Mapping Potential Risk Factors for MERS-CoV Spillover Events Along the Camel Value Chains of Garissa and Isiolo Counties of Kenya



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Abbreviations

ASAL	Arid and Semi-Arid Lands
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
ILRI	International Livestock Research Institute
KALRO	Kenya Agricultural & Livestock Research Organization
KES	Kenya Shilling
MERS-CoV	Middle East Respiratory Corona Virus

Executive Summary

The Middle East Respiratory Corona Virus (MERS-CoV) has since 2012 been recognised by the World Health Organisation (WHO) as a zoonosis that has the potential to evolve into the next pandemic event. Antibodies mounted against the virus have been repeatedly detected in dromedary camels (Camelus dromedarius) from Middle East and Africa with studies reporting a high (>70%) seroprevalence rate. Studies have documented that dromedary camels are a natural host for MERS-CoV, but little is known if camels are also the natural reservoir hosts for the virus. There is lack of detailed evidence on MERS-CoV transmission patterns to man due to lack of knowledge on the viral shedding patterns in camels and seroconversion dynamics including duration of immunity in camel herds. Since 2016, FAO-Kenya through the project "Ending Pandemic Threat-2" has been undertaking MERS-CoV research whose overall objective is to contribute knowledge on the epidemiology of the disease in camels through serological, molecular and value chain studies. To better understand the potential risk factors for MERS-CoV spread at the camel-human-environment interface. FAO-Kenya commissioned a camel value chain study in Garissa and Isiolo counties. The study was conducted between September and October 2020 and was largely a desk review study with minimal field visits. This report highlights the study findings. The report is structured to first gives a broad overview of the camel production system in Kenya before detailing the current status of the camel milk and meat value chains in Garissa and Isiolo counties. The primary focus of the report is mapping the value chain actors, their roles and relationships and their level of integration into the formal market systems. The report also highlights the mobility flow of the value chain products. The report concludes by highlighting risk factors along the camel milk and meat value chains that can potentially cause MERS-CoV amplification and spillover events.

The literature review identified existing information gaps concerning camel meat value chains in most camel keeping counites of Kenya. This was attributed to the highly informal nature of the operations. The camel meat value chain is governed by middlemen traders who benefit most as demonstrated by the Garissa county case study. There was existing and comprehensive data on the camel milk value chain in Isiolo county but scarce information on the Garissa camel milk value chain. Given that Garissa is one of the counties with the highest camel population in Kenya, there is need to conduct value chain and zoonotic disease research in Garissa and other

counties with a high camel population. Kenya has a camel population of 4.6 million animals, Mandera and Wajir have more than 1 million camel population. Garissa county with an annual camel meat production of 27,000 metric tonnes is the largest consumer of camel meat in the country while Isiolo is the main supplier of camel milk to Nairobi county. The study revealed that Garissa county is not supplying camel milk to Nairobi as indicated in previous studies, this was because there was a high and often unmet demand for camel milk in Garissa town. In addition, despite the decade long investment in improving camel milk quality in Isiolo county, the practice of using non-food grade plastic containers is still prevalent as there are no practical alternatives. The study found that peri-urban camel milk production in both Garissa and Isiolo counties was common with most peri-urban producers maintaining a predominately female herd. The main value addition activity in the camel milk value chain was transferring the milk from one location to another. However, in Laikipia county, private investors are processing camel milk and supplying a consumer base that is utilising the milk for its medicinal and nutritional benefits.

Camel meat in both Garissa and Isiolo county is mainly consumed fresh with no value addition. However, most women traders engage in production of a cooked dried camel meat product locally know us 'nyirinyiri'. This product has an erratic production cycle as it is only demanded for during cultural and religious celebrations. The camel meat processor located in Isiolo town was producing camel sausages and hamburger patties. However, the uptake of the processed products was low amongst Nairobi consumers who predominately prefer beef, chicken or pork (non-Muslim consumers) products. The Isiolo processors idea of diversifying into vacuum packed specialised camel meat cuts could improve uptake of camel meat consumption by non-Muslim communities. The camel milk and meat value chains are governed by strong family and clan relations hence the reason they have remained informal and unable to integrate into the formal milk and meat market systems. This challenge also make it difficult to regulate the chains as well as quantify their contribution to the county's and national economy. The study revealed that women are playing and important role in both the camel milk and meat value chains and this should be considered by policy makers as they strive to regulate and integrate the value chains into formal market systems. The study identified potential risk factors along the camel milk and meat value chain that could promote MERS-CoV amplification and spillover events. They include;

- I. Lack of water to wash off the calf's saliva from the udder and milkers' hands. The lack of proper hand milking hygiene may expose the herders to zoonotic pathogens as well as increase the likelihood of milk contamination with pathogens.
- II. Congregation of camel herds from neighbouring counties in Isiolo dry season grazing areas may result in widespread geographical transmission of diseases.
- III. The increased number of producers engaging in peri-urban camel milk production means that camels are now being reared in close proximity to the high urban human population. This means that more people are at an increased risk of zoonotic disease exposure.
- IV. The study found that most camel livestock markets in Isiolo and Garissa had no animal health officers. This makes the markets possible hot spots areas for zoonotic disease transmission and spread. The lack of officers means that there is also a delay in detection of disease events.
- V. The primary and secondary milk traders are at an increased risk of zoonotic pathogen exposure as they usually use the organoleptic test of taste to accept or reject the milk.
- VI. Slaughter house workers especially in Garissa county are at an increased risk of zoonotic pathogen exposure as they do not wear personal protective clothing. In addition, in both Isiolo and Garissa, the slaughter men do not wear masks or safety googles putting them at an increased risk of MERS-CoV exposure.
- VII. Slaughter houses in both Garissa and Isiolo counties do not have equipment to hoist the camel carcasses off the ground. The prolonged contact of the carcass with blood increases the risk of meat being contaminated with harmful pathogens.
- VIII. The lack of a fence at the Isiolo slaughter house and lack of walls at the Garissa camel slaughter slab allows the wild birds to scavenge on camel tissues including respiratory tract organs. The repeated exposure of the wild birds to camel respiratory tissue may promote MERS-CoV amplification and eventual spill over to humans.
 - IX. The unregulated camel bones trade to Thika and Nyeri counties and camel skin to Athiriver tanneries means that zoonotic pathogens can spread to counties that are not linked to camel rearing making it difficult to link disease outbreak incidences in these counties to camel products.
 - X. Lack of proper solid and liquid waste management in both slaughter houses may contaminate the ground water. Given that most residents in Isiolo and Garissa towns rely

on shallow wells for their domestic and livestock water needs, the ground water contamination may result in zoonotic disease outbreaks.

XI. The consumer preference for raw milk consumption puts them at an increased risk of zoonotic disease exposure specifically Brucellosis.

The study makes the following recommendations;

- I. County governments from the main camel producing areas need to use existing platforms like the Kenya Camel Association and Frontier Counties Development Council (FCDC) to lobby for the national government to provide sanitary guidelines and policies that will regulate the camel milk and meat value chains. However, as policy makers move towards regulating and integrating the chains into formal market systems. They should be cognizant of the important role played by family and clan ties that offer the value chain actors access to funds and loans as well as social support. Most of the value chain actors cannot access funds from formal financial lending institutions.
- II. The county should ensure the slaughter houses are designed and operated according to the existing meat control act guidelines.
- III. There is need for NGOs and development partners to offer innovation grants/funds that will spur engineers to design hygienic and non-bulky containers that are practical for use in the harsh ASAL setting.
- IV. FAO and other research institutions need to shift surveillance efforts to counties with high camel populations like Mandera, Wajir and Garissa. Research findings need to be shared widely within relevant county departments especially livestock production and health.
- V. There is need for broad based studies that focus on MERS-CoV seroprevalence surveillance in the general Kenyan population. This will identify if there is a causal linkage between contact with camels or camel products and positive MERS-CoV results in man.
- VI. Further investigation on the role played by wildlife in MERS-CoV epidemiology is needed. Research should focus on capture and testing the Marabou stork in and around the slaughter houses.
- VII. There is need for research to dispel the myths that pasteurising camel milk reduces or removes its health and nutritional benefits.

1.0 Introduction

The current global camel population is estimated to be more than 35.9 million animals, with an annual growth rate of 3 per cent (%). More than 80% of the world's camel population is found in the African continent, specifically, the Horn of Africa and Sahel countries. Chad and Somalia have the highest population of domesticated dromedary camels, with over 7 million animals (FAO, 2019). Kenya accounts for the fourth-largest population, with 4.6 million animals (Figure 1).



Figure 1: Global Camel Population Numbers (Source FAOSTAT 2019 and KNBS 2019)

Camel production has, for centuries, played a vital role in providing food and economic security for nomadic pastoral and agro-pastoral communities. Camels are reared in arid and semi-arid areas where crop agriculture is limited, and production of other livestock species is often challenged due to the spatial and temporal distribution of rainfall and vegetation. The anatomical and physiological adaptation of camels allows them to utilise low-quality browse foliage and convert it to high-quality milk and meat protein that is available throughout the year. In the Sahelian and Sub-Saharan African regions, climate change deduced from the long-term observation of the weather patterns is characterised by frequent and prolonged drought periods that are interspaced by shorter periods of abundant rainfall (Nyariki and Amwata 2019). Dryland communities residing in these regions have adopted the use of camels as an auxiliary agricultural asset that has allowed the integration of camel products into human food and market

systems. This shift into commercial camel production means that more people across the camel value chains are now at risk of zoonotic pathogen exposure. This zoonotic risk was recently highlighted by outbreaks of Middle Eastern Respiratory Syndrome Corona Virus (MERS-CoV) in Saudi Arabia. Zoonotic diseases disproportionally affect the most impoverished communities, who tend to live in close proximity to livestock and often have limited access to medical and veterinary services. This situation is further compounded by the fact that camel research is minimal when compared to that of cattle or other domesticated ruminant species. Research funding is rarely directed to camel research, and this may be due to the limited geographical distribution of camels when compared to the other livestock species. There is a need to develop a better understanding of the role played by camels in propagating zoonotic diseases in man (Hughes and Anderson 2020). In light of these concerns, the Food and Agriculture Organization of the United Nations (FAO) in Kenya has since 2016, been implementing the project dubbed "Ending Pandemic Threat-2". The project is being conducted in collaboration with the director of veterinary services from the Ministry of Agriculture, Livestock and Fisheries and the International Livestock Research Institute (ILRI). The project has several research outputs that have contributed to a better understanding of the epidemiology of MERS-CoV in Kenyan camels (Kiambi et al. 2017; Gikonyo et al. 2018).

1.1 Study Purpose

It is within this background that FAO-Kenya in September 2020 commissioned a camel value chain study that aimed at identifying the potential risk factors that may contribute to MERS-CoV spillover events along the camel milk and meat value chains of Garissa and Isiolo counties of Kenya. The current study was informed by a 2018 FAO-Kenya research that determined MERS-CoV hot spot sites in Kenya using camel population density data, camel production system characteristics, MERS-CoV seroprevalence data and camel convergence routes data. The 2018 study proposed that future camel studies adopt a value chain approach to assess risks in counties that have high camel population densities. Garissa and Isiolo counties have one of the highest camel population numbers in Kenya. The counties are also the leading suppliers of camel products to Kenya's capital city, Nairobi, and other major urban towns in the country (Muloi et al. 2018; Musinga et al. 2008).

1.2 Terms of reference

The study was conducted in two target counties of Garissa and Isiolo in Kenya. The assigned tasks included;

- 1. Quantifying the camel population distribution up to ward level including identification of trade and migration routes;
- 2. Characterising the camel meat and milk value chains actors, their roles, relationships, product flow and level of integration into the formal market systems;
- 3. Use of the market profiling tool to collect georeferenced data on the live camel markets inflows and outflows including seasonal variation;
- 4. Analysing biosecurity practices of the value chain actors at the live camel markets, slaughterhouses, camel products retail and processing outlets.
- Identifying areas along the camel value chains that could serve as potential hot spots for MERS CoV spillover events.

1.3 Methodology

The value chain analysis study applied a mixed-methods approach that included an extensive literature search and minimal field visits to the target counties to conduct Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs). PubMed, Google Scholar and Google search engines were used to retrieve peer-reviewed articles and grey literature. The search terms and Boolean Operators used included Camel Value Chain Kenya OR Camel Production Kenya; Camel Milk Value Chain Kenya AND Camel Meat Value Chain Kenya; MERS -CoV Kenya OR Camel Zoonotic diseases Kenya. The online literature search was expanded to include databases from the University of Nairobi, Egerton University, Kenya Agricultural & Livestock Research Organization (KALRO) and ILRI. Data on camel production and population retrieved from the literature search was validated through a phone interview with staff from the state department of livestock in Nairobi. Retrieved literature information informed the development of data collection tools that were designed as a checklist of questions that guided the KIIs and FGDs. These questions are attached in the appendices section. Consent to conduct the field visits was sought from the Garissa and Isiolo county directors of livestock and veterinary services through phone calls and emails. Once permission was granted, the consultant sent the directors an email listing the people to be targeted for KIIs and FGDs.

The directors then assigned a focal person who mobilised the camel milk and meat value chain actors in preparation for the field visits. The field visits were conducted from 28th September to 8th October 2020. A total of 10 KIIs and 7 FGDs were carried out as shown below;

Klls

- i. Director of veterinary services who was also the acting director of livestock production -Garissa County
- ii. Directors of livestock production -Isiolo County
- iii. Livestock market revenue officer- Garissa county
- iv. Subcounty veterinary officer- Garissa county
- v. Subcounty animal health officer Isiolo county
- vi. County meat inspector and slaughterhouse manager- Isiolo county
- vii. Private sector slaughterhouse manager- Garissa county
- viii. Private sector camel meat processor-Isiolo county
- ix. Private sector camel milk processor- Nanyuki county
- x. Private sector camel hide trader- Garissa county
- xi. Butcher trader Garissa county
- xii. Chairman of a camel milk trader group Garissa county

FGDs

- i. 2 FGDs with livestock marketing association members- Garissa and Isiolo counties
- ii. 3 FGDs with camel milk traders Garissa and Isiolo County
- iii. 1 FGD with female camel butchers- Isiolo county
- iv. 1 FGD with slaughter slab workers- Isiolo county

2.0 Background of the study

MERS-CoV has since 2012 received increased attention as a zoonosis that has the potential to evolve into a pandemic. The World Health Organisation (WHO) statistics indicate that as at the end of January 2020, a total of 2519 laboratory-confirmed cases of MERS-CoV infections were reported globally. The disease has mainly occurred in Saudi Arabia and has since April 2012 caused 866 deaths with an estimated case-fatality rate of 34.3 % (WHO 2019). Human-to-human transmission of MERS-CoV accounts for half of all MERS-CoV cases reported. Reports from the Middle East and Korea indicate that most outbreaks occur in health care settings with

minimal community transmission. The exact role played by dromedary camels in the transmission of the virus and the exact route(s) of transmission to man are largely unknown. This knowledge gap has led researchers to focus studies at the camel-human nexus with particular geographical preference directed to the Middle East and Horn of African countries (Sherif et al. 2019). Widespread serological studies have determined that MERS-CoV has a narrow host range with most domestic species such as horses, cattle, pigs, water buffalo, chickens, goats, and Bactrian camels testing negative for MERS-CoV antibodies. Studies in wild birds, wild hogs and feral camels have also returned negative antibody results (Killerby et al. 2020). The risk pathways for MERS-CoV transmission are yet to be quantified, and there is a need to conduct more inclusive epidemiological studies that incorporate anthropology and sociology components to allow characterisation of the camel-human relationship, including behaviours and practices. Given that MERS-CoV research is still in its early stages, researchers are advocating for studies that use a risk-based approach to explore scenarios and hypotheses with the aim of identifying likely and unlikely MERS-CoV transmission pathways (Funk et al. 2016). It is within this background that a camel value chain study was conducted in Garissa and Isiolo counties of Kenya. The study aimed at identifying potential risk factors that could result in MERS-CoV spillover events at the camel-human-environment interface.

2.1 Specific Study objectives

- 1. Undertake desk review of previously conducted camel value chain studies in Kenya with a specific focus on Garissa and Isiolo camel value chains.
- Conduct minimal field visits to target counties to collect primary data on camel population densities at ward level, camel production systems, trade routes, migration patterns and market systems.
- 3. Support the FAO-Kenya GIS and Epidemiology teams to develop camel density maps, that identify and characterise interfaces using MERS-CoV antibody distribution maps.
- 4. Compile and present a report of the study findings.

3.0 Study Findings

Google Scholar search engine and the research institution databases were the main sites used to retrieve peer-reviewed articles and grey literature on camel value chain studies in Kenya. National and County government officials provided the current camel population and production data. A total of 124 documents were retrieved. Of these, 55% (69/124) were peer-reviewed articles, while 44% (55/124) were grey literature. The 69 peer-reviewed papers were categorised according to the main areas of research. Most (23/69) of the peer-reviewed articles focused on public health and biosecurity through quantifying the microbial load in milk and meat products or assessing the knowledge and hygienic practice of value chain actors. The literature search also included zoonotic research conducted in Kenya. Other than MERS-CoV, the three other zoonotic diseases documented across the camel value chains were brucella, Q-fever and Echinococcus. Studies that assessed public health risk dominated the bulk of peer-reviewed research in Kenya (Figure 2).



Figure 2: Percentage distribution of Camel Value Chain Research in Kenya.

Analysis of the 124 retrieved documents revealed that most of the research work was conducted in Isiolo county (Figure 3). Researchers cited insecurity and inaccessible terrain as the main reasons that hindered studies in Mandera, Wajir and Turkana, these are the main camel producing counties of Kenya.



Figure 3: County distribution of camel value chain research in Kenya

3.1 Camel Production Systems in Kenya

Camels are mainly reared in counites located in the northern part of Kenya under the pastoralist production system. Northern Kenya is classified as Arid and Semi-Arid Lands (ASALs) that fall under agroecological zones V to VII (Tura and Kimindu 2019; Gikonyo et al. 2018). The nomadic nature of the pastoralist system is characterised by livestock mobility that is influenced by social, ecological, political and economic conditions. Pastoralist mobility is a rational strategy that aims at making optimal use of the natural resources that vary in time and space. Pastoralism is both an economic activity and a cultural identity whose main production goal is to increase herd size and milk yield while maintaining an appropriate herd structure for short- and long-term reproductive success (Farah et al. 2004, Turner and Schlect 2019). Camels are well adapted to the harsh ASAL conditions and continue to offer food and economic security for pastoralists households even during severe drought periods (Yazan and Wasonga 2015). The droughttolerant ability of camels has seen more communities in Kenya embrace camel production. Camel production systems have expanded to the central and southern rangelands of Kenya such as Kajiado, Samburu, Meru, Laikipia, West Pokot, Kilifi, Kitui, Mwingi and Narok (Gikonyo et al. 2018; Tura and Kimindu 2019). Most of the emerging camel rearing counties practice nomadic camel production systems. However, in Laikipia county, commercial camel ranching

has taken root. The Laikipia ranches produce pasteurised and bottled camel milk for a niche customer base that is drawn from within the country and across the East African Region (Tura and Kimindu 2019). Camels produce milk, meat, hides and bones and are used to meet both the subsistence and commercial needs of the pastoralist's households. Camels are also used for transport, ecotourism and draught power (Yazan and Wasonga 2015). Traditionally, camel breeds in Kenya were classified according to the communities that kept them. However, a 2003 study that assessed the phylogenetic relationship found that Kenya has only three distinct breed groups the Somali, Pakistani and the Gabbra/Rendille/Turkana (Mburu et al. 2003). The Somali and Pakistani breeds produce more milk when compared to the Rendille/Gabbra/Turkana breed. Studies conducted in Marsabit, Isiolo and Laikipia counties found that during a lactation length of 10 to 12 months, the Somali breed produced an average daily yield of 5 to 8 kilograms (kgs) when compared to 2 to 4 kgs from the Rendille/Gabbra/Turkana breed (Simpkin et al. 1996). One major constraint to milk production is that camels stop lactating within the first four weeks of gestation. However, if camels do not become pregnant, the lactation length may continue for 24 months. Another constraint that hinders milk production is the short milk let-down reflex. Lactating camels require the suckling action of the calf to initiate the milk let-down reflex (Alhadrami and Faye 2016). The literature review found a general lack of information regarding camel meat production systems in Kenya. However, a project report by ILRI (Wainaina et al. 2018) indicates that red meat in Kenya is generally of low quality as most consumers do not demand quality meat cuts.

The 2019 Kenya Population and Housing Census data estimates that the country has a camel population of 4,640,085 million animals. The figure represents a 41.7% increase in the number of camels when compared to 3,273,445 animals in 2018. The rise in camel numbers was attributed to the availability of browse and high fertility rates (GoK _b 2019). During the field visits, KIIs and FGDs respondents indicated that almost all breeding female camels were pregnant and expected to calve down at the end of the year. The respondents confirmed that the suitable climatic conditions experienced from September 2019 provided a year supply of good forage that supported high fertility rates that camel keeping occurs in 27 out of the 47 counties of Kenya (KNBS 2019). The camel population distribution ranges from 1.8 million animals in Mandera county to 58 animals in Mombasa county. Of the 27 camel keeping counties, 20 have camel

populations of more than 1000 animals. Table 1 below illustrates the distribution of the camel population in traditional and emerging camel keeping counties of Kenya.

Table 1: Distribution of camel numbers in traditional and emerging camel keeping counties in Kenya
(Source KNBS 2019)

Traditional Camel Keeping Counties							
County Camel Name populatio							
1	Mandera	1,828,665					
2	Wajir	1,176,532					
3	Garissa	816,057					
4	Turkana	261,923					
5	Marsabit	215,234					
6	Isiolo	148,859					
7	Tana River	53,298					
E	merging Came Countie	l Keeping s					
	Camel population						
8	Samburu	48,172					
9	Baringo	38,500					
10	West Pokot	19,389					
11	Laikipia	7,827					
12	Meru	5,732					
13	Kitui	5,202					
14	Kajiado	3,584					
15	Taita Taveta	2,630					
16	Kilifi	2,022					
17	Narok	1,619					
18	Machakos	1,473					
19	Makueni	1,111					
20	Kwale	1,096					



3.2 Overview of the camel milk marketing channels in Kenya

The world milk production in 2018 stood at 838 metric tonnes composed of 81% cow milk, 15% buffalo milk, and a combined 4% for goat, sheep and camel milk (OECD/FAO 2019). Kenya in 2019 produced 3.98 billion litres of milk worth 178.74 billion Kenya Shillings (KES). Cattle accounted for 88% of the milk produced while camel and goat milk contributed 22% (GoK 2019 b). Quantification of camel milk production figures is difficult because the milk is mostly (90%) consumed raw at household or local level (Musinga et al. 2008; Blackmore et al. 2020). The FAO department of statistics estimates that in 2019 the world production of fresh camel milk was 2.85 Million Tonnes (MT), Somalia and Kenya were the highest producers with 953,673 and 876,224 tonnes respectively (FAO 2019). FAO in 2017, estimated that the gross production value of camel milk in Kenya stood at USD 450 million, which is higher than that of sugar cane, green coffee, indigenous chicken and lint cotton. However, the contribution of camels to the national economy is underestimated because camel products and are not integrated into formal marketing systems (Tura and Kimindu 2019).

Furthermore, the national plan to improve the dairy sector in Kenya does not mention how the camel milk sector contributes to the economy and fails to mention how it will be integrated into the formal dairy sector (GoK 2013). The only regulatory document that offers standards for the camel milk sector is the 2016 Kenya Bureau of Standards (KEBS) draft guidelines on pasteurised and raw whole camel milk. Moreover, analysis of county planning documents (2018-2022 CIDPs) from 29 ASAL counties, confirms that only seven arid counties have made mid-term plans to improve camel productivity and products (Tura and Kimindu 2019). The Kenyan dairy sector as a whole is struggling to formalise milk trade, reports from the state department of livestock estimate that 80% of milk sold in Kenya is marketed raw through informal channels. This situation has resulted in gross underutilisation of milk processing facilities (GoK 2013). To address this challenge, the Kenya camel association is lobbying for the government to engage value chain actors to draft a camel milk policy. The government, on its part, is investing in expanding the state-owned processor (New KCC) to open a goat and camel milk production line that will produce camel milk powder for Asian and Middle East export markets. However, this move will not be viable if the government does not put in place policies and hygiene standards to regulate the sector (VSF 2020). The camel milk marketing system in Kenya is mainly informal,

featuring traders acting as conduits between producers, bulking agents, processors and consumers. The formal marketing channel that deals with pasteurised and bottled milk is through private commercial processors such as the Ngamia Milk suppliers (White gold brand) located in Nanyuki, Laikipia County (Muloi et al. 2018). Most of the camel milk produced in most of the counties is marketed and consumed within the county; for example, in Turkana and Garissa, the large refugee camps are profitable markets for camel milk traders. The exception to this rule is Isiolo and Laikipia counties that supply large urban towns outside the county. The terminal market for the Isiolo informal marketing channel is Eastleigh, a suburb in Nairobi that is mostly inhabited by the Somali community (Mwaura et al. 2015). The formal Laikipia marketing channel has a more diverse and a niche customer base who utilise the milk for health benefits. The Laikipia private processors supply customers located in Maua, Meru county, Thika in Kiambu county, South B in Nairobi county, and Nakuru county. They also supply customers in the neighbouring countries of Tanzania, Uganda and Rwanda (Tura and Kimindu 2019). Figure 4 below summarises the camel milk marketing channel in Kenya.



Figure 4: Summary of the Camel Milk Marketing Channels in Kenya

(Source: Tura and Kimindu (2019))

3.4 Garissa and Isiolo bio-physical characteristics

Garissa County covers an area of 44,174.1 square kilometres (km²) its geographical coordinates are 0.4532° South, 39.6461° East, the road distance between Garissa town and Nairobi is 367 kilometres. The county borders the Republic of Somalia to the East, Lamu County to the South, Tana River County to the West, Isiolo County to the North West and Wajir County to the North. The county has a human population of 841,353 based on the 2019 Census. Most of Garissa's inhabitants are ethnic Somali. The county hosts more than 260,000 Somali refugees in the refugee camps at Dadaab sub-county. Garissa has six sub-counties, namely Fafi, Garissa township, Ijara, Lagdera, Balambala and Dadaab. The sub-counties are further divided into 30 wards. The county is a flat plain with no hills or mountains and falls within agro-ecological zones V-VI. The annual rainfall in the county is 275 millimetres (mms) with two rainy seasons. The short rains occur from October to December and the long rains from March to May. The southern parts of the County Hulugho, Masalani and Bura, receive more rainfall than the northern regions. During the dry season, there is a general migration of livestock to areas near River Tana where water is readily available. Tana River runs along the western part of the county and is the only permanent natural source of water for Garissa town and surrounding areas. Seasonal Rivers (locally called 'Laggas') provide water during the wet season for both human and livestock. The county also hosts the Boni forest, part of the Boni National Reserve, a protected wildlife conservation area. The county experiences acute water shortages during the dry seasons. Most livestock keepers during the dry season migrate their camels to adjacent counties of Isiolo, Tana River and Lamu (Garissa CIDP 2018).

Isiolo county covers an area of approximately 25,700 km² its geographical coordinates are 0.3556° North and 37.5833° East. The road distance between Isiolo town and Nairobi is 274 kilometres this makes Isiolo town closer to Nairobi when compared to Garissa town, giving the county a strategic advantage that has allowed it to dominate the Nairobi Camel milk market. The county borders Marsabit County to the north, Samburu and Laikipia Counties to the west, Garissa County to the south-east, Wajir County to the north-east, Tana River and Kitui Counties to the South and Meru and Tharaka Nithi Counties to the south-west. The county has three subcounties namely Merti, Garbatulla and Isiolo central. The sub-counties are further divided into ten electoral wards. Based on the 2019 census, the county has a human population of 267,997

inhabitants. The county has a diverse community when compared to Garissa county. The Borana community is the largest ethnic community other inhabitants include the Meru, Somali, Turkana and Samburu communities. The county is a flat low lying plain endowed with groundwater resources such as the Lorian swamp (Habaswein), springs such as the Gotu and six perennial rivers. The county utilises the underground water resources to drill strategic boreholes to provide water during the dry seasons. The county falls within agro-ecological zones V-VI, and just like Garissa, it experiences two rainy seasons. The short rains occur between October and December with a peak in November while the long rains occur between March and May with a peak in April. The semi-arid zone covers the wards of Wabera, Bulla Pesa and parts of Burat Ward in Isiolo north and southern parts of Kinna Ward in Isiolo South. The semi-arid zones receive an annual rainfall of 400 - 670 mms that supports sedentary agro-pastoral livestock production. The arid zone which are the main camel rearing areas in the county receives less than 300 mms of annual rainfall and cover the wards of Oldonyiro, Ngare mara, Chari, Cherab and parts of Burat in Isiolo North and Garbatulla, Sericho and parts of Kinna wards in Isiolo south. Isiolo county has a more diverse animal wildlife species when compared to Garissa. The county has three game reserves namely; Shaba, Buffalo Springs and Bisanadi. The Samburu and Meru national park also borders the county forming part of the northern tourist circuit (Isiolo CIDP 2018).

3.4.1 Camel population distribution in Garissa and Isiolo

Garissa county has a camel population of 816,057 animals while Isiolo county camel population is significantly less at 148,859 animals. Garissa has the third-largest camel population in Kenya while Isiolo is in the sixth position. The Somali camel breed is the main camel type reared in both counties. Garissa and Isiolo counties are traditional camel rearing areas in Kenya. The table below highlights the population distribution of camels in the two counties.

		ISIOLO COUNTY	
Sub- county		Ward	Number of camels
laiala Control		1. Wabera	0
		2. Bulla Pesa	0
		3. Burat	10,964
		4. Ngare Mara	8,964
		Sub-County Total 1	19,928
Morti		5. Chari	26,619
		6. Cherab	20,000
		Sub-County Total 2	46,619
		7. Kinna	35,000
Garbatulla		8. Garbatulla	35,000
		9. Sericho	12,312
		Sub-County Total 3	82,312
	Tota	I Camel Population in the county	148,859
	-	GARISSA COUNTY	
Sub-County	Wa	rd	Camel Population
	1.	Waberi	100
Garissa	2.	Galbet	350
Ganada	3.	Township	0
	4.	Iftin	2,000
	T	Total Sub-County 1	2,450
	5.	Balambala	57,276
	6.	Danyere	25,448
Balambala	7.	Jarajara	10,000
	8.	Saka	7,000
	9.	Sankuri	25,000
		Total Sub-County 2	124,724
	10.	Modagashe	31,669
	11.	Bename	12,000
Ladera	12.	Goreale	20,000
Laguera	13.	Maalamin	10,000
	14.	Sabena	10,000
	15.	Baraki	40,000
		Total Sub-County 3	123,669
	16.	Dertu	54,000
Dadaah	17.	Dabaab	59,483
	18.	Labasigale	15,000
	19.	Damajale	84,207

Table 2: Camel population distribution in Isiolo and Garissa Counties

	20. Liboi	79,208
	21. Abakaile	20,000
	Total Sub-County 4	311,898
	22. Bura	37,384
	23. Dekaharia	12,000
Fafi	24. Jarajila	99,883
	25. Fafi	47,384
	26. Nanighi	7,000
	Total Sub-County 5	203,651
	27. Hulugho	43,365
lioro	28. Sangailu	1000
Ijara	29. ljara	4,900
	30. Masalani	400
	49,665	
	816,057	

(Source: KNBS 2019 and County Department of Livestock Production Reports 2019)

3.4.2 Garissa and Isiolo Camel Milk Value Chains

Garissa county has a high and often unmet demand for camel milk with study respondents indicating there is no or very little camel milk exported out of the county for sale in Nairobi or neighbouring counties. The county director of livestock estimates that Garissa town receives a daily average of 8,000 litres of camel milk during the wet season and 5,000 litres during the dry season. The town has six camel milk selling points they include (i) Black market locally known as Sug Mugdi (ii) Garissa ndogo market also known as Malin-Aden (iii) Garissa livestock market (iv) Bulla medina market (v) Towfiq camel milk outlets and (vii) Al- Naim camel milk outlet. Camel milk traded in Garissa town is sourced from 5 clusters located withing Garissa county (4) and Tana River county (1) as detailed below;

- 1. Saka, Higle, Saka junction, Ashadin, Dujis, Abdisemed, Shimbirey, Ohiye, Nunow and Lago (in Garissa, Balambala sub-county),
- Modagashe-Baraki, Shantaabaq- Maalimin-Afwein- Modika- Benane (in Garissa, Lagdera sub-county),
- 3. Dashow, Harbole, Diise, Bura, Degwardey, Nanighi, Hagadera, Hagarbal (Alangoarba), and Lago (in Garissa, Fafi sub-county),
- 4. Dertu, Saretho, Hagarbul and Alangoarba (in Garissa Dadaab sub-county).
- 5. Bura sub-county in Tana-River county.

There are very few studies documenting the Garissa camel milk value chain. The field visit was also not able to get an accurate representation of the milk volume flows from the five camel milk clusters mentioned above. The Garissa camel milk value chain is highly informal and not regulated by the national (Kenya Dairy Board) or county government (Care 2009). The county earns some revenue from the value chain when issuing single business licenses for the camel milk outlets in Garissa town and public health certificates for the traders and workers running the milk outlets (Garissa CIDP 2018).

Based on reports from the county director of livestock, Isiolo town in 2019 was supplied with 2.7 million litres of fresh camel milk, of these 1,440 litres was processed into yoghurt that was sold locally by the Tawakal women group. The director estimates that Isiolo town receives a daily supply of 9,400 litres of camel milk during the wet season and 5,600 litres during the dry season. A 2015 study estimated that Isiolo town was supplied daily with 8,700 litres of camel milk during the wet season and 4,600 during the dry season (Mwaura et al. 2015). This indicates an 8 % increase of camel milk supplied during the wet season and a 22% increase during the dry season. The Isiolo camel milk value chain is identical to the Garissa one as it is also highly informal and not well regulated by the national (Kenya Dairy Board) or county government (Mwaura et al. 2015). Isiolo county earns some revenue from the camel milk value chain through the issuance of single business licenses for the camel milk outlets in Isiolo town and public health certificates for the traders and workers running these outlets (Mwaura et al. 2015). A 2015 University of Nairobi study by Mwaura and others, estimated that camel milk traders in Isiolo town collectively generated a monthly gross income of 10.58 million KES, 94% of this income was from sale of milk to the Nairobi terminal market. The study also observed that formalising the camel milk trade through the creation of functional marketing groups increased the women trader's income as well improved the revenue collected by the county government as more traders were paying for single business permits. Camel milk traded in Isiolo town is sourced from 4 clusters. They include the Central, Kulamawe, Garbatulla and Sericho clusters, as shown in figure 5 below. The Central and Kulamawe clusters due to their proximity to the town supply the highest quantity of milk (Mwaura et al. 2015).



Figure 5: Map of Isiolo county highlighting the four camel milk Supply Clusters (Source Yazan and Wasonga 2015)

3.4.3 Mapping Garissa and Isiolo Camel Milk Value Chains

The camel milk value chain in Garissa and Isiolo has six main actors (Figure 6). The lack of cold chain facilities means the milk must pass through a short chain to reach the consumer before spoilage occurs (Blackmore et al. 2020).



Figure 6: Garissa and Isiolo Camel value Chain Actors (Sourced and modified from Nori et al. 2006)

Producers

Camel herds in both Garissa and Isiolo counties are highly mobile in search of ideal browsing areas. Producers are men who are experienced camel herders; their role in the value chain is to milk the animals and store the milk in smoked plastic jerry cans. The calf is an integral part of the milking process as the camel cow will not have a sufficient milk-let down reflex unless the calf suckles. During the smoking process, the containers are inverted over hot smouldering tree twigs and branches (Figure 7) that have been harvested from specific tree species such as Acacia meifera, Acacia nilotica, Olea africana and Balanites aegyptiaca. After the smoking process, charcoal pieces from the twigs are put into the containers (Wanjala et al. 2006). This traditional practice gives the camel milk the smoky taste that consumers from the main camel keeping communities prefer (Akweya et al. 2012). The field visit to Garissa and Isiolo revealed

that inbreeding is a common practice as the producers will keep a good breeding male for over ten years. Male calves born in the herd are sold for slaughter when they reach 2 to 3 years. Female calves are maintained in the herd as replacement animals. Most females remain in the herd for over 15 years and are only culled if they are infertile or are too old. The hand-milking process begins with the cow and calf being put in separate enclosures (a), the herder then smokes the milk collection container (b). Each calf is then let out of the enclosure to suckle its mother(c), the herder waits for the calf to suckle and observes for the milk let-down reflex signified by the swallowing action of the cal. The herder then pushes the calf's head from the udder and begins to hand milk (d). The milk is then transferred into the smoked transport container, the motorbike transporter (f) delivers the milk to Isiolo town.



Figure 7: Camel hand milking process at Burat area Isiolo County (Source: Consultant)

In both counties, FGD respondents indicated that for a litre of milk, the primary trader pays the producer 60 KES during the wet season and 80 KES during the dry season. The producer supplies 10 litres of milk during the dry season and 20 litres during the wet season. The producer monthly milk sale earnings may range from 36,000 KES during the wet season and 24,000 KES during the dry season. The milk sale earnings could be higher; however, value chain studies in Isolo have found that over 80% of camel milk produced is consumed by calves and household members (Musinga et al. 2008). The main challenges faced by producers include predation (hyenas), high prevalence of diseases, especially mastitis. There is also a lack of input supplies like veterinary and extension services or easily accessible agro vet outlets. Lack of water to clean milk containers, udders, and milkers' hands was also another major challenge documented in the literature (Musings et al. 2008).

Primary traders

These are women who are located at the village town centres, they operate as a group, and they are the first milk bulking point in the value chain. They are responsible for ensuring the quality of milk. When the motorcycle riders or herders deliver the milk from the producer, they first conduct an organoleptic test to ascertain the milk is fresh. They then bulk the milk into 10 or 20-litre jerricans and wait for the transporter. In both counties, transportation is a challenge due to remote location of primary collection points and in both counties old land rover trucks are used as public service vehicles used to ferry people, livestock and goods such as milk (Figure 8). If the traders are located near Garissa or Isiolo town, they engage a motorbike rider to deliver to the town. The transporter charges 100 KES to transport a 20-litre jerrican.



Figure 8: A milk transport land rover truck in Garissa County (Source Care 2009)

The primary traders invest in the plastic jerricans and ensure they are well labelled and clean. Some traders may have access to water to clean the containers before they send back to the producers. However, in remote areas where the water is scarce, the trader relies on smoke to disinfect the containers. Some retailers may also depend on the secondary traders in Isiolo or Garissa towns to clean for them the plastic jerry cans as well as pay them to source replacement cans when the plastic jerricans break. On average, each primary trader, purchases milk from 8 to 20 herding households, women who have been in the trade for years have a high number of herders supplying them with milk (Musinga et al. 2008). The primary traders have family or clanship ties with the herders and secondary traders. The high mobility of the herds makes these ties loose and flexible. Most of the primary traders in Garissa and Isiolo also run a grocery shop (Figure 9). Most producers request the primary trader to use the milk sale earnings to purchase and deliver to them essential staple foods such as maise flour, beans, sugar or tea leaves. The producer often has no use for cash as there are no grocery stores in the remote location where camels are reared.



Figure 9: Primary milk traders milk collection and bulking sheds at Dujis (a) and Modika (b) in Lagdera sub-county, Garissa

The primary traders in both counties also rely on their family herds to offer a sustained supply of camel milk. The family herds are reared not more than 30 kilometres from where the primary trader operates. Thus allowing the trader a consistent and reliable supply of milk all year round.

Based on the KII with the county director of livestock, primary traders on a daily basis collectively supply Garissa town with 8,000 litres of camel milk during the wet season and 5,000 litres during the dry season. Using purchase price data of 70 KES during the wet season and 90 KES during dry season mentioned by secondary traders in Garissa and Isiolo towns. The primary traders in Garissa county can collectively earn a monthly income of 16.8 million KES during the wet season and 13.5 million KES during the dry season. Similarly, in Isiolo county, the primary traders supply on a daily basis 9,500 litres of milk during the wet season and 5,600 litres of milk during the dry season. The primary traders in Isiolo county can collectively earn a monthly income of 20 million KES during the wet season and 15 million KES during the dry season. The earnings calculated in both counties have not taken into account the cost of operation. This information was difficult to gather from literature and during the field visit interviews as there are no records of business operations maintained by the primary traders as majority do not have formal education. However, studies in other counties like Wajir indicate that the primary traders incur the highest cost of operation when compared to other value chain actors (Kuria and Gitonga 2016). Based on literature review findings from Isiolo and Wajir counties, the main challenges faced by primary traders include; Lack of water to clean the plastic containers, lack of cold storage and lack of hygienic milk containers. The primary traders are aware that plastic containers are not sanitary. However, they have no alternative as the current aluminium cans used to transport cow milk are not practical as they are too bulky and have a high milk spillage rate given the rough terrain. In addition, the transporters do not consider milk as an essential load that earns them income and hence will not agree to carry the bulky aluminium containers. Other challenges identified include high mobility of herds, especially during the dry season resulting in a reduced supply of milk from producers, impassable roads during the wet season results in high milk wastage. The primary traders in both counties experience high rates of milk spoilage as transporters often delay in the delivery of milk. The use of plastic containers that are not cleaned well also contributes to the increased milk spoilage. Breakage of the plastic milk containers resulting in loss of milk during the transportation is also a significant challenge (Musinga et al. 2008; Kuria and Gitonga 2016).

Secondary traders

These are predominately women whose main role is to bulk milk received from primary traders and sell it from roadside locations or county licensed milk outlets within Garissa and Isiolo towns. In Isiolo town, secondary traders also bulk and chill the milk to extend its shelf life and sell it at wholesale price to the terminal market in Nairobi. The secondary traders in both Garissa and Isiolo towns have organised themselves into cooperative milk groups. Garissa town has two registered camel milk cooperatives the AI- Naim and Towfig groups. The AI- Naim group has 24 members composed of 8 men and 16 women and was formed in 2013. The Towfig group has 60 members consisting of 10 men and 50 women. The Towfig group was formed in 2015 after the merger of two groups the Saka group based in Balamabala sub-county and the Jarirot group based in Garissa township sub-county. Both groups in Garissa have registered with the county government as cooperatives and have a management committee that is composed of a chairman, treasurer and secretary. New officials in the committee are elected every two years. The group members pooled resources to rent milk selling outlet in the central business area of Garissa town. Al-Naim group has one outlet while Towfig has two. The outlets have running water and electricity and are equipped with freezers. The outlets, in addition to selling raw camel milk, also sell tea and chilled unpasteurised camel milk. The formation of milk cooperatives has allowed members to be trained by NGOs on milk hygiene and milk value addition. The groups have also received capital assets from NGOs such as aluminium milk cans and for the Towfig group an automatic milk dispensing machine.

In Garissa town, the secondary traders conduct organoleptic tests to ensure the milk received from primary traders is not spoiled. The milk is then sieved, and the quantity supplied noted against the members' name. The milk is bulked into clean 20 litre jerricans or 10 litres aluminium containers and stored in the freezers. The Al-Naim group sells 300 litres of milk daily at KES 150 during the wet season and 100 litres of milk at KES 200 during the dry season. The Towfiq group sells 800 litres at 100 KES during the wet season and 400 litres at KES 150 during the dry season. Both groups purchase milk from primary traders at KES 70 per litre during the wet season and KES 90 per litre during the dry season. The milk outlets are not certified by KEBS or the Kenya Dairy Board (KDB). However, they are licensed by the county government through the issuance of a single business permit, food license permit and food handlers' certificate. The groups' main customer bases are hotels and restaurants in and around the town, households and small-scale market retailers who sell milk by the roadside or in the open-air markets. Members of the two groups also indicated they doubled as producers with most having purchased female animals that browse 10 to 30 kms from Garissa town.

The personal herds ensures they have a reliable supply of camel milk throughout the year. The group members diversify their incomes by running grocery shops, tea kiosks and processing camel meat into a dried product preserved in solid animal fat called 'nyirinyiri'. The income from nyirinyiri is not consistent as it is based on the occurrence of ceremonies like weddings. Table 3 below summarises the monthly net earnings for the secondary camel milk traders in Garissa. The operation cost for the groups includes payment of rent, electricity, water, cleaner and transporter.

Group Name	Monthly Milk sales Wet season (KES)	Monthly Milk sales Dry season (KES)	Wet season Input cost (Purchase of milk cost, Rent, licenses, electricity, water, worker salaries) (KES)	Dry season Input cost (Purchase of milk cost, Rent, licenses, electricity, water, worker salaries) (KES)	Monthly Group Net income Wet season (KES)	Monthly Group Net income Dry season (KES)	Individual Net income Wet season Less 100 monthly contribution (KES)	Individual Net income Dry season Less 100 monthly contribution (KES)
Towfiq 60 members	2.4 M	1.8 M	1.7 M	1.1M	700, 000	700,000	11,567	11,567
Al-Naim 24 members	1.35 M	600,000	660,000	300,000	690,000	300,000	28,750	12,400

Table 3: Secondary	v Camel milk trader monthly	v net earnings in Garissa	county (September 2020)
		y not carmings in Oanssa	county (ocptombol 2020)

On average, the Towfiq group has an estimated monthly operation cost of 1.7M KES during the wet season and 1.1 M KES during the dry season. Of these costs, the monthly purchase cost for milk from primary traders is the highest at 1.68 M KES during the wet season and 1.08 M KES during the dry season. The Al-Naim group has a monthly operation cost of KES 660,000 during the wet season and 300,000 during the dry season. The monthly purchase of milk is the highest cost at KES 630,000 during the wet season and 270,000 during the dry season. The individual net earnings for Towfiq group members is lower when compared to the Al-Naim group. However, the Towfiq income is stable across the year. The Al-Naim group are competitively priced but have significant fluctuation of income, especially during the dry season, which in most

cases is most of the year. Neither of the groups in Garissa engages in milk value addition despite being trained in yoghurt making and milk pasteurisation. The main reason given is that their customer base prefers raw camel milk. Besides, after the training, the groups realised that making yoghurt came with a higher operation cost which they could not afford. The daily sales made are banked, and the chair lady and treasurer of the groups divide the earnings to each member based on milk quantity delivered less the operation cost. The secondary traders receive their earning every month. Some members, however, prefer weekly payment so that they can be able to pay the primary traders. Payment of the primary trader is the sole responsibility of the individual secondary trader. Most primary traders are paid after every two days using either mobile money transfer or cash which is given to the transporter or put in the empty plastic jerrican being returned to the primary trader. The milk groups in Garissa town act as a social and economic support system for the members, each group member saves through a monthly contribution of 100 KES (50 for the merry go round fund and 50 for saving). Members are then able to access funds on a rotational basis as well as apply for unsecured loans. The main challenges mentioned by that Garissa town camel milk traders is the high operation cost incurred as they currently rent their premises. The Garissa groups are unable to get KEBS certification as the premises they operate in do not meet the required standards. The traders would also like to get dedicated vehicles to transport milk as they currently rely on the PSV buses and trucks to deliver milk. FGDs revealed that the camel milk business in Garissa town was not affected by the COVID-19 pandemic. However, most camels are pregnant, and this has significantly reduced the milk supplied to the town. During the field visit, the consultant observed that the Towfig group was not operating as a group as their premises, including the freezer, had not been used for many months. There was also no milk being delivered despite it being a peak time for milk delivery in the town. This is contrary to what was observed at the Al-Naim milk selling outlet where the consultant observed milk being delivered and customers streaming in to consume the chilled unpasteurised camel milk.

Similar to Garissa county, Isiolo town has two registered camel milk cooperatives. The Tawakal cooperative society which was founded in 1998 and registered as a cooperative in 2017. The group has 25 active members with only two male members. The second group is the Anolei women camel milk cooperative that has 42 active members and one male patron. When

compared to the Garissa groups, the Isiolo groups have received significant support from NGOs and development partners. The support includes training on milk hygiene and value addition, purchase of aluminium cans, fitting of bulking, chilling tanks and pasteuriser machines. The Anolei group was recently supported with the purchase of a refrigerated transport truck while the Tawakal group which owns land where their milk outlet is located was recently built a fully equipped milk and Nyirinyiri processing outlet that meets KEBS standards. The Anolei group do not own land and have been renting the premises where they bulk and sell milk. Similar to Garissa, the milk groups in Isiolo act as a social and economic support system for the members allowing them access to a revolving fund and unsecured loans. Also similar to Garissa, the secondary traders in Isiolo town conduct organoleptic tests to ensure the milk received from primary traders is not spoiled. The milk is then sieved, and the quantity supplied noted against the members' name. For the Anolei group, the milk is bulked in aluminium cans and put into the bulking tank for chilling, the bulking tank (Figure 10) has a capacity of 3,000 litres. Excess milk is stored in 20 and 10 litres plastic jerricans and stored in the members' freezers. The milk is kept chilled overnight and transported as early as 4 am to the terminal market in Maua, Meru and Eastleigh in Nairobi using the groups refrigerated truck. The Tawakal group also has a 3000litre bulking tank that was donated, but it is not used as they are still trading in milk quantities that are below its holding capacity. The Tawakal members store in members freezers the sieved milk in 10 and 20-litre plastic containers (Figure 10) before transporting the milk the following day to the terminal market in Nairobi's Eastleigh area using public service transport buses.

The business relationship between the secondary traders in Isiolo towns and traders at the terminal market depends on trust, as money is usually sent two to five days after delivery of milk via mobile money transfer to the group's bank account. Therefore, like the camel milk producers and primary traders' relationship, the secondary trader's relationship with the terminal market is deep-rooted in clan and family relations. The labelling of the plastic containers, as shown in figure 11, allows the identification of the secondary trader and the terminal market retailer. The Isiolo town milk traders buy milk individually from their network of primary traders. Some members also have family herds located 10 to 30 kilometres from Isiolo town. The secondary traders receive their earning every month less operation cost. Some members, however, prefer weekly payment so that they can be able to pay the primary traders. Payment of the primary

trader is the sole responsibility of the individual traders. Most primary traders are paid after every two days using either mobile money transfer or cash which is given to the transporter or put in the empty plastic jerrican being returned to the primary trader.



Figure 10: Camel milk handling process at secondary traders' level, Isiolo town

(Source Consultant)

Non-food grade plastic jerricans delivered at the secondary milk outlet (a); The milk is sieved and put in aluminium cans (b); before being put in the bulking tank for overnight chilling Anolei outlet (c) and freezers Tawakal outlet (d).



Figure 11: Labelled plastic containers at the reception of the Anolei group milk bulking premises (Source Nato et al. 2018)

The Tawakal group in Isiolo town sells 600 litres of camel milk during the dry season and 2000 litres during the wet season. While the Anolei group sells 2,500 litres of camel milk during the dry season and 6000 litres during the wet season. The current wholesale sale price to the terminal market for the Anolei group is KES 100 during the wet season and KES 125 during the dry season while the Tawakal group sells a litre of camel milk at 150 KES during the dry season and 100 KES during the wet season. The operation cost for the Isiolo town groups includes payment for fuel, rent, electricity, water and workers salary for the Anolei group. The operation cost for the Tawakal group includes payment of electricity, water, cleaner and bus fare transport to Nairobi.

Table 4 below summarises the monthly net earnings for the secondary traders in Isiolo. The Tawakal group has an estimated monthly operation cost of 4.3 million (M) KES during the wet season and 1.7 M KES during the dry season. Of these costs, the monthly purchase cost for milk from primary traders is the highest at KES 4.2 M during the wet season and KES 1.62 M during the dry season. The Anolei group has a monthly operation cost of KES 13 M during the wet season and KES 7.2 M during the dry season. The monthly purchase cost of milk is the highest expense at KES 12.6 M during the wet season and KES 6.8 M during the dry season.

Group Name	Milk sales Wet season (KES)	Milk sales Dry season (KES)	Wet season Input cost (Purchase of milk cost, Rent, licenses, electricity, water, worker salaries) (KES)	Dry season Input cost (Purchase of milk cost, Rent, licenses, electricity, water, worker salaries) (KES)	Group Net income Wet season (KES)	Group Net income Dry season (KES)	Individual Net income Wet season Less 100 monthly contribution (KES)	Individual Net income Dry season Less 100 monthly contribution (KES)
Tawakal								
(25)	6 M	2.7 M	4.3 M	1.7 M	1.7 M	1 M	67,900	39,900
Anolei (42)	18 M	9.4 M	13 M	7.2 M	5 M	2.2 M	118,948	52,280

Table 4: Secondary traders monthly net earnings from camel milk sales Isiolo county(September 2020)

The cooperative groups in Isiolo earn significantly more than their counterparts in Garissa as they trade in larger quantities of milk due to the demand from the terminal markets outside the county. The current study findings in Isiolo indicate a marked increase in milk quantities traded and a significant increase in the group's monthly earnings when compared to results of a 2015 study. The 2015 study found that the Anolei group earned an average a gross monthly income of KES 200,995 during the dry season and KES 211,579 during the wet season (Mwaura et al. 2015). The NGO support with trainings on milk handling and provision of bulking and chilling equipment's has resulted in a marked increase in the Isiolo camel milk group incomes. The Tawakal milk group in Isiolo was the only group engaged in milk value addition activities of yoghurt and ice-cream making during the wet season.

The main challenges mentioned by the secondary traders in Isiolo was the lack of practical and hygienic aluminium cans as well as delayed payment by the terminal market traders. The COVID-19 pandemic did not affect the milk group operations. However, traders noted that most camels in Isiolo were pregnant; hence the milk quantity had significantly reduced. During the field visit to Isiolo town. The consultant observed that several individuals in the town were operating as secondary traders without being members of a cooperative milk group. One such individual was Councillor Ibrahim who is participating in the FAO longitudinal MERS-CoV study. The Councillor has a herd of 200 animals composed of mainly female animals except for one breeding bull. He supplies the terminal market in Nairobi with 200 litres of camel milk daily regardless of the season. He sells a litre of milk at 125 KES, earning him 750,000 KES every month.

Open-air market milk retailers

The open-air market milk retailers are mainly women who sell camel milk by the roadside or in open-air markets in and around Garissa and Isiolo towns (Figure 12). In Garissa county, the Towfiq group with 60 members may also play the role of market milk traders as there was no evidence that they were bulking milk to sell to a common terminal market as witnessed in Isiolo county. Garissa county did not have records of how many women operate as market milk traders or what quantity of milk is traded. Making it challenging to analyse the income earned. However, the county director of livestock production indicated that the current selling price of camel milk in the town was 150 KES during the dry season and 100 KES during the wet season.



Figure 12 Open-air camel milk market in Garissa county

In Isiolo county, a 2015 value chain study estimated that the town had 22 roadside camel milk retailers. The women split themselves into two groups with half selling milk during the day and the other half in the evening. The retailers traded in smaller quantities of milk when compared to the secondary traders. During the dry season, they sold 10 litres of camel milk at 100 KES while during the wet season they sold 20 litres of milk at 90 KES. The retailers also sold goat and cow milk. The 2015 study also noted that although the retailers had not formed groups, they had an existing merry go round saving scheme in place that allowed them to access funds on a rotational basis as well borrow unsecured loans. The open-air camel milk retailers source milk either directly from the producers or through the secondary traders who offer the milk at a negotiated wholesale price (Mwaura et al. 2015). The monthly income earned for both Garissa and Isiolo market retailers is challenging to calculate as there is no information on the purchase price and cost of operation. Literature findings indicate that the main challenges faced by market retailers include lack of market infrastructure to allow them to conduct their business hygienically. The traders also face high milk spoilage rates as they have no cold storage. Consumers have also indicated that some market retailers adulterate camel milk by mixing it with cow or goat milk (Kuria and Gitonga 2016).

Transporters

These are men contracted by the primary or secondary traders to transport milk. Depending on the distance to be covered, they transporter uses motorbikes (Figure 13) or public service vehicles. Study respondents indicated that the transporters charge KES 100 for a 20-litre jerrican in both Garissa and Isiolo counties. There was lack of information of the income earned by transporters in Garissa county. However, in Isiolo county, a 2015 study estimated that the bus owners who transport camel milk to Nairobi earn a monthly income of 2.157 million KES while motorbike owners make a monthly income of KSh12,450 (dry season) and KSh16,500 (wet season). Truck owners who transport goods to Wajir along the Kulamawe route earn a monthly income of 72,000 KES during the dry season and 90,000 KES during the wet season.



Figure 13: Motorbike transporter delivering camel milk to Anolei milk outlet in Isiolo town

Camel milk processors

A private investor couple Zama Zam Haji and Jama Warsame were interviewed. The couple own the camel milk processing company called Ngamia camel milk suppliers. The milk processing company sells pasteurised and packaged camel milk under the brand name 'White Gold'. The processing plant is based in Nanyuki, Laikipia county. The processing plant began operations in 2017 following the closure of the Vital camel milk, which was the first camel milk processing plant in Kenya. The family currently has a herd of 70 animals composed of female cows and their calves. The family does not keep a breeding bull, and male calves are sold to the local market for slaughter when they reach 2 to 3 years for an average price of KES 60,000. During the breeding season that falls between November and March, the couple negotiate with ranchers to borrow a breeding bull. The entrepreneur family land is not big enough to maintain the current family herd. The couple are currently leasing land located in different parts of Nanyuki at a monthly cost of 20,000 KES. The camel herd is supplemented with hay, bran and salts during

the dry season to ensure milk production is maintained. The processing plant is currently pasteurising and packing on a daily basis 500 litres. Most of the milk (300) litres is sourced from two ranchers Impala and Lolldaiga. Depending on the season, 5 to 10 small scale producers collectively bring 100 litres and the remaining 100 litres also depending on the season is sourced from the family herd. Payment to the producers is made every ten days at a rate of 100 KES for a litre of camel milk. The processing plant accepts fresh milk (warm or chilled) that is not smoked. To ensure the standards are maintained, the processor has partnered with the county department of livestock production to offer extension services to the small-scale producers. Figure 14 below highlights the processing steps taken from milk delivery to packaging and transport to the terminal markets.



Figure 14: Camel Milk Processing Process Nanyuki, Laikipia County

Camel milk delivered to the processing plant first undergoes platform tests that include (a) organoleptic test of smelling and observing for milk curdling. There is no tasting as this is a public health risk for the staff. The milk also undergoes chemical testing using ethanol, if the milk clots after addition of the ethanol it is rejected. The final platform test is the physical test using a lactometer; milk is only accepted if the lactometer reading is between 26 to 32. Once it passes the platform tests, the milk is sieved, weighed and quantity recorded against the name of the

supplier. The supplier is then issued with a receipt as proof of delivery. Milk that fails the platform tests is returned to the supplier. The accepted milk is then taken for processing, where strict hygiene measures are followed (b). Milk is pasteurised (c) using indirect heating (Water jacket pasteuriser), the milk is indirectly heated to 75°C and held at this temperature for 15 minutes. The milk is then pumped to the cooling tank to cool to 40°C. Once cooled, the milk is packaged in 500 mls bottles (d), that are labelled and stored in the freezer (e). On the day of delivery, the milk bottles are put in a cool box lined with black paper and ice (f) this ensure the milk remains chilled during transportation to the terminal markets. The processor has captured a niche Nairobi market that is consuming the milk for its health benefits. The company supplies individual consumers in Meru, Thika, Nairobi, Kisumu and supermarkets in Nairobi such as Carrefour and Chandarana. The customer base has now expanded to the East African region, with individual consumers based in Uganda, Tanzania and Rwanda. The retail price for a litre of pasteurised milk is KES 280, while a litre of raw chilled camel milk supplied to restaurants in South B is sold at 260 KES. About 30% (150 litres) of the 500 litres delivered to the processing plant is sold as raw milk the rest is pasteurised and packaged in half-litre containers. The plant is now diversifying into the production of flavoured milk. The main challenges faced by the processor is lack of consistent milk quality by the small-scale producers who sometimes adulterate the milk by adding sugar, water and wheat flour. In addition, the small-scale producers are not willing to wait for ten days to receive their payments; hence the supply from the small-scale producers is erratic when compared to the ranchers' supply chain. The other major challenge is the lack of regulation and policies to govern the camel milk value chains. The processor indicated that he had secured an export market. However, the lack of national standards and guidelines on camel milk has hindered him from accessing the export market. The processor monthly milk sales earnings are approximately 4.2 M KES. Once the milk purchase cost (KES 50,000) and operation costs (KES 336,000) are deducted, the processor is left with a monthly income of 3.8 M KES.

Consumers

There is a high consumer demand for fresh raw camel milk due to the perception that the pasteurisation process reduces the camel milk health benefits (Akweya et al. 2012). Lack of research on camel milk benefits means that most perception and myths concerning camel milk cannot be validated or dispelled (Getha et al. 2020).

Consumers are concerned about the camel milk safety due to the use on non-food grade plastic containers (Akweya et al. 2012; Kuria and Gitonga 2016; Bebe et al. 2020). Camel milk research in Kenya has shown that when camel milk is not handled hygienically the milk becomes contaminated with high levels of microbes, including zoonotic bacteria such as brucella (Nato et al. 2018). The Interview with the private camel milk processor in Nanyuki indicated that most urban consumers prefer camel milk that is pasteurised and does not have the smoky flavour and the consumers were willing to pay more for milk that met this standard. This means that there is an emerging market for camel milk that meets food safety standards.

Input service providers and Regulators

There is scanty literature on the type and role of input suppliers along the camel milk value chains in Kenya. Some of the possible input suppliers for the value chain are the animal health and extension service providers, as well as agrovet outlets selling veterinary medicinal products. Other Input providers include retailers selling used vegetable oil containers, vehicle and motorbike dealers including village-level mechanics who service the motorbike and trucks transporting the milk. Due to lack of budget allocation to develop the value chain by the national and county governments. NGOs such as VSF-Suisse, Biovision, care international and SNV and development partners such as USAID, World Bank and European Union have invested in the value chain development with the ultimate goal of having it formalised. The training and provision of hygienic equipment have significantly improved the income of value chain actors as more milk is now being traded. The revenue gained from camel milk value chains by Garissa and Isiolo county governments is minimal and often negligible.

Historically, milk trading in pastoralist communities was done by the very poor. This perception still holds today as most county governments do not want to set a tax bracket for an informal sector dominated by women who are often widowed and considered to be amongst the most vulnerable in the society (Mwaura et al. 2015). Garissa and Isiolo county governments through the support of NGOs and development partners are moving towards formalisation of the camel milk value chains. However, these efforts should be conscious of the deep-rooted social-cultural ties that govern the value chains. A hybrid system that respects and improves on these social relationships should be considered this will ensure an equitable and sustainable avenue to regulate the sector (Blackmore et al. 2020).

3.5 Mapping Garissa and Isiolo camel meat value chains

In 2019, Kenya's meat production was estimated to be approximately 598,416 Metric Tonnes (MT); of these, 10% (57,569 MT) was from camel meat. Garissa county is the largest camel meat-producing county in Kenya with an annual production of 27,000 MT. Isiolo is the fourth with an annual production of 2,232 MT (GoK _b 2019). The Kenyan meat industry as a whole is characterised by sub-optimal operations with significant post-harvest losses and low-value addition (KMT 2019). Pastoralist production systems are the primary source of red meat consumed in Kenya. Mobility of livestock is a crucial strategy that ensures the survival of livestock. Mobility occurs across vast geographical areas, as shown in figure 15 below.



Figure 15: Map depicting livestock mobility routes during dry and drought periods in Northern Kenya

(Source ADA 2014)

Different ethnic communities control access to the vast Northern Kenya grazing areas; this means that communities have to negotiate reciprocal access rights to ensure adequate resource

sharing and management. The Borana ethnic group in Isiolo county has an active traditional system of land management that is enforced by the Dedha council of elders. The council limits the over-exploitation of natural resources, such as water, pasture and forests. The elders negotiate on behalf of the community as well as grant access rights to the drought reserve areas. Isiolo county drought reserve such as Kom in Merti, Kinna in Garbatulla and Isiolo holding ground in Isiolo central are hot spots for conflict as communities from Wajir, Garissa and Samburu migrate into Isiolo without necessarily seeking access rights from the Dedha elders (ADA 2014).

The primary source of animals for the camel meat value chains are the livestock markets. The livestock trade business is an arbitrage system that earns profits by buying at low prices in one area and selling at higher prices in another. Livestock trade in Kenya occurs within and outside formal marketing systems. Primary markets do not necessarily refer to a physical place or location with most transactions occurring at watering points or homesteads/villages. The buyers at the primary market, also referred to as livestock collectors are often itinerant traders from the same community as the producers who are selling their livestock. For instance, primary market traders in Isiolo central are from the Borana community while those in Escot market are from the Somali community (Guyo, 2020). Livestock collectors depending on their purchasing power, buy livestock from producers at the primary market. However, in most cases especially at the village level, the producer will rely on trust and family/clanship ties to hand the animals to the collector with the hope that they will get a better price for their animal at the secondary or tertiary markets (Mahmoud 2008). The livestock collectors will buy livestock and aggregate them while utilising the grazing resources at village level until they reach the desired number before trekking them to the secondary markets. At the secondary market, the livestock collectors meets with other brokers hired to negotiate rates by medium and large-scale livestock traders. Large scale traders often own trucks and have contracts with terminal markets. At the livestock markets other actors include trekkers employed by medium or large-scale traders to trek animals to the markets, there are also animal loaders and branding workers who mark animals after their sale to prove new ownership (Ngasike 2019; Guyo 2020).

Camels for slaughter in Garissa county are sourced from five markets, four of these are in Garissa county, and one is in Tana River county. The Garissa markets include Modagashe located in Lagdera sub-county, Garissa in Garissa township sub-county, Dagahley in Dadaab sub-county and Hagardera in Fafi sub-county. The four markets mainly trade in camels destined for the Somalia export market. A summary of the market inflow and outflow characteristics is outlined in the appendix section of this report. Garissa has three camel slaughter premises one is a category B slaughterhouse while the other two are slaughter slabs. The specifications for the slaughter house are outlined in the appendices section of this report.

Almost all camels slaughtered in Garissa town slaughterhouse are sourced from Bangale market located in Tana River County. The camels slaughtered in Garissa town are supplied by five traders who have monopolised the value chain. The traders purchase on a weekly basis 150 camels at an average individual animal cost of 60,000 KES. The purchased animals are then trekked to Garissa town, which is approximately 80 kms away. The traders hire four trekkers who are paid a daily wage of 500 KES. The Garissa slaughterhouse is currently being managed by a private investor who has been running it for seven years. The private entrepreneur invested approximately 4 million KES to renovate the slaughterhouse, including building the camel killing slab and offals cleaning area. The investor also built a perimeter fence. The slaughterhouse operates every day of the week on almost a 24-hour basis. The investor ensures that two county government meat inspectors are available to inspect the meat. The slaughterhouse has three cleaners to ensure cleaning is ongoing throughout the day. Slaughter operations start at 4 pm, and end at 10 am to allow cleaning in preparation for the 4 pm slaughter.

On average, 27 camels are slaughtered every day in Garissa town. During religious festivals, this number rises to 45 animals a day. The traders pay 600 KES as slaughter fee for each animal. The five traders have a monopoly over the camel meat value chain and are the main suppliers for butchers in the town. One camel carcass is split into 16 cuts the butchers purchase each cut from the traders at 7,500 KES. The traders sell the camel head and offals to women traders from Tana River County at the cost of 1,500 KES and the camel skin for 200 KES. The meat is not weighed when being purchased by the butchers at the slaughterhouse. Butchers interviewed commented that the business was a chance game where they either had less or more meat than

expected. The butchers weigh the meat before selling it to consumers. A kilogram of meat without bones (Steak) is sold at 600 KES, and a kilogram of meat with bones is sold at 400 KES. The monthly income from meat sales earned by butchers was difficult to compute as there was no information on how many kilograms of meat was purchased by butchers at the slaughterhouse. The butchers play the role of slaughter person for the traders; they also eviscerate and split the carcass. The trader hires male flayers for 500 KES. The main challenges mentioned by the butchers was lack of protective clothing and monopoly of the traders who ensure that prices of live camels are too high for the butcher to purchase animals for slaughter. The butchers indicated the demand for meat is high in the town, but they are not able to meet it as they have no cold chain equipment. However, despite the trader's monopoly, the butchers were quick to mention that the traders supported them during difficult periods through the provision of credit facility inform of meat cuts. The five traders earn a combined monthly income of 48.6 million KES as shown in table 5 below

Purchase price (27 animals) @ average price KES 60,000	Sale Price of camel meat @ KES 7,500 for each cut (Each camel gives 16 cuts 27 camels give 432 cuts)	Camel Trader's Daily Gross income from the sale of camel meat cuts	Camel Trader's Monthly Gross income from the sale of camel meat cuts
1.62 M	3.24 M	1.62 M	48.6 M

 Table 5: Garissa Traders Gross Income from Camel Meat Trade

The Dagahley slaughter slab located in Dadaab sub-county, Dadaab ward, slaughters 4 to 7 camels daily while the Hagardera slaughter slab located in Fafi sub-county, Fafi ward. Slaughters 7 to 13 camels daily. The camel meat from the two slabs is consumed locally as the areas host the largest refugee camps in the world.

Isiolo has three camel markets, Isiolo town livestock market is located in Isiolo central subcounty, Escot and Duse markets are situated in Garbatulla sub-county. During the field visit, interviews with the livestock marketing association officials established that camels were not traded in the Isiolo town market. This was despite evidence indicating that weekly transactions were occurring as camel traders paid to use the livestock loading ramp in the market on Tuesdays and Thursdays. The traders loaded every week about 70 animals destined for the Molongo slaughterhouse located in Athiriver, Machakos county. The camels are not inspected as loading occurs outside the market days (Monday, Wednesday and Friday). The loading ramps at the markets are managed by the livestock marketing association and not the county government. Isiolo county has a severe shortage of animal health staff. The primary camel markets located at Escot and Duse do not have animal health staff. Camels traded in Escot and Duse are rarely slaughtered in Isiolo with the majority being trekked to Garissa county. The Isiolo slaughterhouse is categorised as category B and is located in Isiolo town. The slaughterhouse operates six days a week. The slaughterhouse has a gate but no perimeter fence, the butchers pooled resources and constructed an overnight holding pen for camels. Unlike in Garissa county, the Isiolo slaughter house is managed by the county department of veterinary services that charges 220 KES as meat inspection fee for each camel slaughtered. In Isiolo county, wholesale butchers are the main suppliers of live camel animals for slaughter. The wholesale butchers collectively slaughter 25 camels daily. The wholesale butchers' source camels from Merille market in Marsabit county, Lolkuniyani market in Samburu county and villages around Isiolo county. Each butcher purchases every week 20 adult male camels that are over five years old at an average price of 50,000 KES.

The butchers collectively pay to have the camels purchased trekked to Isiolo town. Due to the insecurity in the area, the butchers 4,000 KES to armed Samburu conservancy workers to trek the animals to Isiolo. Isiolo town has 11 wholesale butchers, two are men, and the rest are women. Interviews with four female wholesale butchers revealed that most had ventured into the butcher business as they were either widowed or had become the sole breadwinners for their family when their husbands remarried and had stopped supporting them. The women butchers raised money to buy camels from male relatives with an understanding that they returned the money at the end of every week. The main challenge mentioned by the women butchers was the high insecurity incidences that resulted in loss of camels being trekked. The women noted that the investors in their business expected them to pay even if the camels were stolen. The women butchers were once supported by an NGO (VSF-Suisse) and were provided with protective aprons and butcher knives. The female butchers individually slaughter 2 to 4 camels daily. The butchers have licensed meat carrying boxes which they use to transport the meat from the slaughterhouse to their butchery outlets.

They pay the motorbike transporter 400 KES a day for this service. The butchers sell the meat to small scale butchers, hotels and restaurants at a wholesale price of KES 330 per kg and 400 KES per kg to consumers. The butchers sell camel offals and camel heads for 3,200 KES. The slaughterhouse has 12 camel offal traders. The offal traders pay 150 KES to have the offals washed and meat from the head removed. The butchers sell the camel skin at 200 KES to two hide and skin traders. The wholesale butchers employ a slaughterman at KES 1000 and a flayer at KES 500 daily. The wholesale women butchers also employ butchers at their outlets for a monthly salary of 10,000 KES. The flayers are required to acquire an annual flayer license for KES 300 from the county veterinary department. The slaughterhouse workers, flayers, slaughtermen and butchers are required to have medical certificate costs 1,000 KES. The slaughterhouse also has petty camel meat traders who purchase camel meat from the skin or head. The petty traders run informal eating outlets (kiosks) or roadside eating outlets. Collectively the 11 wholesale butchers make monthly a gross income of 18 Million KES from camel meat trade.

Purchase price (20 animals) @ average price KES 50,000	Sale Price of camel meat @ KES 400 per kg. (Each camel yield 200 kgs carcass weight 20 camels yield 4000 kgs)	Camel Trader's Daily Gross income from the sale of camel meat	Camel Trader's Monthly Gross income from the sale of camel meat
1 M	1.6 M	0.6	18 M

Table 6: Isiolo Camel Butchers Gross income from Came Meat Trade

Isiolo County has two private investors who engage in camel hide trade. The county department of livestock production estimated that in 2019, the county exported 5712 camel hides. The camel hide traders use sun-drying and wet salting preservation techniques. The processors sell the preserved hides to tanneries in Athiriver. The hides and skin traders buy the camel skin from wholesale butchers at 200 KES. They then remove the hard pads and spits the skin into two before sun drying or wet salting. The hide and skin trader preserving the camel hide through wet salting supplies the Athi-river tannery every two months with 11 tonnes equivalent to 500 pieces of camel skin. He receives 25 KES for every kg delivered. The trader noted that since he has not been trained, he experiences heavy losses through spoilage and rejection rates.



Figure 16: Flow diagram of the Camel meat Value chain in Garissa and Isiolo Counties of Kenya

(Source: own data October 2020)

The study identified only one camel meat processor. The private processor located in Isiolo town processes camel meat into camel sausages and hamburger patties. The processor is now venturing into vacuum packing of specialised camel meat cuts. He sells his products to consumers within Isiolo town and in Nairobi.

3.6 Seroprevalence of MERS-CoV in Kenya

Dromedary camels are implicated as reservoirs for MERS-CoV. The respiratory route is the main mode of transmission. A recent study in Kenya found that two slaughtermen (person cutting the throat of the camel) tested positive for MERS-CoV neutralizing antibodies. However, the two workers did not have any symptoms or history of flu-like symptoms (Kiyanga et al. 2020). Numerous studies in Kenya have demonstrated a high seroprevalence rate of MERS-CoV antibodies in camel populations. A 2018 nationwide seroprevalence and genetic analysis study that sampled 1,163 camels and 486 humans from 13 counties in Kenya (Figure 17) found that all camel-rearing counties of Kenya had positive seroprevalence results for MERS-CoV antibodies. Marsabit county had the highest (87.34%) seroprevalence. The study also found that seroprevalence in camels increased with age, with the highest prevalence being in adult camels. The phylogenetic analysis collaborated findings from a 2018 study by Kiambi and others, that found that Kenya's MERS-CoV clustered within sub-clade C2, which is associated with the African clade and not the Arabian Peninsula viral strains (clades A and B). Young Juvenile female camels had a high viral load than adults indicating that they may play a role in maintenance and spread of MERS-CoV. However, the study did not have an equal gender representation due to the husbandry practice that retains more female animals than males. The human plasma did not contain neutralizing antibodies against MERS-CoV, as was reported previously (Munyua et al. 2013). The current research findings may indicate that the MERS-CoV strain in Kenya may have a low pathogenicity in humans (Ommeh et al. 2020). There is little evidence suggesting the possibility of transmission of MERS-CoV from camel products to humans. There is need for more research to conclusively determine if camel products are involved in the transmission of the virus to man (Killerby et al. 2020).



Variable	Category	Ecotype/Breed	No. tested	No. positive	Prevalence % (95% CI)	Odds Ratio (95% CI)	P value
Region	Region A	Turkana	156	76	48.72 (95% CI 41.00-56.50)	4.72 (2.39–9.86)	<i>P</i> < 0.001
	Region B	Rendille/Gabbra	293	234	79.86 (95% CI 74.90-84.06)	19.62 (10.11-40.44)	
	Region C	Somali	611	460	75.29 (95% CI 71.72–78.54)	15.16 (8.17-30.01)	
	Region D	Improved/Pakistani	84	14	16.67% (95% CI 10.20-26.05)	1	
	Region E	Somali	19	8	42.11% (95% CI 23.14-63.72)	3.58 (1.05-12.00)	
Sex*	Male		348	187	53.74% (95% CI 48.48-58.90)	1	<i>P</i> < 0.001
	Female		801	595	74.28% (95% CI 71.14-77.19)	2.49 (1.89-3.26)	
Age*	Juvenile		319	115	36.05% (95% CI 30.98-41.46)	1	<i>P</i> < 0.001
	Sub-adult		70	41	58.57% (95% CI 46.88-69.37)	2.5 (1.43-4.42)	
	Adult		760	626	82.37% (95% CI 79.50-84.91)	8.27 (6.1–11.25)	

*Data for 14 samples were not available.

Figure 17: MERS-CoV Seroprevalence in 13 Camel Rearing Counties of Kenya (Source Ommeh et al. 2018)

3.7. Mapping MERS-CoV risk factors along the Garissa and Isiolo camel meat and milk value chains

The value chain study found that all actors in the value chain had existing knowledge on zoonotic diseases such as brucellosis, Rift Valley Fever and Rabies. However, only the county veterinary department directors had existing MERS-CoV knowledge. Field interviews did not identify interactions between camels and wildlife with most respondents indicating the main wildlife convergence zone was in the grazing areas that had Giraffe and small ruminants like Impala, grant gazelles and dik-dik. Hyenas were mainly associated with predation of camel calves. Respondents indicated that camels rarely came into contact with bats. During the field visit, it was observed that the Marabou stork was a prominent wild bird in both the Garissa and Isiolo slaughterhouses. The study identified the following risk factors along the camel milk and meat value chains that could promote MERS-CoV amplification and spillover events;

At the producer level

- XII. Lack of water to wash off the calf's saliva from the udder and milkers' hands could potentially expose the herders to zoonotic pathogens as well as increase the likelihood of milk contamination with pathogens.
- XIII. Congregation of camel herds from neighbouring counties in Isiolo dry season grazing areas may result in widespread geographical transmission of diseases.
- XIV. The increased number of producers engaging in peri-urban camel milk production means that camels are now being reared in close proximity to the high urban human population. This means that more people are at an increased risk of zoonotic disease exposure.

At camel milk and meat traders' level

- XV. The study found that most camel livestock markets in Isiolo and Garissa had no animal health officers. This makes the markets possible hot spots areas for zoonotic disease transmission and spread. The lack of officers means that there is also a delay in detection of disease events.
- XVI. The primary and secondary milk traders are at an increased risk for zoonotic pathogen exposure as they usually use the organoleptic test of taste to accept or reject the milk.
- XVII. Slaughter house workers especially in Garissa county are at an increased risk of zoonotic pathogen exposure as they do not wear personal protective clothing. In addition, in both

Isiolo and Garissa, the slaughter men do not wear masks or safety googles putting them at an increased risk of MERS-CoV exposure.

- XVIII. Slaughter houses in both Garissa and Isiolo counties do not have equipment to hoist the camel carcasses off the ground. The prolonged contact of the carcass with blood increases the risk of meat being contaminated with harmful pathogens.
 - XIX. The lack of a fence at the Isiolo slaughter house and lack of walls at the Garissa camel slaughter slab allows the wild birds to scavenge on camel tissues including respiratory tract organs. The repeated exposure of the wild birds to camel respiratory tissue may result in MERS-CoV amplification and eventual spill over to humans.
 - XX. The unregulated camel bones trade to Thika and Nyeri counties and camel skin to Athiriver tanneries means that zoonotic pathogens can spread to counties that are not linked to camel rearing making it difficult to link disease outbreak incidences in these counties to camel products.
 - XXI. Lack of proper solid and liquid waste management in both slaughter houses may contaminate the ground water. Given that most residents in Isiolo and Garissa towns rely on shallow wells for their domestic and livestock water needs, the ground water contamination may result in zoonotic disease outbreaks.

At consumer level

XXII. The consumer preference for raw milk consumption puts them at an increased risk of zoonotic disease exposure specifically Brucellosis.

4.0 Conclusion and Recommendations

The literature review identified existing information gaps concerning camel meat value chains in most camel keeping counites of Kenya. This was attributed to the highly informal nature of the operations. The camel meat value chain is governed by middlemen traders who benefit most as demonstrated by the Garissa county case study. There was existing and comprehensive data on the camel milk value chain in Isiolo county but scarce information on the Garissa camel milk value chain. Given that Garissa is one of the counties with the highest camel population in Kenya, there is need to conduct more value chain and zoonotic disease research. Despite literature indicating that Garissa county supplied camel milk to Nairobi, the study revealed that this was not the case as there was a high unmet demand for camel milk in Garissa town.

In spite of the decade long investment in improving the camel milk quality in Isiolo county, the practice of using non-food grade plastic containers is still prevalent as there are no practical alternatives. The study found that peri-urban camel milk production in both Garissa and Isiolo counties was common with most peri-urban producers maintaining a predominately female herd. The main value addition activity in the camel milk value chain was transferring the milk from one location to another. However, in Laikipia county private investors are producing non-smoked and pasteurised camel milk for a consumer base that is utilising the milk for its health and medicinal benefits. Camel meat in both Garissa and Isiolo county is mainly consumed fresh with no value addition. However, most women traders engage in production of a cooked dried camel meat product locally know us 'nyirinyiri'. This product has an erratic production as it is only demanded for during cultural and religious celebrations. The camel meat processor located in Isiolo town was producing camel sausages and hamburger patties. However, the uptake of the processed products was low amongst Nairobi consumers who predominately prefer beef, chicken or pork (non-Muslim consumers) products. The Isiolo processors idea of diversifying into vacuum packed specialised camel meat cuts could improve uptake of camel meat consumption by non-Muslim communities. The camel milk and meat value chains are governed by strong family and clan relations hence the reason they have remained informal and unable to integrate into the formal milk and meat market systems. This challenge also make it difficult to regulate the chains as well as quantify their contribution to the county's and national economy. The study has highlighted the important role played by women in both the camel milk and meat value chains and this should be considered by policy makers as they strive to regulate and integrate the value chains into formal market systems. The study makes the following recommendations;

I. County governments from the main camel producing areas need to use existing platforms like the Kenya Camel Association and Frontier Counties Development Council (FCDC) to lobby for the national government to provide sanitary guidelines and policies that will regulate the camel milk and meat value chains. However, as policy makers move towards regulating and integrating the chains into formal market systems. They should be cognizant of the important role played by family and clan ties that offer the value chain actors access to funds and loans as well as social support. Most of the value chain actors cannot access funds from formal financial lending institutions.

- II. The county should ensure the slaughter houses are designed and operated according to the existing meat control act guidelines.
- III. There is need for NGOs and development partners to offer innovation grants/funds that will spur engineers to design hygienic and non-bulky containers that are practical for use in the harsh ASAL setting.
- IV. FAO and other research institutions need to shift surveillance efforts to counties with high camel populations like Mandera, Wajir and Garissa. Research findings need to be shared widely within relevant county departments especially livestock production and health.
- V. There is need for broad based studies that focus on MERS-CoV seroprevalence surveillance in the general Kenyan population. This will identify if there is a causal linkage between contact with camels or camel products and positive MERS-CoV results in man.
- VI. Further investigation on the role played by wildlife in MERS-CoV epidemiology is needed. Research should focus on capture and testing the Marabou stork in and around the slaughter houses.
- VII. There is need for research to dispel the myths that pasteurising camel milk reduces or removes its health and nutritional benefits.

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1.0 Appendices Section

6.1 KII County Department of Livestock Production and Veterinary Services Questionnaire

Background:

My name is Dr Pauline Gitonga contracted by FAO-Kenya's project "Ending Pandemic Threat-2". The project has for the last five years, conducted a longitudinal study in Isiolo and Garissa County that followed sentinel camel herds and determined their seroprevalence status for MERS-CoV antibodies. The next step in the research is to understand how the camel value chains in the counties may potentially contribute to MERS-CoV spread. I am requesting your office to provide the current data on the following information;

(A) Camel Density Population Data (Ward Level)- 2018 data (2019? Census Data if available)								
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
	Total Camel Population in the County							

(B) Production levels of Camel Value Chains in the County (2018 data if possible 2019 if available)								
Type of Camel Val	ue Chain Product	Annual production Quantity						
1. Camel Milk (Fresh Milk)								
 Camel Milk (processed sweets etc) 	products yoghurt, soft cheese,							
Camel Meat (Fresh Slaug	hter)							
4. Camel Meat processed (N	lyirinyiri) and Tallow							
5. Camel animals export (ou	t of the county)							
6. Camel skin								
7. Camel bones								
8. Camel offals								

(C) Cam	(C) Camel Market Data for County (Ward Level) 2018 data (2019 County or State Department data if available)										
Name of market (List of top 3 markets per sub- county)	Name of ward market and note the Please indicate village/location where possible	Type of Market - Primary, - Secondary, -Terminal	Number of days in the week market operates (Please indicate actual days if possible)	Average Number of camel animals sold during the Dry season	Average Number live of animals sold during the wet season						

(D)Type of camel production system in the county (use base map to guide discussions on congregation areas and camel movement patterns)

(E) List common zoonotic diseases occurring in the county and identify hot spot areas- (If the respondents fails to mention MERS-CoV ask them if they have had of the disease)

(F) Main challenges faced in regulation of the camel meat and milk value chains in the county

6.2 FGD Questionnaire Secondary Milk Traders/ bulkers

- 1. Name of Group and year established
- 2. Number of members (gender disaggregation)
- 3. Group governance structure
- 4. Quantity of milk traded daily during the wet and dry season
- 5. Top 4 areas milk is sourced from
- 6. Main customer base
- 7. Challenges faced when conducting business
- 8. List of zoonosis diseases

6.3 FGD Questionnaire Livestock marketing Association

- 1. Year association was established
- 2. Number of members (gender disaggregation)
- 3. Association governance structure
- 4. Is there revenue sharing with the county
- 5. Four main sources of camels sold in the market
- 6. Four main destination (terminal markets) for the camels
- 7. Number of camels sold daily during the dry and wet season
- 8. Is there a county animal health inspector? Are camels examined before issuance of a movement permit?
- 9. Disposal strategies of camel dies in the market
- 10. List any zoonotic diseases

6.4 Check list for livestock market and slaughter house

- 1. Does the market or slaughter house have a perimeter fence and gate
- 2. Are there separate holding pens for different livestock species in the market / is there a lairage at the slaughter house?
- 3. Is there a waste disposal management system in the slaughter house and market?
- 4. Do the workers in the market wear personal protective clothing

Do the market and slaughter house infrastructure have bio-containment ability (see check list for category B slaughter house below sourced from the Sourced from Meat Control (Local Slaughterhouses) Regulations, 2010).

Category B slaughter house specification

- The land size should not be less than five hectares to allow for future expansion, the slaughter house design should be approved by relevant authorities;
- Access road should be of suitable permanent surface that is free from dust;
- There should be a complete perimeter fence made from chain link or permanent stone or brick wall with lockable gates;
- There should be a properly designed off-loading ramp and an isolation pen;
- There should be lairages with adequate space depending on the livestock species to hold animals. The lairage floor should be made of permanent surfaces that are easy to wash;
- The slaughter slabs should be made of permanent floor surfaces and walls that are easy to clean and well drained;
- There should be sufficient pests and vermin control facilities at all entrances;
- There should be in place a humane stunning method approved by the Director of Veterinary Services;
- There should be hanging rails to allow for the carcass to be bled in a hanging position;
- There should be well demarcated areas for bleeding, flaying, evisceration and carcass splitting that utilises an onward process flow;
- There should be a clear separation of dirty and clean areas with proper drainage flows;
- Blood tank or receptacles should be constructed to prevent environmental contamination;
- The slaughter house should be linked to a laboratory approved by the competent authority to conduct food quality and safety analysis and conformity testing;
- There should be sufficient refrigeration of not less than negative ten degrees centigrade for carcasses with cysts (measles);

- There should be an incineration facilities or condemnation pits kept under lock and key at all the time by the inspecting officer;
- The slaughter house should comply with the provisions of the Environmental Management Coordination regulations on slaughterhouses for environmental protection through acceptable effluent treatment systems and solid wastes disposal;
- There should be sufficient changing rooms and toilets for employees;
- There should be sufficient natural or artificial lighting of at least five hundred and forty lux where meat is being inspected and two hundred and twenty lux in other work areas;
- There should be separate room for keeping hides and skins, hair, heads, feet and inedible materials;
- There should be separate room for offals cleaning and a manure shed that can hold at least one and a half days slaughter operations;
- There should be an emergency slaughter area and a separate entrance to the killing floor;
- The entrances to the clean areas should be fitted with decontamination facilities including washing basins, boot wash, apron wash and refuse container;,
- There should be offices for the inspecting officers and management staff;
- There should be an area provided to clean and sanitise meat carriers or containers;
- The slaughter house should be managed by a competent person with basic training in food hygiene or meat technology and proof of the same provided to the competent authority;
- The manager should ensure that all employed staff have a medical certificate authorising them to handle food.

6.5 Garissa and Isiolo camel livestock market commodity flow characteristics

Location	Market name & operation day	Market type	Ownership LMA partnership	Catchment area	Average number of traders	Average numbers of camel sold	Average selling Price	Revenue collected	Terminal market
County: Garissa Sub-county: Lagdera Ward Modagashe	Modagashe Operates on Monday	Primary	County LMA in place but there are no county by- laws authorising revenue sharing LMA collect loading ramp fees	Surrounding villages (50%) Garbatulla in Isiolo county (30%) Habaswein in Wajir south (20%)	15-20 Most are refugees from Dadaab	60 – 100 dry season 20-40 wet season	Calves KES 25- 35, 000 Juvenile KES 50-60,000 Adult KES 70-80,000	Auction fee KES 200 Export fee KES 200 Per animal	Garissa livestock market for slaughter (5%) Degahley Market (5%) Adult males export market Somalia (70%) Taita
									Taveta Ranches (Voi) 20%
County: Tana-River Sub-county: Bura Ward Bangal	Bangale Tuesday	Primary Secondary	County No LMA in place	Bura	6 only 4- Garissa 2- Athi-river Traders have several brokers	150 Mainly Adult Male All seasons	Adult Males 50-60,000	Auction Fee 500 per animal Movement Permit per truck KES 500	100 - Garissa slaughter house 50- Mlolongo slaughter house
County Garissa Sub-county Garissa Township Ward Waberi	Garissa Livestock Market Saturday Camels	Secondary	County LMA in place and revenue sharing done for every KES 300 paid they get KES 25	Balambala (60%) Modagashe (5%) Dadaab (5%) Fafi (10%) Waberi (5%) Ladgwdwra (5%) Nanighi (5%) Bura (5%)	200	Dry season 200-300 Wet season 70-150 Mostly adult male	Juvenile male KES 75-80,000 Adult Male KES 85-90,000	Auction fee KES 150 Export fee KES 150 Per animal Movement permit per	Most of the adult male trekked to Somalia (70%) Sold for KES 120- 130,000

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Location	Market name & operation	Market type	Ownership LMA partnership	Catchment area	Average number of traders	Average numbers of camel sold	Average selling Price	truck KES 100 Revenue collected	10% slaughter in Garissa town 20%-Voi Ranches Terminal market
Garissa	day Degahley livestock market Saturday	Primary	None	Dadaab (80%) Modagashe 15% Wajir (5%)	20-30	30-50 Dry season 70-80 wet season Religious festivals mainly sheep and goat sold	Juvenile male KES 50-60,000 Adult male KES 70-80,000	Auction fee KES 150 Export fee KES 150 No movement permits issued	Somalia export market (80%) Taita Taveta (Voi Ranches) (15%) Slaughter slab (5%)
Garissa	Hagadera livestock market Daily	Primary	None	Fafi sub-county area (100%)	10- 15	10 wet season 25-30 Dry season	Juvenile male KES 50-60,000 Adult male KES 70-80,000	Auction fee KES 150 Export fee KES 150 No movement permits issued	Degahley livestock market (90%) Slaughter slab (10%)
Isiolo	Eskot livestock market Saturday	Primary	?	Garbatulla (100%)	?	60-70 Wet season; 40-50 dry season	?	No Animal health on site	Garissa county (100%)
Isiolo	Duse livestock market Tuesday	Primary	?	Garbatulla (100%)	?	170-200 wet season; 100-150 dry season	?	No Animal health on site	Garissa county (100%)