase the interactions
Increase off-take rates when required	• Changing the traditional of keeping 'special' animals for subsistence only but sell the animals when necessary.

The practices were adopted in a bid to comply with the requirements of buyers under the SCP systems. To minimize the costs associated with making many trips to the markets, the buyers preferred to purchase from those who can sell many animals at once. The pastoralists indicated that they had always managed to supply the required number of cattle when the demand arose. This was partly achieved by not sparing the "special" animals− those having unique horns or attractive colours or those gifted out to mark special relationships or obligation such as marriage. For instance, Orma pastoralists reported that they could now sell *Arirros* (animals given to a first-born child at the time of his birth) and *Walde* (animals given to a wife at the time of the marriage). This trend contravenes the traditional norm that "special" animals were never sold, and would be

only slaughtered at home for consumption by the villagers when they aged. In addition to the market demand, the need to sell "special" animals was associated with the economic pressure to pay school fees, construct houses, and buy food as well as with the fear of losing them when drought occurs. Consequently, the number of cattle sold for fattening over a period of 12 months constituted about a quarter of the annual off-takes by the households in both counties (Table 5.2).

Table 5. 2: Pastoral household cattle herds and sales in Tana River and Narok counties of Kenya, (October 2015−September 2016)

Variable	Value (Mean ± S.E per household)	
	Tana River	Narok
Average household cattle holding	22.4 ± 3.5^{a}	32.2 ± 4.0^{a}
Average number of cattle sold annually	1.7 ± 0.4^{b}	4.2 ± 0.4^{a}
Sales as % of the household cattle holding	10.8 ± 1.7^{b}	15.4 ± 1.9^{a}
Average number of cattle sold for fattening annually	0.8 ± 0.2^{b}	1.8 ± 0.2^{a}
Sales for fattening as % of the total annual off-take	28.3 ± 4.1^{a}	28.1 ± 4.6^{a}

n = 86 in Tana River, n = 69 in Narok. Mean values in the same row with the same superscripts were not significantly different at $P < 0.05$.

The number of cattle sold for fattening was dependent on the size of the household cattle holding, households with large herds selling significantly higher ($P < 0.05$) number than those with small herds (Table 5.3).

Table 5. 3: Cattle off-take for fattening from different categories of pastoral households in Tana River and Narok counties of Kenya

Household herd size	Cattle off-take for fattening (Mean ± S.E household^{-1})			
	Tana River		Narok	
	Number sold	% of the household cattle holding	Number sold	% of the household cattle holding
1-9	0.4 ± 0.2^{b} (36)	9.5 ± 2.7^{a}	0.0 ± 0.0^{c} (7)	0.0 ± 0.0^{c}
10-19	0.5 ± 0.3^{b} (22)	4.1 ± 3.5^{b}	0.9 ± 0.5^{b} (18)	6.1 ± 1.5^{a}
20-39	0.6 ± 0.4^{b} (14)	2.4 ± 4.3^{c}	1.3 ± 0.4^{b} (20)	4.5 ± 1.4^{b}
> 40	2.2 ± 0.4^{a} (14)	2.5 ± 4.3^{c}	3.4 ± 0.4^{a} (24)	5.8 ± 1.3^{b}

Mean values in the same column with the same superscripts were not significantly different at $P < 0.05$. Figures in parentheses under the sub-heading "Tana River" or "Narok" indicate the number of sample households for the corresponding household cattle holding category.

The sales were made mainly to pay school fees, buy basic essentials (food, clothes and household items) but barely for making business investments, or for meeting social and religious obligations (Figure 5.3).

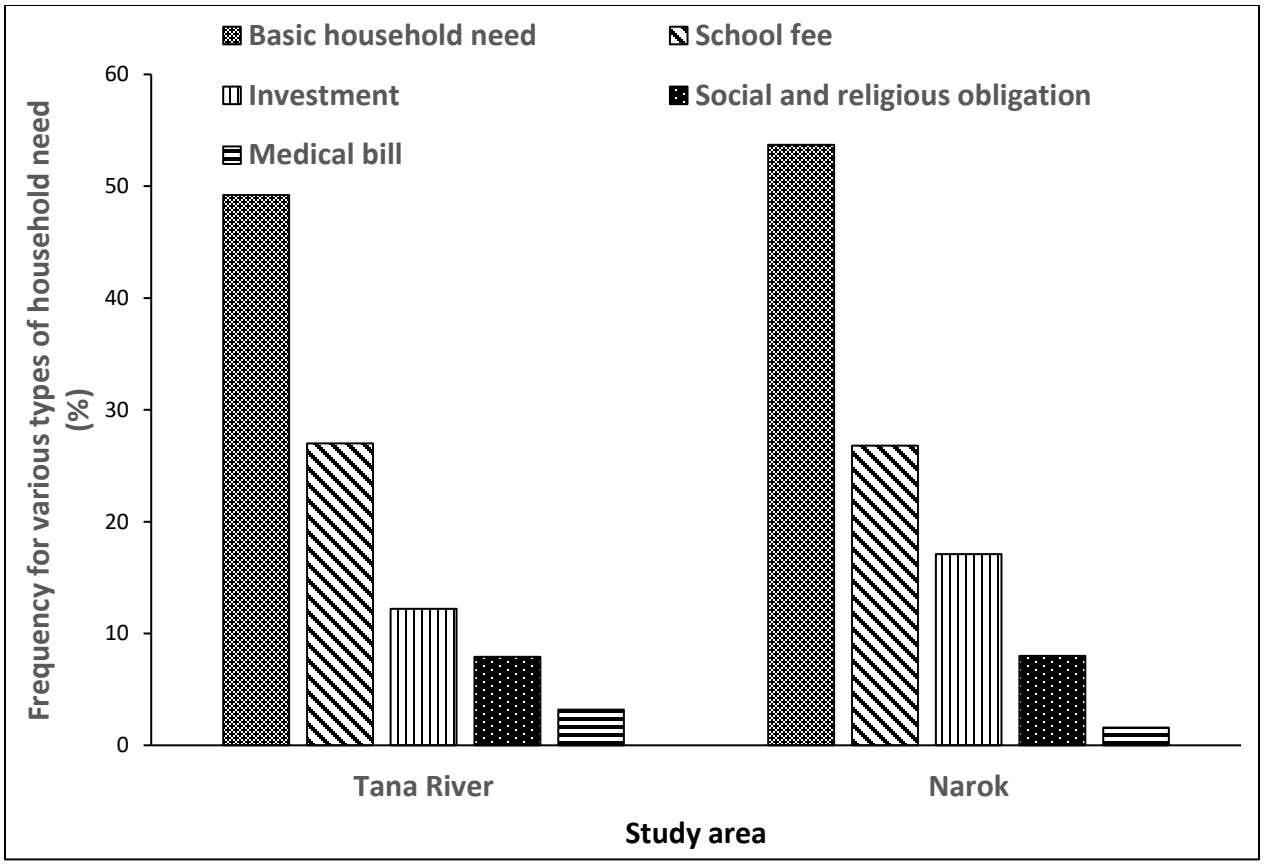


Figure 5. 3: Types of household needs covered by selling cattle through stratified cattle production systems in Tana River and Narok counties

Interviews with the traders and pastoralists revealed that the orders to supply cattle for fattening were normally received when there was adequate pasture in the fattening areas, while at the same time, there was an availability of lean animals in the pastoral production areas. Due to these conditions, the buyers kept shifting their choice of supply areas depending on the availability of lean animals, thereby making the supply orders sporadic. To comply with the unpredictable supply orders, the pastoralists kept "emergency animals" in the home-based herds for sale whenever the demand arose. By doing this, they managed to make substantial sales even during the dry season when most of the animals migrated to distant grazing areas (Table 5.4).

Traditionally, only the milking cows and immature animals were kept as the home-based herds and therefore, the only animals available for sale during the dry season.

Table 5. 4: Cattle off-take for fattening during various seasons in Tana River and Narok counties, Kenya

Season	Cattle off-take for fattening (Mean ± S.E household^{-1})			
	Tana River (n = 86)		Narok (n = 69)	
	Number sold	% of the annual off-take	Number sold	% of the annual off-take
Short-rains season (October–December 2015)	0.2 ± 0.1^{a}	11.2 ± 2.4^{a}	0.2 ± 0.1^{b}	3.7 ± 2.1^{c}
Dry-season (January–February 2016)	0.2 ± 0.1^{a}	6.5 ± 2.4^{b}	1.0 ± 0.1^{b}	13.3 ± 9.0^{a}
Long-rains season (March–May 2016)	0.2 ± 0.1^{a}	6.2 ± 2.4^{b}	0.4 ± 0.1^{a}	8.9 ± 2.1^{b}
Cold-season (June–September 2016)	0.16 ± 0.1^{a}	5.6 ± 2.4^{b}	0.2 ± 0.1^{b}	2.4 ± 2.1^{c}

Mean values in the same column with the same superscripts were not significantly different at $P < 0.05$.

Due to fear of theft (involved in carrying cash to primary or bush markets), the buyers preferred purchasing animals from secondary markets or near urban centres. Additionally, the buyers also saved a considerable proportion of the transport cost when the animals were purchased in secondary markets or near urban centres. Therefore, they either purchased from secondary markets or used sale agents who would source animals from pastoralists and bring them to specific convenient locations. In responding to this requirement of selling in secondary markets, the pastoralists jointly trekked or pay market intermediaries to trek the animals to markets. If the animals failed to fetch expected prices at the secondary markets, they arranged with clan members who reside around the markets to keep the animals until the next market day or up to the time when the prices become favourable. The clan members usually keep the animals for free but sometimes given a small financial appreciation when the animals are sold. In a situation where no clan

members reside around the markets, an arrangement was made with market intermediaries to keep the animals (at a fee) until the owner is ready to sell. In Tana River, the market intermediaries charged USD 1.0 per animal per day for the management of the animals (herding, watering, and housing) until the owners sell them.

It was also reported that the buyers usually purchase cattle through trusted sale agents who can be contacted in case a dispute over the ownership of the animals arise. The sale agents also help the buyers in sourcing the required number of animals from pastoralists and assist in making a price deal. Considering the role played by the sale agents in facilitating sales, the pastoralists were required to sell cattle for fattening through an agent. To comply with this requirement, the pastoralists created trust and social relations with sale agents. They reported that they could even deliver animals to an agent without demanding immediate payment and could wait for several months for the agent to pay them. However, such an arrangement was based on previous interactions with the sale agent in livestock marketing and therefore, the pastoralists choose to work only with honest agents. The following quote portrayed how the pastoralists created trust and relation with sale agents to sell cattle for fattening:

> *"Buyers sometimes fear carrying large sums of money to the markets and they prefer to pay using cheques. They pay the sellers through brokers who are given cheques long after the animals are sold. We sometimes receive cash from the brokers one month after the animals have been sold. There are honest and trustworthy brokers who don't take the sellers dues. They are known based on the earlier experiences in facilitating livestock sales"* (R01)[2].

[2]Respondent number 01.

5.5.1 Emerging animal management practices under stratified cattle production systems

The practices for producing animals demanded under the SCP systems are summarized in Table 5.5.

Table 5. 5: Emerging management practices among pastoralists in Kenya's drylands for producing animals required for the stratified cattle production systems

Type of cattle demanded	Emerging practice among the pastoralists
Bulls (or steers castrated at the age of about 3 years)	• Changing from keeping a few breeding bulls to keeping several commercial bulls. • Late castration of bulls.
Cattle of Borana, Sahiwal, or any other breed with good body conformation for fattening	• Changing from keeping small East Africa Zebu (SEZ) to rearing crosses (SEZ-Borana, SEZ-Sahiwal, or SEZ-Orma)
Cattle in 3-4 age category	• Changing from solely keeping breeding herds to rearing additional herds of young bulls of 1-2 years old, which are purchased from other pastoralists and reared until they are 3-4 years in anticipation for the market demand.

The various practices adopted by pastoralists were informed or motivated by the market requirements or "by the type of animals demanded by the market under the SCP systems. The practices emerged in response to the market demand for a certain type of animals to be fattened under the SCP systems. Bulls or steers were mostly preferred for the SCP systems, mainly because of their better weight performance compared to other cattle classes. The weight gain for steers castrated at the age of about 3 years was indicated to be higher than those castrated at a younger age−although the latter were said to have tender meat with more fat content.

"*Cattle castrated at a tender age (2-3 months) and those castrated at the age of 3 years could have a weight difference of about 50kg at the end of the fattening period even if they had similar body weight prior to fattening"(*R09)[3].

It was also reported that castrates of the Sahiwal breed were said to gain weight faster than bulls of the same breed, whereas bulls of the Borana breed were reported to have faster weight gain than their counterpart castrates. Cows were also demanded for fattening but should have a good body conformation in terms of long legs, and a long and wide rump. To meet such market demands and specifications, the pastoralists changed some of their cattle husbandry practices. For example, in the past, every male cattle that was not required for breeding was castrated by removing testicles (or by making injuries to the testicles' blood vessels) at the age of 1-2 years. As a way to capture the market demand, the pastoralists were keeping commercial bulls or castrating male animals at an older age (3-4 years) as depicted in the quote below:

"Nowadays we wait until they are about to breed and then castrate them using a burdizzo. Alternatively, we practice some breeding control measures such as isolation of bulls from the herds at night by keeping them in separate enclosures" (R03)[4].

In adopting the new animal husbandry practices, the pastoralists managed to sell mostly bulls, and steers for fattening (Figure 5.4).

[3]Respondent number 09.
[4]Respondent number 03.

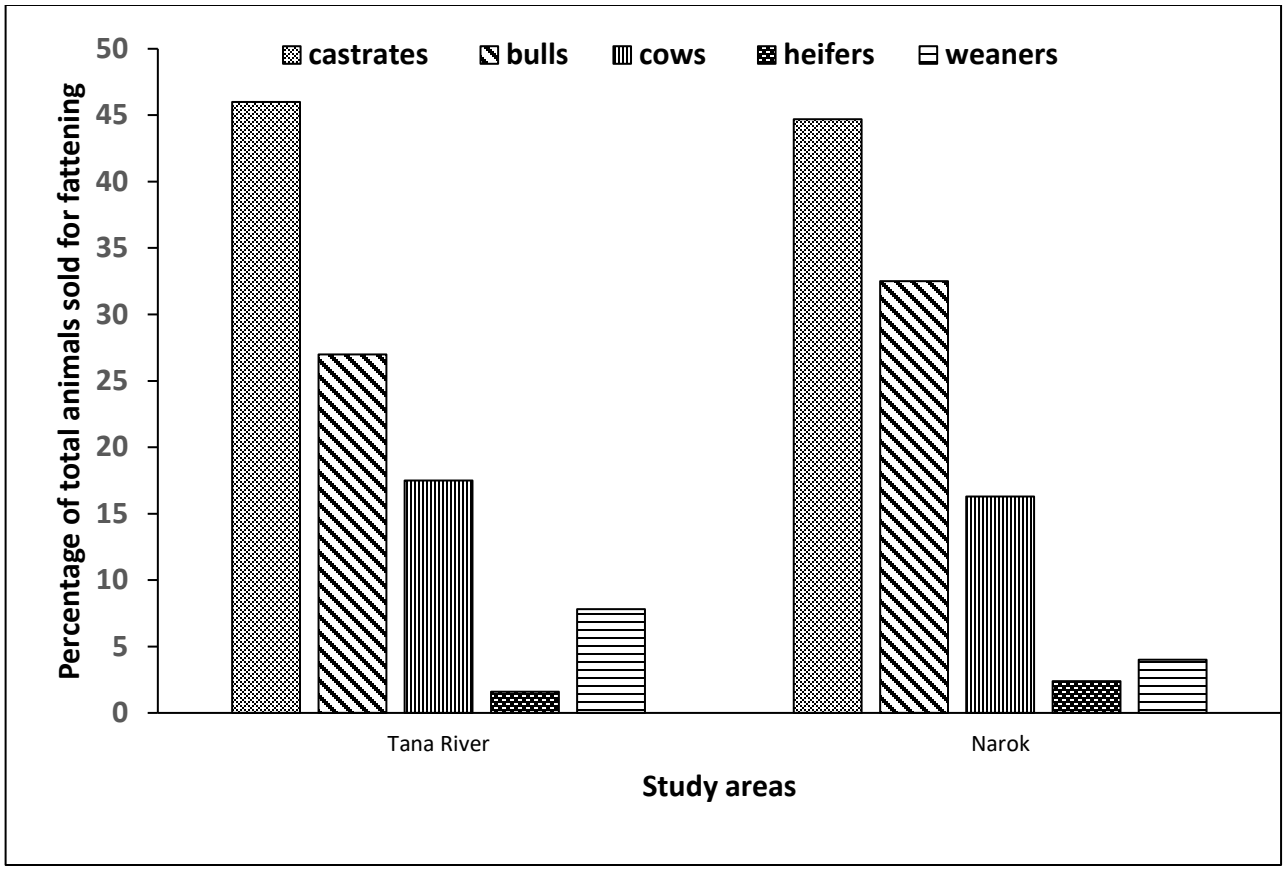


Figure 5. 4: Classes of cattle sold for fattening by interviewed households from October 2015 to September 2016 in Tana River and Narok counties

Cattle of Boran or Sahiwal breed was reported to add weight faster and provide better financial returns than the local zebu and thus, mostly demanded for fattening. In quest for better returns pastoralists in both counties were reported to be upgrading their herds by cross-breeding the zebu with Borana and Sahiwal breeds. In Narok, they were shifting from keeping small East African Zebu (SEZ) to SEZ-Borana crosses or SEZ-Sahiwal crosses. The rearing of the crosses was suggested useful in balancing pasture availability with the market demand as they take less feeds compared to improved pure breeds and have better market demand than the SEZ. In Tana River, the change of breed in response to the market demand was not reported, but a shift from rearing the traditional Orma breed to crosses of Orma and Abdalla breeds was reported, and attributed to

the dwindling pasture condition−crosses of Orma and Abdalla breeds have small body size and can survive on limited pastures. The quote below depicts the pastoralists' strategy to balance the market demand with the declining pastures in Tana River:

> *"Cattle of Orma breed are the most preferred for fattening. They are similar to Borana breed. But our people are crossing Orma with Abdalla which is found around Ijara and southern part of Garissa. Cattle of Abdalla breed are smaller in size and crosses with Orma are hardy and can survive on limited pasture"* (R04)[5].

It was also reported that animals for fattening should be matures of moderate age since young or old animals were reported to take long to fatten and thus have high production costs. Three to four years old steers and bulls, and , cows in three to four lactations were preferred. To ascertain suitability of animals for fattening, buyers normally inspect them to confirm the age and any other abnormality:

> "*The buyers sometimes check the completeness of the dental formula to ascertain the age of the animals and the ones with broken teeth were assumed to be old and therefore, rarely bought for fattening"* (R21)[6].

As a response to the demand for the medium aged animals, pastoralists in Tana River purchased bulls or steers of about 1-2 years from other pastoralists and kept them in the communal grazing areas until the animals reached 3-4 years. The animals were then sold to those who fatten them in other areas with adequate grazing resources. However, the pastoralists also indicated that despite the good profit and the convenience of fattening young bulls in the communal lands, the business has declined. This was attributed to continuous loss and deterioration of grazing resources in the

[5]Respondent number 04.
[6]Respondent number 21.

communal lands, which was associated with increasing conversion of the *Omara* areas (the warm upland areas) into private ranches and encroachment of *Prosopis juliflora* into the *Chaffa* areas (the floodplains of Tana River). Due to the pasture shortage attributed to these factors, it was reported that animal growth performance has reduced in recent times. The respondents indicated that bulls of 3-4 years now look as if they are merely 1-2 years old. In Narok County, since most of the communal grazing lands were already subdivided, the business of fattening young bulls was not reported. Nonetheless, the pastoralists reported that they sell cattle at their moderate age as demanded by the buyers. To ensure this happens, the pastoralists constantly monitored calving cycles or the number of rings on an animal's horns as several rings indicate old age. The more the rings, the older the animal, and for a female animal, the number of rings on the horns corresponds to the number of calving cycles. In addition to the moderate age, animals demanded for the buyers should also be of a fair body condition. The buyers explained that to fatten animals of fair body condition, it takes one rainy season when the available pastures are adequate, but they take at least two rainy seasons to fatten those of a poor body condition with the same amount of pastures. The pastoralists responded to the demand for animals of fair body condition as shown in the following quote:

> *"In the past, people would wait until the animals die and then regret later. But now people are changing that mentality, they sell animals while they are still in fair body condition"* (R17)[7].

[7]Respondent number 17.

5.5 Discussion

This study revealed how pastoralists in Kenya's drylands changed some of their cattle production and marketing practices for integration and participation in the SCP systems. Two categories of management changes were observed−those for increasing cattle off-take rates and those for producing animals demanded for the SCP systems. The changes for increasing the off-take rates included keeping 'emergency' animals in the home-based herds, arrangements for accessing secondary markets, building buyer-seller trust, and selling 'special' animals when the demand arose. These changes were intended to circumvent cattle marketing challenges such as unpredictable demand and supply orders, limited market access, and weak connection between actors in pastoral livestock value chains. Owing to these challenges, livestock traders often experience difficulties to source pastoral animals from Kenya's drylands (Mahmoud, 2008). This might have prompted the buyers under the SCP systems to set supply requirements for pastoralists to shift the terms of trade in their favor and thus evade the challenges in sourcing animals. However, the observed changes in management practices for supply cattle under the SCP systems, imply that pastoralists can invent innovative ideas for connecting with traders by coping with challenges in a pastoral livestock supply chain. Other studies have also observed that pastoralists can adapt to market risks and poor conditions of trade (Bailey et al., 1999; Tessema et al., 2013) as well as to adverse socio-economic and ecological changes (Homann et al., 2008; Galvin, 2009; Moritz et al., 2009).

The study further showed that pastoralists in Kenya's drylands changed some of their management practices to market cattle of the desired classes, breeds, and sell at their appropriate age and in required body condition. This evidenced that pastoralists align their practices to market demands and opportunities, contrarily to the incorrect perception that they are resistant and lack

marketing prospects. The findings corroborate those of previous studies (Galaty, 2008; Mahmoud, 2013; Little et al., 2014), in which pastoralists were found responsive to price incentives and balance the strategies for improved production and the need to capture market opportunities. In the urban towns of Mali, Gautier et al. (2016) also found that pastoralists responded to the increased demand for quality animals by investing in cattle fattening and seeking direct communication linkages with livestock traders in terminal markets. Moreover, Amano (1995) also observed an increasing commercial off-take rate of young cattle at the beginning of the dry season in West Africa and attributed it to environmental changes and market opportunities.

The study also revealed that pastoralists in Tana River and Narok counties sold 10-15% of their household cattle holdings annually, which translates into about 2-4 animals per household. The sales for fattening formed about 28% of the households' average annual off-take rate but they varied with seasons. Pastoralists are usually prompted to sell more animals for fear of drought-related losses if the livestock condition was poor during a particular season, and adequate rains are not expected in the subsequent seasons (McPeak, 2004). This livestock marketing strategy among pastoralists may have caused the sales variation with seasons. The sales for fattening also varied with the size of household cattle holding. The households owning large (> 40) cattle herds sold a significantly higher number of cattle for fattening than those with smaller herds (1-20) ($P < 0.05$). This suggests that households with large herds may have the capacity to meet the market requirements and cope with risks than their counterparts with small herds. Additionally, households with large herds might have a wide range of choices when making decisions on which animals to sell and therefore, they can sell a larger number of cattle of the desired attributes as opposed to those households with small herds who have limited choice when deciding which animals to sell.

This study's findings also indicate that the revenues from the cattle sold for fattening were mainly used to meet the basic household needs (food, clothes, and household items) and to pay school fees but seldom used for making investments. This shows that there were limited alternative investment options that can provide better economic returns than livestock production in both counties and thus, the animals were sold mainly to meet immediate household expenditure needs rather than to make investments. Previous studies have also indicated that pastoral livestock production is the most economically attractive form of investment in drylands (Dercon and Krishnan, 1996; Behnke and Kerven, 2013), and that pastoralists rarely engage in other alternative economic ventures (Little et al., 2001).

5.6 Conclusions

In response to market requirements under SCP systems, pastoralists in Kenya's drylands are adjusting some of their production and marketing strategies to produce the required type of animals and fulfil other market conditions. Through the adjustments, they can sell a substantial proportion of their household cattle holdings. This study's findings imply that pastoralists are responsive to the market economy, and therefore, their production and marketing practices can be improved for enhance commercial livestock off-take.

CHAPTER SIX

6.0 GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

6.1 Discussion

The high and widespread drought-related livestock mortalities in pastoral areas might be avoided if pastoralists have sustainable market outlets for drought-stricken animals. In this regard, this thesis analysed SLP as an option for providing a reliable marketing channel for pastoralists in Kenya's drylands. The first part of the analysis focused on identifying existing forms of SCP as well as characterising their management practices. This part of the analysis showed that various forms of SCP, which are run by different practitioners, exist in Kenya's drylands (Chapter 3). Unlike the previous form of SCP in Kenya that was initiated and supported by the government in 1960s (Raikes, 1981), the forms identified and described in this thesis are mainly driven by socio-economic and ecological factors. These factors include increasing demand for quality meat in the country's terminal markets, which are not sufficiently met by pastoralists given the high variability of grazing resources that make pastoral animals fall short of the market requirements. In this context, the various forms of SCP in Kenya's drylands have relevance to the cattle fattening entrepreneurs who intend to supply the country's terminal livestock markets, as well as to the producers who are struggling to find markets for their drought-stricken animals. However, the identified SCP systems are faced with diverse socio-economic challenges, including poor marketing infrastructure and limited availability of feeds and other production inputs.

The second part of the thesis focused on the potential of the SCP systems in improving live-weights of pastoral cattle and the profits accruing to cattle fattening entrepreneurs. To enable this analysis, the data on purchase and fattening costs, revenues, and weights of the animals at the time of purchase and at sale were collected over the years from Laikipia, Taita Taveta, and Narok

counties. Considering that drylands have spatio-temporal variability of grazing resources (Anav et al. 2015), the collection of spatial and time-series data was necessary for a holistic understanding of the potential of the SCP systems. The results show that pastoral animals gain substantial weight following fattening under different forms of SCP, and therefore, making it a profitable venture to the fattening entrepreneurs (Chapter 4). However, the weight gains and net revenues significantly varied within and across the three forms of SCP, which is attributable to the spatio-temporal variation of grazing resources as well to the disparities among the practitioners in resource endowment for livestock production. Owing to the unreliable data on the clear genetic make-up of the fattened animals, the effect of breed on the animal weight gain was not investigated, and therefore, the best performing breed in terms of weight gain and profitability to the practitioners under the SCP systems could not be ascertained. Moreover, the net revenues reported under different forms of SCP should be considered as gross since they were not inclusive of the fixed costs.

The performance of SCP systems is dependent on a regular and sufficient supply of cattle for fattening (Desta et al. 2006). To understand supply of animals to terminal markets from pastoral areas, it is crucial to gather information regarding pastoralist livestock marketing practices and market participation (Ng'eno et al., 2010). In view of this, the thesis investigated the market requirements under SCP systems and pastoralists' strategies and practices for fulfilling them. The results showed that the pastoralists are embracing the various forms of SCP as livestock marketing channels by adjusting their production and marketing practices to respond to arrays of requirements by the cattle fattening entrepreneurs (Chapter 5).

6.2 Conclusions

The results of this study reveal various forms of SCP in Kenya's drylands, which are practised by ranchers, traders, and agro-pastoralists. These models of SCP differ with respect to access of grazing resources, sizes of herds kept, and the length of fattening period. In addition, the findings show that SCP adds value to pastoral cattle upon fattening, in terms of weight gain that translates to better returns for the practitioners. This study has also shown that pastoralists are responsive to market demands and opportunities as evidenced by the shifts in their husbandry and marketing practices in response to the prevailing market requirements. The findings from the study imply that existing forms of SCP have the potential as marketing channels to commercially off-take pastoral cattle from Kenya's drylands.

6.3 Recommendations

The national and county governments should consider reducing purchasing and marketing costs to promote pastoralists' participation in the market economy through the SCP systems. Such interventions could make the SCP systems more attractive for investors, enhance pastoral cattle off-take and eventually improve returns for all actors. The governments or other stakeholders should also consider to formalize existing ranch lease arrangements and promote optimal use of the otherwise understocked ranches for the mutual benefit of both the leasee and lessor. This is particularly important for traders who were had depending on nonbinding ranch lease arrangements to access grazing and water resources.

To fill research gaps that were not addressed in this study, further studies are recommended, particularly those that use researcher-managed experiments to reveal, among others, the performance of animals in terms of weight gain and profitability disaggregated by the animal genetic variations, age, sex, and body condition prior to fattening.

REFERENCES

Abebe, D., Cullis A., Catley, A., Aklilu, Y., Mekonnen, G., Ghebrechirstos, Y., 2008. Impact of a Commercial Destocking Relief Intervention in Moyale District, southern Ethiopia. Disasters 32 (2), 167–89.

Abebe, D., Catley, A., 2013. Participatory impact assessment in drought policy contexts: lessons from southern Ethiopia. In: Hollands, J., Dunsmore, B. (Eds.), Who Counts? The power of participatory Statistics. Practical Action, Rugby.

AfDB-African Development Bank, 2010. Regional study on sustainable livestock development in the Greater Horn of Africa. Main Synthesis Report (Volume 1). Available at: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Final_Synthesis_Report_AfDB_Regional_Livestock_Study_20_January_2010%5B1%5D.pdf (accessed September 26, 2018).

African Union, 2010. Policy framework for pastoralism in Africa: Securing, protecting and improving the lives, livelihoods and rights of pastoralist communities. Department of Rural Economy and Agriculture, African Union, Addis Ababa, Ethiopia. Available at: http://www.achpr.org/files/instruments/policy-framework (accessed April 20, 2017).

Aklilu, Y., Irungu, P., Alemayehu, R., 2002. An audit of the livestock marketing status in Kenya, Ethiopia and Sudan (Volume 1). Community-Based Animal Health and Participatory Epidemiology Unit, Pan African Programme for the Control of Epizootics, Organization of African Unity/Interafrica Bureau for Animal Resources, Nairobi, Kenya. Available at:

http://www.eldis.org/vfile/upload/1/document/0708/DOC11334.pdf (accessed October 10, 2017).

Aklilu, Y., Wekesa, M., 2002. Drought, Livestock and Livelihoods: Lessons from the 1999-2001 Emergency Response in the Pastoral Sector in Kenya. HPN Network Paper 40, Overseas Development Institute, London.

Aklilu, Y., 2008. Livestock Marketing in Kenya and Ethiopia : A Review of Policies and Practice. Feinstein International Centre, Addis Ababa, Ethiopia. Available at: http://www.fao.org/fileadmin/user_upload/drought/docs/Livestock%20Marketing%20in%20Kenya%20and%20Ethiopia%20-%20Aklilu%202008.pdf (accessed November 20, 2017).

Aklilu, Y., Little, P.D., Mahmoud, H., McPeak, J., 2013. Market access and trade issues affecting the drylands in the Horn of Africa. Brief prepared by the Technical Consortium, a project of the Consulting Group on International Agricultural Research, at the ILRI. Brief No. 2. Available at: http://technicalconsortium.org/wp-content/uploads/2014/05/Brief-2-Market-access-and-trade-issues.pdf (accessed November 25, 2019).

Alarcon, P., Fevre, E., E.M., Murungi, M.K., Muinde, P., Akoko, J., Dominguez-Salas, P., Kiambi, S., Ahmed, S., Hasler, B., Rushton, J., 2017. Mapping of beef, sheep and goat food systems in Nairobi−A framework for policy making and the identification of structural vulnerabilities and deficiencies. Agricultural Systems 152, 1−7.

Ahmed, A.G., Azeze, A., Babiker, M., Tseganye, D. 2002. Post-drought recovery strategies among the pastoral households in the Horn of Africa. A review. Organisation for Social Sciences Research in Eastern and Southern Africa. Development Research Report Series No. 3.

Amano, K., 1995. Dynamics of Herd Structures and Herding Strategies in West Africa. A study of market integration and ecological adaptation. Africa 65(3), 351–594.

Anav, A., Friedlingstein, P., Beer, C., Cias, P., Harper, A., Jones, C., Sitch, S., Viovy, N., Wiltshire, A., Zhao, M., 2015. Spatiotemporal patterns of terrestrial gross primary production: A review. Review of Geophysics 53, 785–818.

Anderson, D., 2010. Kenya's cattle trade and the economies of empire, 1918-1948. In: Brown, K., Gilfoyle, D., (Eds.), Healing the Herds: Disease, livestock economies and the globalization of veterinary medicine. Ohio University Press, Athens.

Angassa, A., Oba, G., 2007. Relating long-term rainfall variability to cattle population dynamics in communal rangelands and a government ranch in southern Ethiopia. Agricultural Systems 94, 715–725.

Aregheore, E.M., 2009. The effect of supplements of crop residues based diets on the performance of steers grazed on natural pasture during the dry season. African Journal of Range & Forage Science 18(1), 25–29.

Asizua, D., Mpairwe, D., Kabi, F., Mutetikka, D., Madsen, J., 2009. Growth and slaughter characteristics of Ankole cattle and its Boran and Friesian crossbreeds. South African Journal of Animal Science 39, 81–85.

AU-IBAR and NEPDP- African Union Inter-African Bureau for Animal Resources and North Eastern Pastoral Development Program, 2006. Kenya livestock sector study: An analysis of pastoralist livestock products market value chains and potential external markets for live animals and meat. AU-IBAR and NEPDP, Nairobi, Kenya. Available at: http://pdf.usaid.gov/pdf_docs/pnady825.pdf (accessed April 20, 2017).

Ayantunde, A., Kango, M., Hiernaux, P., Udo, H.M.J., Tabo, R., 2007. Herders' perceptions on ruminant livestock breeds and breeding management in south western Niger. Human Ecology 35, 139–149.

Ayele, G., Jabbar, M., Teklewold, H., Mulugeta, E., Kebede, G., 2006. Seasonal and inter-market differences in prices of small ruminants in Ethiopia. Journal of Food Products Marketing 12 (4), 59–77.

Ba, A., Lesnoff, M., 2011. Demographic dynamics and off-take of cattle herds in southern Mali. Tropical Animal Health and Production 43, 1101–1109.

Bailey, D., Barrett, C.B., Little, P.D., Chabari, F., 1999. Markets and risk management among East African pastoralists: A review and research agenda. CRSP Project Technical Report (no. 03/99). Utah State University, Logan.

Barrett, C., 2001. Livestock pricing and markets performance. Research Brief 01-05-PARIMA. Global Livestock Collaborative Research Support Program (GL-CRSP), University of California, Davis.

Barrett, C.B., Chabari, F., Bailey, D., Little, P.D., Coppock, D.L., 2003. Livestock Pricing in the Northern Kenyan Rangelands. Journal of African Economies 12 (2), 127–55.

Bartholomew, P.T.K., Little. D., Ba. S., 1993. Effect of change in body weight and condition during dry season on capacity for work of draft Oxen. Tropical Animal Health and Production 25, 50–58.

Behnke, R., 2010. The contribution of livestock to the economies of IGAD Member States. IGAD Working Paper No. 02-10. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/24968/IGAD_LPI_WP_02-10.pdf?sequence=1 (accessed November 11, 2019).

Behnke, R., Muthami, D., 2011. The contribution of livestock to the Kenyan economy. Policy Brief Series. IGAD Center for Pastoral Areas and Livestock Development. Available at: https://igad.int/attachments/714_The%20Contribution%20of%20Livestock%20to%20the%20Kenyan%20Economy.pdf (accessed September 26, 2019).

Behnke, R., Kerven, C., 2013. Counting the costs: Replacing pastoralism with irrigated agriculture in the Awash Valley, northern-eastern Ethiopia. IIED Climate Change Working Paper No. 4. Available at: http://pubs.iied.org/pdfs/10035IIED.pdf (accessed October 25, 2017).

Bekele, G., Abera, T., 2008. Livelihoods-based drought response in Ethiopia: Impact assessment of livestock feed supplementation. Pastoralist Livelihoods Initiative Program, Ethiopia. Available at: https://www.alnap.org/system/files/content/resource/files/main/bekele-and-tsehay-pia-aug-082.pdf (accessed September 25, 2018).

Belasco, E.J., Taylor, M.R., Goodwin, B.K., Schroeder, T.C., 2009. Probabilistic models of yield, price, and revenue risks for fed cattle production. Journal of Agricultural and Applied Economics 41 (1), 91–105.

Bell, C. and Prammer J., 2012. Linking livestock markets to wildlife conservation. In: C. Eder, D. Kyd-Rebenburg, J, Prammer (Eds.), Global growing casebook insights into African Agriculture. Available at: http://global-growing.org/sites/default/files/GGC_Lewa.pdf (accessed November 16, 2017).

Bergevoet, R., Engelen. A., 2014. The Kenyan meat sector opportunity for Dutch agribusiness. LEI Wageningen UR, Wageningen. Available at: http://library.wur.nl/WebQuery/wurpubs/fulltext/370228 (accessed September 25, 2018).

Blanco, M., Joy, M., Ripoll, G., Sauerwein, H., Casasús, I., 2011. Grazing Lucerne as fattening management for young bulls: technical and economic performance and diet authentication. Animal 5(1), 113–22.

Campbell, B., Gordon, I., Luckert, M., Petheram, L., Vetter, S., 2006. In search of optimal stocking regimes in semi-arid grazing lands: One size does not fit all. Ecological Economics 60, 75–85.

Catley, A., Admassu, B., Bekele, G., Abebe, D., 2014. Livestock mortality in pastoral herds in Ethiopia and implications for drought response. Disasters 38(3), 500−516.

Catley, A., Lind, J., Scoones, I., 2016. The future of pastoralism in the Horn of Africa: pathways of growth and change. Revue Scientifique et Technique (International office of Epizootics) 35 (2), 389–403.

Chantylew, D, Belete, A., 1997. A statistical analysis of demands for beef, mutton/goat, pork and Chicken in Kenya, 1961-1991, Agricultural Economics Research. Policy and Practice in Southern Africa 36 (1), 1–11.

Chulayo, A.Y., Tada, O., Muchenje, V., 2012. Research on pre-slaughter stress and meat quality: A review of challenges faced under practical conditions. Applied Animal Husbandry and Rural Development 5, 1–6.

Choc, C., Neelin, J., Chen, C., Tu, J., 2009. Evaluating the 'richer-get-richer' mechanism in tropical precipitation change under global warming. Journal of Climatology 22, 1982−2005.

Conelly, W.T., 1998. Colonial era livestock development policy: Introduction of improved dairy in high-potential farming areas of Kenya. World Development 26, 1733–1748.

Creek, M.J., 1973. UNDP/FAO Feedlot Project in Kenya. Selected articles from the 3rd World Conference on animal production. Available at: http://www.fao.org/docrep/004/X6500E/X6500E18.htm#ref181 (accessed November 2, 2017).

Dabasso, B., Okoti, M., 2015. Changing pattern of local rainfall: Analysis of 50-year record in Marsabit central. Weather 7 (10).

Dabasso, B., Wasonga, O., Irungu, P., Kaufmann, B. 2018. Stratified cattle production in pastoral areas of Kenya: Existing forms, driving factors and management practices. Applied Animal Husbandry and Rural Development 11 (1), 22–33.

Dabasso, B., Wasonga, O., Irungu, P., Kaufmann, B., 2019. Stratified livestock production adds value to pastoral cattle: evidence from the drylands of Kenya. Bulletin of Animal production and Health 67 (1), 109−121

Dai, A., 2011. Drought under global warming. A review. WIRES Climate Change 2, 45−65.

Dai, A., 2013. Increasing drought under global warming in observations and models. Nature Climate Change 3, 52−58.

Davies, J., Hatfield, R., 2007. The economics of mobile pastoralism: A global summary. Nomadic Peoples 11, 91–116.

Delgado, C.L., 2003. Rising consumption of meat and milk in developing countries has created a new food revolution. Journal of Nutrition 133 (11 Suppl. 2), 3907S–3910S.

Dercon, S., Krishnan, P., 1996. Income portfolios in rural Ethiopia and Tanzania: Choices and constraints. Journal of Development Studies 32 (6), 850–875.

Desta, S., Coppock, D.L., 2002. Cattle population dynamics in southern Ethiopian Rangelands, 1980-97. Journal of Range Management 55(5), 439–451.

Desta, S., Gebru, G., Tezera, S., Coppock, D.L., 2006. Linking pastoralists and exporters in livestock marketing chain: Recent experiences from Ethiopia, In: McPeak, J.S, Little, PD (Eds.), Pastoral Livestock Marketing in Eastern Africa, Research and Policy Challenges. Intermediate Technology Publications Limited, Warwickshire.

Dioli, M., 2018. Nomad aesthetic: Cattle modifications among the northern Turkana of northwest Kenya. Pastoralism: Research, Policy and Practice 8:6.

Dunn, B.H., Smart, A.J., Gates, R.N., Johnson, P.S., Beutler, M.K., Diersen, M.A., Janssen, L.L., 2010. Long-term production and profitability from grazing cattle in the Northern Mixed Grass Prairie. Rangeland Ecology & Management, 63 (2), 233–42.

Egeru, A., Wasonga O., Kyagulanyi, J., Mwanjalolo, M., MacOpiyo, L., Mburu, J., 2014. Spatial-temporal dynamics of forage and land cover changes in Karamoja sub-region, Uganda. Pastoralism: Research, Policy and Practice, 4 (6).

Engelen, A., Malope, P., Keyser, J., Neven, D., 2013. Botswana Agrifood Value Chain Project: Beef value chain study. FAO and the Ministry of Agriculture, Botswana. Available at: http://www.fao.org/3/a-i3158e.pdf (accessed October 21, 2017).

Erb, K., Mayer, A., Kastner, T., Sallet, K., Haberl, H., 2012. The impact of industrial grain fed livestock production on food security: an extended literature review commissioned by Compassion in World Farming. The Tubney Charitable Trust and World Society for the Protection of Animals, United Kingdom. Available at: https://www.ciwf.org.uk/includes/documents/cm_docs/2012/t/the_impact_of_industrial_grain_fed_livestock_production_on_food_security_2012.pdf (accessed June 26, 2018).

Ericksen, P., Leeuw J., Quiros, C., 2010. Livestock drought management. Final Report (no. OSRO/RAF/915/RFF PR 44865). ILRI, Nairobi, Kenya. Available at:

https://cgspace.cgiar.org/bitstream/handle/10568/3331/drought%20ILRI%20final%20report%20_OSRO-RAF-915-RFF_.pdf?sequence=1&isAllowed=y (accessed September 19, 2019).

ESRI-Environmental System Research Institute, 2011. ArcGIS Desktop: Release 10. Redlands. Environmental Systems Research Institute, New York.

Farmer, E., Mbwika, J., 2012. End market analysis of Kenyan livestock & meat: Microreport (no. 184). USAID. Available at: https://www.microlinks.org/sites/microlinks/files/resource/files/Kenya_Livestock_End_Market_Study.pdf (accessed April 20, 2017).

FAO, 2006. Livestock's long shadow. Environmental issues and options. Food and Agriculture Organisation of the United Nations, Rome.

FAO, 2009. The state of food and agriculture 2009−Livestock in the balance. FAO, Rome. Available at: http://www.fao.org/docrep/012/i0680e/i0680e.pdf (accessed June 26, 2019).

Farrington, T., Marsh, D.K.V., Mayers, L., 1988. Winter fattening of beef cattle: From research station trials to implementation by farmers. Agricultural Systems 29, 165–178.

Fatchamps, M., Gavian, S., 1997. The determinants of livestock prices in Niger. Journal of African Economies, 6(2), 255–295.

Fratkin E.A., 2001. East African Pastoralism in transition: Maasai, Boran, and Rendille cases. African Studies Review 44 (3), 1–25.

Fratkin, E., Roth, E., 2005. As pastoralists settle: Social, health, and economic consequences of the pastoral sedentarization in Marsabit District, Kenya. Kluwer Academic Publishers, New York.

Galaty, J., 1994. Ha(1)ving the land in common: The subdivision of Maasai group ranches in Kenya. Nomadic Peoples 34/35, 109–22.

Galaty, J., 2008. Revisiting pastoralism and marketing in East Africa. African Studies Review 51(1), 131–-134.

Galvin, K.A., 2009. Transitions: Pastoralists living with change. Annual Review of Anthropology 38 (1), 185–98.

Garanganga, B.J. 2007. Climate monitoring in the southern Africa development community. In: Sivakumar, V.K, Ndiang'ui (Eds.), Climate and Land Degradation. Springer, New York.

Gautier, D., Locatelli, B., Corniaux, C., Alary, V., 2016. Global changes, livestock and vulnerability: the social construction of markets as an adaptive strategy. The Geographical Journal 182 (2), 153–164.

Goe, M.R., Alldrege, J.R., Light, D., 2001. Use of heart girth to predict body weight of working oxen in the Ethiopian highlands. Livestock Production Science 69, 187–195.

GoK-Government of Kenya, 2007. Kenya Vision 2030: The blueprint for globally competitive and prosperous Kenya. Available at: https://www.researchictafrica.net/countries/kenya/Kenya_Vision_2030_-_2007.pdf (accessed November 6, 2017).

GoK-Government of Kenya, 2008. Session Paper No. 2 of 2008 on National Livestock Policy. Available at: https://www.kenyamarkets.org/wp-content/uploads/2016/06/National-Livestock-Policy-2008.pdf (accessed June 18, 2018).

GoK-Government of Kenya, 2012. Vision 2030 development strategy for northern Kenya and other arid lands. Final Report. Available at: http://www.hsnp.or.ke/index.php/our-work/downloads?download=6:v2030-asal (accessed June 18, 2018).

GoK-Government of Kenya, 2013a. The First Edition of Laikipia County Integrated Development Plan for 2013-2017. Available at: https://laikipia.go.ke/assets/file/Laikipia-CIDP-2013-2017-compressed.pdf (accessed September 12, 2018).

GoK-Government of Kenya, 2013b. The First Edition of Narok County Integrated Development Plan for 2013-2017. Available at: www.narok.go.ke/component/j2store/downloads/getfreefile?pfile_id=990 (accessed September 12, 2018).

GoK-Government of Kenya, 2013c. First edition of Taita Taveta County Integrated Development Plan for 2013-2017. Available at: https://taitataveta.go.ke/sites/default/files/Taita%20Taveta%20CIDP%20as%20at%207th%20August%202014.pdf (accessed September 12, 2018).

GoK−Government of Kenya, 2017. National policy for the sustainable development of northern Kenya and other arid lands. Unlocking our full potential for realization of the Kenya Vision 2030. Sessional Paper No. 8 of 2012. Available at: http://devolutionasals.go.ke/wp-content/uploads/2018/03/ASAL-POLICY-August-2017-.pdf (accessed July 6, 2018).

Goldman, M., Riosmena, F., 2013. Adaptive capacity in Tanzania Maasailand: Changing strategies to cope with drought in fragmented landscapes. Global Environmental Change 23, 588–597.

Greiner, C., 2012. Unexpected consequences: Wildlife conservation and territorial conflict in northern Kenya. Human Ecology 40, 415−425.

Gwelo, A.F., Tefera, S., Muchenje, V., 2015. Temporal and spatial dynamics of mineral levels of forage, soil and cattle blood serum in two semi-arid savannas of South Africa. African Journal of Range & Forage Science 32, 279–287.

Hailemariam, T., Getachew, L., Dawit, A., 2001. Market structure and function for live animal and meat exports in some selected areas of Ethiopia. Research Report (no. 79). Ethiopia Institute for Agriculture Research. Available at: http://agrilife.org/borlaug/files/2012/03/Market-Structure-and-Function-for-Live-Animal-and-Meat-Exports-in-Some-Selected-Areas-of-Ethiopia.pdf (accessed March 2, 2018).

Hall, D.C., Ehui, S., Delgado, C., 2004. Livestock revolution, food safety, and small-scale farmers: Why they matters to us all. Journal of Agriculture and Environmental Ethics 17, 425–444.

Hardin, G., 1968. The tragedy of the commons, Science 162, 1243–1248.

Hary, I., Schwartz, H., King, J., Carles, A., 2003. Effect of controlled seasonal breeding on reproductive performance traits of pastoral goats herds in northern Kenya. Journal of Arid Environments 55, 555–579.

Heath, B., 2001. The feasibility of establishing cow-calf camps on private ranches as a drought mitigation measure. A report for the Natural Resource Institute. StockWatch Ltd. Nairobi, Kenya. Available at: http://nri.org/projects/pastoralism/stockwatch.pdf (accessed April 27, 2017).

Herskovits, M.J., 1926. The cattle complex in East Africa. American Anthropologist 28 (3), 494–528.

Hesse, C., MacGregor, J., 2006. Pastoralism: Drylands' invisible asset? Developing a framework for assessing the value of pastoralism in East African. Issue paper (no. 142). International Institute for Environment and Development. London. Available at: https://pubs.iied.org/pdfs/12534IIED.pdf (accessed September 26, 2019).

Ho, P., 2001. Rangeland degradation in North China revised? A preliminary statistical analysis to validate non-equilibrium ecology. Journal of Development Studies 37, 99–133.

Homann, S., Rischkowsky, B., Steinbach, J., Kirk, M., Mathias, E., 2008. Towards endogenous livestock development: Borana pastoralists' responses to environmental and institutional Changes. Human Ecology 36 (4), 503–20.

Homewood, K., Trench, P., Randall, S., Lynen, G., Bishop, B., 2006. Livestock health and socio-economic impacts of a veterinary intervention in Maasailand: Infection-and-treatment vaccine against East Coast fever. Agricultural Systems 89, 248–271.

Hsieh, H.F., Shannon, S.E., 2005. Three approaches to qualitative content analysis. Qualitative Health Research 15(9), 1277–88.

IBM Corp. SPSS, 2011. IBM SPSS Statistics for Windows (Version 20.0). IBM Corp, Armonk, New York.

Iles, K., 1994. The progeny history data collection technique: A case study from Samburu District. Kenya. Rapid Rural Appraisal Notes 20, 71–77.

Irungu, P., Ithondeka, P., Wafula, E., Wekesa, S., Wesonga, H., Manga, T., 2014. An audit of constraints and opportunities in Kenya's livestock export value chain. Journal of Agricultural Science and Technology B4, 102–120.

Jahnke, H.E., 1982. Livestock production systems and livestock development in tropical Africa. Kieler Wissenschaftsverlag Vauk, Kiel.

Johnson, N.C., Xie, S.P., 2010. Changes in seas surface temperature threshold for tropical convection. Nature Geoscience 3, 842−845.

Jovchelovitch, S., Bauer, M., 2000. Narrative interviewing [online]. LSE Research, London. Available at: http://eprints.lse.ac.uk/2633/1/Narrativeinterviewing.pdf (accessed January 25, 2018).

Kabubo-Mariara, J., 2008. Climate change adaptation and livestock activity choices in Kenya. An economic analysis. Natural Resources Forum 131−141.

Kahi, A.K., Wasike, C.B., Rewe, T.O., 2006. Beef production in the arid and semi-arid lands of Kenya. Constraints and prospects for research and development. Outlook on Agriculture 3, 217–225.

Kanuya, N.L., Matiko M.K., Nkya R., Bittegeko S.B.P., Mgasa M.N., Reksen, O., Ropstad E., 2006. Seasonal changes in nutritional status and reproductive performance of zebu cows kept under a traditional agro-pastoral system in Tanzania. Tropical Animal Health and Production 38, 511–519.

Kenya National Bureau of Statistics, 2020. Kenya economic survey 2020. Available at: https://s3-eu-west-1.amazonaws.com/s3.sourceafrica.net/documents/119905/KNBS-Economic-Survey-2020.pdf (accessed August 25, 2020).

Kerven, C., 1992. Customary commerce: a historical assessment of pastoral livestock marketing in Africa. Overseas Development Institute, London.

Koknaroglu, H., Loy, D.D., Wilson, D.E., Hoffman, M.P., Lawrence J.D., 2005. Factors affecting beef cattle performance and profitability. The Professional Animal Scientist 21, 286–296.

Kosgey, I.S., Mbuku, S.M., Okeyo, A.M., Amimo, J., Philipsson, J., Ojango, J.M., 2011. Institutional and organization framework for dairy and beef cattle recording in Kenya: a review and opportunities for improvement. Animal Genetic Resources 48, 1–11.

Krätli, S., Schareika, N., 2010. Living off uncertainty: The intelligent animal production of dryland pastoralists. European Journal of Development Research 22, 605–622.

Krätli, S., Huelsebush, C., Brooks, S., Kaufmann, B., 2013. Pastoralism: a critical asset for food security under global climate change. Animal Frontiers 3(1), 42–50.

Krejcie, R.V., Morgan, D.W., 1970. Determining sample size for research activities. Educational and Psychological Measurement 30, 607–610.

Kumar, R., Lardner, H.A., McKinnon, J.J., Christensen, D.A., Damira, D., Larson, K., 2012. Comparison of alternative backgrounding systems on beef calf performance, feedlot finishing performance, carcass traits, and system cost of grain. The Professional Animal Scientist 28, 541–551.

Kyeyamwa, H., Speelman, S., Huylenbroeck, G., Opudo-Asibo, J., Verbeke, W., 2008. Raising offtake from cattle grazed on natural rangelands in sub-Saharan Africa: a transaction cost economic approach. Agricultural Economics 39, 63–72.

Lamidi, O.S., Adeyinka, I.A., Alawa, C.B.I., Barje, P.P., Ali-Balogun, R., 2008. Survey dry season feed resources for smallholder fattening schemes in Northern Nigeria. Asian Journal of Animal and Veterinary Advances 3, 92–97.

Lamprey, H.F., 1983. Pastoralism yesterday and today: the overgrazing controversy. In: Bourliere, F (Ed.), Tropical Savannas. Ecosystems of the World. Elsevier, Amsterdam.

Lamprey, R.H., Reid, R.S., 2004. Expansion of human settlement in Kenya's Maasai Mara: What future for pastoralism and wildlife? Journal of Biogeography 31(6), 997–1032.

Lane, C., 2014. Custodians of the commons. Pastoral land tenure in Africa. Routledge, London.

Leloup, S., Mannetje, L., Meurs, C., 1996. Seasonal fodder consumption and live weight changes of sedenatry cattle in southern Mali. Tropical Grasslands 30, 229–36.

Lengoiboni, M., van der Mole, P., Bregt, A.K., 2011. Pastoralism within the cadastral system: Seasonal interactions and access agreements between pastoralists and non-pastoralists in northern Kenya. Journal of Arid Environments 75, 477–486.

Lesosky, M., Dumas, S., Conradie, I., Handel, I., Jennings, A., Thumbi, S., Toye, P., Bronsvoort, B., 2013. A live weight-heart girth relationship for accurate dosing of East African shorthorn zebu cattle. Tropical Animal Health and Production 45, 311–316.

Little, P.D., Smith, K., Cellarius, B.A., Coppock, D.L., Barrett, C.B., 2001. Avoiding disaster: Diversification and risk management among East African herders. Development and Change 32, 401–433.

Little, P.D., 2009. Hidden value on the hoof: Cross-border livestock trade in Eastern Africa. Policy Brief (no. 2). Common Market for Eastern and Southern Africa Comprehensive African Agriculture Development Program. Available at: https://fic.tufts.edu/pacaps-project/Pastoralism%20&%20Policy/COMESA%20CAADP%20Policy%20Brief%202%20Cross%20Border%20Livestock%20Trade.pdf (accessed September 26, 2019).

Little, P.D., Dejene, D., Tiki, W., 2014. How pastoralists perceive and respond to market opportunities: The case of the Horn of Africa. Food Policy 49: 389–97.

Mahmoud, H.A., 2006. Innovations in pastoral livestock marketing: The emergence and the role of Somali cattle traders-cum-ranchers' in Kenya. In: McPeak, J.G., Little, P.D. (Eds.), Pastoral Livestock Marketing: Research and Policy Challenges. Practical Action Publishing, Warwickshire. pp. 129-144.

Mahmoud, H. A., 2008. Risky trade, resilient traders: Trust and livestock marketing in northern Kenya. Africa 78 (4): 561–81.

Mahmoud, H.A., 2013. Pastoralists' innovative responses to new camel export market opportunities on the Kenya/Ethiopia borderlands. In: Catley A, Lind J, Scoones I. (Eds.), Pastoralism and Development in Africa: Dynamic Change at the Margins. Routledge, New York.

Majid, N., 2010. Livestock trade in the Djibouti, Somalia and Ethiopian borderlands. Chatham House Briefing Paper (no. AFP BP 2010/01). Chatham House, London.

Malole, J.L., Kadigi, R.J., Sangeda, A.Z. 2014. Costs and Benefits of Beef Cattle Fattening Schemes in Some Selected Areas of North West Tanzania. Iranian Journal of Applied Animal Science 4 (4), 699–706.

Malope, P., Tsopito, C.M., Aganga, A.A., Madibela, O.R. 2007. Profitability of dry season beef feed-lotting in grain deficit countries: the case of Botswana. Livestock Research for Rural Development 19 (6).

Mason, M., 2010. Sample size and saturation in PhD studies using qualitative interviews. Forum: Qualitative Social Research 11 (3), 8.

Mayring, P., 2014. Qualitative Content Analysis: theoretical foundation, basic procedures and software solution. Klagenfurt. Available at: http://www.psychopen.eu/fileadmin/user_upload/books/mayring/ssoar-2014-mayring-Qualitative_content_analysis_theoretical_foundation.pdf1(accessed April 20, 2017).

McDermott, J.J, Staal, S.J., Freeman, H.A., Herrero, M., van de Steeg, J.A., 2010. Sustaining intensification of smallholder livestock systems in the tropics. Livestock Science 130, 95–109.

McPeak, J., 2004. Contrasting income shocks with asset shocks: livestock sales in northern Kenya. Oxford Economic Papers 56 (2), 263–84.

Miehe, S., Kluge J., Wehrden, H., Retzer, V., 2010. Long-term degradation of Sahelian rangeland by 27 years of field study in Senegal. Journal of Applied Ecology 47, 692–700.

Millar, J., Photakoun, V., 2011. Livestock development and poverty alleviation: revolution or evolution for upland livelihoods in Lao PDR?, International Journal of Agricultural Sustainability 61(1), 89–102.

Mlote, S., Mdoe, N., Lsinika, A., Mtenga, L., 2012. Value addition of beef cattle fattening in the lake zone in Tanzania: challenges and opportunities. Livestock Research for Rural Development 24 (6).

Moritz, M., Kyle, B.R., Nolan, K.C., Patrick, S., Shaffer, M.F., Thampy, G., 2009. Too many people and too few livestock in West Africa? An evaluation of Sandford's Thesis. Journal of Development Studies 45, 1113−1133.

Morton, J. and Barton, D., 2002. Destocking as a drought–mitigation strategy: Clarifying rationales and answering critiques. Disasters 26, (3), 213–28.

Morton, J., Barton, D., Collinson, C., Heath, B., 2005. Comparing drought mitigation interventions in pastoral livestock sector. Natural Resource Institute report. NRI, Greenwich

Mugenda, O., Mugenda, A. 2003. Research methods. Quantitative and qualitative approaches. African Centre for Technology Studies, Nairobi, Kenya

Muhuyi, W.B., 1997. A comparison of the productivity of Kenya Sahiwal cattle and their crossbreds in large dairy-dual purpose and beef Production systems. PhD thesis, University of Nairobi, Kenya.

Muir, J., Alage, A., 2009. Seasonal herbage production from two range types in southern Mozambique. African Journal of Range & Forage Science 18, 37–41.

Muller, B., Schulze, J., Krener, D., Linstadter, A., Frank, K., 2015. How to avoid unsustainable side effects of managing climate risk in drylands−The supplementary feeding controversy. Agricultural Systems 139, 153–165.

Mummed, Y., Webb, E., 2014. Ethiopian beef carcass characteristics. African Journal of Agricultural Research 9 (51), 3766–75.

Muriuki, H.G., 2003. Milk and dairy products, post-harvest losses and food safety in Sub-Saharan Africa and the Near East. A review of the small-scale dairy sector in Kenya for FAO

Prevention of Food Losses Programme. Available at: http://www.fao.org/fileadmin/templates/ags/docs/dairy/P1assessmentkenya.pdf (accessed June 18, 2018).

Musa, A.M., Wasonga, O.A., Mtimet, A., 2020. Factors influencing livestock exports in Somalilands's terminal markets. Pastoralism 10 (1).

Musemwa, L., Mushunje, A., Chimonyo, M., Mapiye, C., 2010. Low cattle market off-take rates in communal production systems of South Africa: Causes and mitigations strategies. Journal of Sustainable Development in Africa (Vol. 12, no. 5).

Mwangi, E., 2005. The transformation of property rights in Kenya's Maasailand: triggers and motivations. CAPRi Working Paper (no. 35). International Food Policy Research Institute, Washington D.C. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.192.143&rep=rep1&type=pdf (accessed September 27, 2019).

Mwangi, E., 2007. Sub-dividing the commons: Distributional conflict in the transitional from collective to individual property rights in Kenya's Maasailand. World Development 35 (5), 815–834.

Negassa, A., Jabbar, M., 2007. Commercial off-take of cattle under smallholder mixed crop-livestock production system in Ethiopia, its determinant and implications for improving live animal supply for export abattoirs. International Conference on Africa Development Archives (Paper No. 129).

Negassa, A., Jabbar, M., 2008. Livestock ownership, commercial off-take rates and their determinants in Ethiopia. Research Report (no. 9). ILRI, Nairobi, Kenya.

Ngethe, J., 1992. Group ranch concept and practice in Kenya with special emphasis on Kajiado District. Proceedings of a workshop on future of livestock industries in East and Southern Africa held in July 1992.

Ng'eno, V., Korir, M.K., Nyangweso, P.M., Kipsat, M.J., Lagat, B.K., 2010. Pastoralists non-responsiveness to livestock markets in East Pokot, Kenya. Poster presented at the Joint 3rd African Association of Agricultural Economists and 48th Agricultural Economists Association of South Africa Conference, held on September 19-23, 2010 in Cape Town, South Africa Available at: http://ageconsearch.umn.edu/record/97090/files/7.%20Pastoralists%20in%20Kenya.pdf (accessed November 23, 2019).

Ngugi, M.K., Conant, R.T., 2008. Ecological and social characterization of key resource areas in Kenyan rangelands. Journal of Arid Environments 72, 820−835

Niamir-Fuller, M., 2005. Managing mobility in African rangelands. In: Collective action and property rights for sustainable rangeland management. CAPRi Research Brief 5–6.

Njogu, J., Dietz, T., 2006. Land use and tenure: entitlement rights for community-based wildlife and forest conservation in Taita Taveta, Kenya. Working Paper No. 542, Institute for Development Studies, University of Nairobi, Kenya.

Nkedianye, D., Leew, J., Ogutu, J., Said, M., Terra, L., 2011. Mobility and livestock mortality in communally used pastoral areas: the impact of 2005-2006 drought on livestock mortality in Maasailand. Pastoralism, Research, Policy and Practice 1(1), 17.

Nori, M., 2006. Mobile livelihoods, patchy resources & shifting rights: approaching pastoral territories. Draft paper for the International Land Coalition. Available at:

http://www.agter.asso.fr/IMG/pdf/08_ILC_mobile_livelihoods_patchy_resources.pdf (accessed September 7, 2018).

Nowers, C.B., Nobumba, L.M., Welgemoed, J., 2013. Reproduction and production potential of communal cattle on sourveld in the Eastern Cape Province, South Africa. Applied Animal Husbandry and Rural Development 6, 48–54.

Nyamukanza, C.C., Scogings, P.F., Kunene, N.W., 2009. Forage-cattle relationships in a communally managed semi-arid savanna in northern Zululand, South Africa, African Journal of Range & Forage Science, 25, 131–140.

Nyariki, D.M., 1990. Economic analysis of beef ranching: the case of Laikipia District, Kenya. MSc thesis, University of Nairobi.

Nyariki, D.M., 2008. Price response of herd off-take under market liberalization in a developing cattle sector: panel analysis applied to Kenya's ranching. Environment and Development Economics 14, 263–280.

Nyariki, D.M., Makau, B.F., Ekaya, W.N., Gathuma, J.M. 2005. Guidelines for Emergency Livestock Off-take Handbook. Arid Lands Resource Management Project, Office of the President, Agricultural Research Foundation, Nairobi, Kenya. Available at: http://repository.mut.ac.ke:8080/xmlui/bitstream/handle/123456789/210/Guidelines%20for%20emergency%20%20livestock%20off-take%20handbook.pdf?sequence=1&isAllowed=y (accessed November 20, 2019).

Oba, G., 2001. The effect of multiple droughts on cattle in Obbu, northern Kenya. Journal of Arid Environments 49, 375–386.

Oba, G., 2012. Harnessing pastoralists' indigenous knowledge for rangeland management: Three African Case Studies. Pastoralism: Research, Policy and Practice 2:1.

Oba, G., Weladji, R., Lusigi, W., Stenseth, N., 2003. Scale-dependent effects of grazing on rangeland degradation in northern Kenya: A test of equilibrium and non-equilibrium hypotheses. Land Degradation and Development 14, 83–94.

Oddoye, E.O.K., Takarma, J.F., Owusu, A. F., Johnson, V. 2008. Supplementation of grazing cattle: The use of a diet containing graded levels of dried cashew pulp. Bulletin of Animal Health and Production in Africa 56, 136−142.

Ogutu, Z.A., 1999. An Investigation of the influence of human disturbance on selected soil nutrients in Narok District, Kenya. Environmental Monitoring and Assessment 58 (1), 39−60.

Okello, B., O'Connor, T., Young, T., 2001. Growth, biomass estimates, and charcoal production of Acacia drepanolobium in Laikipia, Kenya. Forest Ecology and Management 142, 143–53.

Okoruwa, V.O., Obadaki, F.O., Ibrahim, G., 2005. Profitability of Beef Cattle Fattening in the Cosmopolitan City of Ibadan, Oyo State. Moor Journal of Agricultural Research, 6 (1 & 2), 45–51.

Onono, J. O., Wieland, B., Rushton, J., 2013. Constraints to cattle production in a semiarid pastoral system in Kenya. Tropical Animal Health and Production 45, 1415–1422.

Onono, J.O., Amimo, J.O., Rushton, J., 2015. Constraints and Efficiency of Cattle Marketing in Semiarid Pastoral System in Kenya. Tropical Animal Health and Production 47 (4), 691–97.

Onwuegbuzie, A., 2007. Sampling designs in qualitative research: making the sampling process more public. Qualitative Report 12(2), 238−254.

Orindi, V., Nyongo, A., Herrero, M., 2007. Pastoral Livelihood Adaptation to Drought and Institutional Interventions in Kenya. Occasional paper 2007/54, UN Human Development Office. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/2511/orindi_nyong_herrero.pdf?sequence=2&isAllowed (accessed April 28, 2017).

Osuji, P.O., Capper, B., 1992. Effect of age on fattening and body condition of draught oxen fed teff straw (*Eragrostis teff*) based diets. Tropical Animal Health and Production 24, 103–108.

Otieno, D., Ruto, E., Hubbard, L., 2011. Cattle Farmers' Preferences for Disease Free Zones in Kenya: An application of the choice Experiment Method. Journal of Agricultural Economics 62 (1), 207–224.

Ott, S.L., Wells, S.J., Wagner, B.A., 1999. Herd-level economic losses associated with Johne's diseases on US dairy operations. Preventive Veterinary Medicine 40, 179–192.

Ouma, R., Mude, A., van de Steeg, J.V. 2011. Dealing with climate-related risks: Some pioneering ideas for enhanced pastoral risk management in Africa. Experimental Agriculture 47(2), 375-393.

Ozluturk, A., Tuzemen, A., Yanar, M., Egenbuga, N., Dursun, E., 2004. Fattening performance, carcass traits and meat quality characteristics of calves sired by Charolais, Simmental and Eastern Anatolian Red dams. Meat Science 67, 463–470.

Pellikka, P.K., Milla, L., Siljander, M., Lens, L., 2009. Airborne remote sensing of spatiotemporal change (1955–2004) in indigenous and exotic forest cover in the Taita Hills, Kenya. International Journal of Applied Earth Observation and Geoinformation 11(4), 221–32.

Plessis, I., Hoffman, L., 2004. Effect of chronological age of beef steers of different maturity types on their growth and carcass characteristics when finished on natural pastures in the arid and sub-tropics of south Africa. South African Journal of Animal Science 34 (1).

Raikes, P. L., 1981. Livestock development and policy in East Africa. Scandinavian Institute of African Studies, Uppsala, Copenhagen.

Ramsey, R., Doye, D., Ward, C., McGrann. J., Falconer, L., Bevers, S., 2005. Factors affecting beef cow-herd costs, production and profits. Journal of Agricultural and Applied Economics 37, 91–99.

Rege J.E.O., Kahi, A.K., Okomo-Adhiambo, M., Mwacharo, J., Hanotte, O., 2001. Zebu cattle of Kenya: uses, performance, farmer preferences, measures of genetic diversity and options for improved use. Animal Genetic Resource Research 1, ILRI, Nairobi, Kenya.

Roba, G. M., Lelea, M. A., Kaufmann, B., 2017. Manoeuvring through difficult terrain: how local traders link pastoralists to markets. Journal of Rural Studies 54, 85–97.

Roba, G. M., Lelea, M.A., Hensel, O., Kaufmann, B., 2018. Making decisions without reliable information: the struggle of local traders in the pastoral meat supply chain. Food Policy 76, 33−43.

Rufael, T., Catley, A., Bogale, A., Sahle. M., 2008. Foot and mouth disease in the Borana pastoral system, southern Ethiopia and implications for livelihoods and international trade. Tropical Animal Health and Production 40: 29–38.

Ruiz, D.E.M., Sempere, L.P., Martinez, A.G., Alcaide, J.J.R., Pamio, J.O., Blanco, F.P., Garcia, V.D., 2000. Technical and allocative efficiency analysis for cattle fattening on Argentina Pampas. Agricultural Systems 65, 179–199.

Rutten, M., Mwangi, M., 2012. Mobile cash for nomadic livestock keepers: The impact of the mobile phone money innovation (M-Pesa) on Maasai pastoralists in Kenya. In: J. Gewald, A. Leliveld, I. Pesa (Eds.), Transforming Innovations in Africa: Explorative studies on appropriate in Africa societies. Brill, Leiden, Netherlands.

Sampaio, C.B., Detmann, E., Paulino, M.F., 2010. Intake and digestibility in cattle fed low-quality tropical forage and supplemented with nitrogenous compounds. Tropical Animal Health and Production 42, 1471–1479.

Scholtz, M.M., Maiwashe, A., Magadlela, M.A., Tjelele, T.J., Nkosi, B.D., Watabane, M., 2016. The reality of drought, consequences and mitigation strategies for livestock production in South Africa. Applied Animal Husbandry and Rural Development 9, 6–10.

Schroeder, C., Tonsor, T., 2012. International cattle ID and traceability: Competitive implications for the US. Food Policy 37 (1), 31–40.

Scoones, I., Bishi, A., Mapitse, N., Moerane, R., Penrith, M., Sibanda, R., Thomson, G.R., Wolmer, W., 2010. Foot-and-mouth disease and market access: Challenges for the beef industry in Southern Africa. Pastoralism: Research, Policy and Practice 1: 2.

Serneels, S., Said, M.Y., Lambin, E.F., 2001. Land cover changes around a major east Africa wildlife reserve: The Mara Ecosystem (Kenya), International Journal of Remote sensing 22:17, 3397–3420.

Shapiro, K., 1979. Livestock Production and Marketing in the Entente States of West Africa. Summary Report (no. PN-AAJ-217). Centre for Research on Economic Development, University of Michigan.

Sheffield, J., Wood, E.F., 2008. Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations. Climate Dynamic 31, 79−105.

Shisanya, C.A., Recha, C., Anyamba, A., 2011. Rainfall variability and its impact on normalized difference vegetation index in arid and semi-arid lands of Kenya. International Journal of Geosciences 2, 36–47.

Sieff, D., 1999. The effects of wealth on livestock dynamics among the Datoga pastoralists of Tanzania. Agricultural Systems 59, 1–25.

Sinange, R., 2007. Improving NAP Implementation through effective use of early warning: Experiences in the IGAD sub-region. In: Sivakumar, V.K, Ndiang'ui (Eds.), Climate and Land Degradation. Springer, New York.

Smalley, R., Corbera, E., 2012. Large-scale land deals from the inside out: Findings from Kenya's Tana Delta. The Journal of Peasant Studies 39 (3–4): 1039–1075.

Strydom, P., Frylinck, L., van der Westhuizen, J., Burrow, H., 2008. Growth performance, feed efficiency and carcass and meat quality of tropically adapted breed types from different farming systems in South Africa. Australia Journal of Experimental Agriculture 48, 599–607.

Stür, W., Khanh, T.T., Duncan, A., 2013. Transformation of smallholder beef cattle production in Vietnam. International Journal of Agricultural Sustainability 11 (4), 363–381.

Sullivan, S., Rohde, R., 2002. On non-equilibrium in arid and semi-arid grazing systems. Journal of Biogeography 29, 1595–1618.

Sundaresan, S.R., Riginos, C., 2010. Lessons learned from biodiversity conservation in the private lands of Laikipia, Kenya. Great Plains Research 20, 17–27.

Taye, T., Lemma, H., 2009. Traditional backyard cattle fattening in Wolayta: Systems of operation and the routine husbandry practices. Ethiopian Journal of Animal Production 9(1), 39–56.

Tegegne, A., Ayele, Z., Hoekstra, D., 2011. Farmers' innovations in livestock feeding and management semi-arid areas of Ethiopia. Proceedings of the annual Tropical and Subtropical Agriculture and Natural Resource (TROPENTAG) held on 5th-7th October 2011 in Bonn, Germany. Available at: http://www.tropentag.de/2011/abstracts/full/484.pdf (accessed June 4, 2017).

Teklebrhan, T., Urge, M., 2013. Assessment of commercial feedlot finishing practices at eastern Shoa, Ethiopia. Open Journal of Animal Sciences 3 (4), 273–280.

Tessema, W. K., Ingenbleek, P.T.M., Trijp, H.C.M., 2013. Pastoralism, sustainability, and marketing. A review. Agronomy for Sustainable Development 34, 75–92.

Tiki, W., 2012. Climate-induced vulnerability and pastoralist livestock marketing chains in southern Ethiopia and northern eastern Kenya. Field Research Report 1. CHAIN Project and Emory Programs in Development Studies, Emory University. Available at: http://devstudies.emory.edu/home/assets/reports/FieldReport_1-25-13.pdf (accessed October 19, 2019).

van der Valk, Y., 2008. Quick scan of the dairy and meat sectors in Kenya. Issues and opportunities. A report for the Office of the Counsellor for Agriculture, Nature and Food Quality of the Royal Netherlands Embassy in Nairobi, Kenya. Available at: https://www.yumpu.com/en/document/view/26368149/quick-scan-of-the-dairy-and-meat-sectors-in-kenya-issues-and-snv (accessed April 28, 2017).

Veit, P. 2011. Rise and fall of group ranches in Kenya. Focus on Land in Africa Brief. World Resource Institute and Landesa, Washington DC. Available at: www.focusonland.com/download/521381711a57a (accessed 6 July 2018).

Vosloo, W., Thompson, P.N., Botha, B., Bengis, R.G., Thomson, G.R., 2009. Longitudinal Study to Investigate the Role of Impala (*Aepyceros melampus*) in Foot-and Mouth Disease Maintenance in the Kruger National Park, South Africa. Transboundary and Emerging Diseases 56, 18–30.

Waller, R., 2004. 'Clean' and 'dirty': Cattle disease and control policy in colonial Kenya, 1900-40. Journal of African History 45, 45–80.

Wario H.T., Roba, H.G., Aufderheide, M., Kaufmann, B., 2017. Reproductive performance and herd growth potentials of cattle in the Borana pastoral system, southern Ethiopia. Animal Production Science 57, 161−169.

Watson, D.J., van Binsbergen, J., 2008. Review of VSF-Belgium's Turkana emergency livestock off-take intervention 2005. Research Report (no. 4). ILRI, Nairobi, Kenya. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/234/RR4_LivestockOfftakeIntervention.pdf (accessed September 25, 2019).

Wehrden, H., Hanspach, J., Kaczensky, J., Fischer, J., Wesche, K., 2012. Global assessment of non-equilibrium concept in rangelands. Ecological Applications 22, 393−399.

Wessels, K., Prince, S., Carroll, M., Malherbe, J., 2007. Relevance of rangeland degradation in semi-arid north-eastern South Africa to non-equilibrium theory. Ecological Applications 17, 815−827.

Wooten, D., 2000. A conceptual overview of the self-presentation concerns and responses tendencies of focus group participants. Journal of Consumer Psychology 9(3), 141−153.

Yonten, N., 2014. A larger herd size as symbol of wealth? The fallacy of the cattle complex theory in Tibetan pastoralism. Royal Geography Society 46 (2).

Zwaagstra, L., Sharif Z., Wambile A., de Leeuw, J., Said, M.Y., Johnson, N., Nyuki, J., Ericksen, P., Herrero, M. 2010. An assessment of the response to the 2008-2009 drought in Kenya. A report of the European Union Delegation to the Republic of Kenya. ILRI, Nairobi, Kenya. Available at: https://cgspace.cgiar.org/bitstream/handle/10568/2057/assessment_drought_2010.pdf;sequence=3 (accessed March 20, 2019).

APPENDICES

Appendix 1. Question guide for characterizing existing stratified cattle production systems in Kenya's drylands

A. Respondent general information

Date of interview……..

Name……..

Age…….

Gender: Male [ ], Female [ ]

Location……..

Education: None [ ], Primary [ ], Secondary [ ], Tertiary College [ ]

B. Description of the stratified cattle production practiced.

Please describe the stratified cattle production you practice, highlighting what is involved in each stage

…….....

.....

Kindly tell the breed of the cattle you usually purchase for fattening under stratified production system

……..

Which of the classes of cattle do buy for fattening under the stratified production system

Steers [ ], Bulls [ ], Cows [ ], Heifers [ ], Weaners [ ].

In which body condition do prefer to purchase the animals?

……..

Where do you normally source the animals?

…….What arrangement(s) do make source the animals?

…….What types of cost you incur in purchasing the animals

…….

What types of costs you incur in transporting the animals?

……

What types of management practice are undertaken once the animals reach fattening area?

……..

Please describe all the management practices you mentioned above

……

Kindly tell how long it takes to the animals

……..Does the fatten period varies with the animal breed, class or body condition? Please explain

……..

What is the estimated live weight of the animals at the time of sale?

……Does the live weight attained at time of the sale vary with the breed, class or the body condition of the animal prior to fattening? Please explain

……

Where do you sell your fattened animals?

……..

What types of marketing costs do incur?

…….

What is the average selling price of the animals?

…….

What constraints do face in fattening and marketing of the animals?

……..

How are managing to cope with the above constraints?

……..

Thank you for your time

Appendix 2: Data sheet for assessing animal weight gain and profitability under stratified cattle production systems in Kenya's drylands A. General information

Type of the practitioner: Rancher [ ], Trader [ ], Agro-pastoralist [ ], other [ ]

Date of purchasing the animals……

Source of the animals……..

Total number of purchased animals……

Fattening location……

B.Characteristics of the purchased herd

No. of steers, [ ], No. of bulls [ ], No. of cows [ ], No. of heifers [ ], No. of weaners [ ].

C.Purchase costs (in Kshs)

Total purchase cost (price only),

Total market levies charged ……..

Total cost of veterinary permit……..

Total of transportation……

Other costs incurred (personnel allowance, middlemen charges)……

D. Losses on transit

No. of cattle lost while on transit…….

Value of the lost cattle while on transit……..

E. Herd-level cost of managing the animals (Kshs)

Month	No. of animals	Cost of feeds/water	Herding cost	Cost of spraying /dipping	Cost of vaccination	Cost of veterinary drugs	Cost of salts /minerals	Overhead costs (repairs, travels, bills, etc)	Other cost if any
1									
2									
3									
4									
5.									
6									
7									

8.									

F. Animal-level cost and revenue (Kshs).

Animal no.	Breed	Class	Buying price	Date of purchase	Date of sale	Selling price	Did the animal had any disease?	If yes, indicate the disease and the cost of treatment	Indicate if the animal recovered from the disease or died

G. Assessment of animal weight gain

Animal no.	Breed	Class	Weight at purchase	Weight at sale

Appendix 3: Question guide for key informant interviews on requirements for selling cattle under stratified cattle production systems

General information

Questionnaire no……..

Date…….

Name of interviewer……

Name of Respondent……..

Age……

Gender: Male [ ], Female [ ]

Location……..

Education: None [ ], Primary [ ], Secondary [ ], Tertiary College [ ]

How long have been in cattle fattening business?……

Kindly share your experience in cattle fattening……

Do you normally give some conditions to pastoralists in buying animals for fattening? Please explain.....

What qualities of animals do you demand from pastoralists?.....

What do you demand from pastoralists in supplying animals for fattening?.....

What do you demand from pastoralists in buying animals? ……

What do you demand from pastoralists in making payments……..

Thank you for your time

Appendix 4: Questionnaire for assessing pastoral cattle off-take under stratified production systems

General information

Questionnaire no……..

Date…….

Name of interviewer……

Name of Respondent……..

Age……

Gender: Male [ ], Female [ ]

Location……..

Education: None [ ], Primary [ ], Secondary [ ], Tertiary College [ ]

Please recall all livestock sold by your household in the last period of Oloirobi (May to September of 2016), indicating species, class, market, price and the purpose of selling

Livestock species	Class	Market	Price	Purpose

In case you sold any cattle in the last 3 months, please recall place of sell, the type of buyer, the price offered, body condition and the purpose of sell for each of the cattle sold.

Name of cattle (if applicable)	Class (1=steer, 2=weaner, 3=cow, 4= cull cow, 5=heifer, 6=cull heifer, 7=breeding bull, 8=non breeding bull	Place of sell	Type of buyer 1=those who buy to fatten 2=those who buy to slaughter 3=those who buy to breed 4=other (specify)	Price offered (Kshs)	Body condition (1=good, 2=Fair, 3=poor)	Purpose of sell 1=basic household needs (e.g food, clothes) 2=school fees 3=medical bills 4=business investment 5=save from drought or restock in future 6=others (specify)

Did your household purchase any cattle in the last 3 months?

If yes, please recall the number, the class, the price and the purchasing purpose for each cattle

Class (1=steer, 2=weaner, 3=cow, 4= cull cow, 5=heifer, 6=cull heifer, 7=breeding bull, 8=non breeding bull	No. of cattle	Price (kshs)	Purchasing purpose

Did your household lose any livestock in the last 3 months?

If yes, please recall all animals lost by your household in the last 3 months, indicating species, class, approx./estimated market price and the cause of their death.

Livestock species	Class	Estimated market price	Cause

Thank you for your time