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# Environmental Factors Influencing the Sustenance of the Camel Milk Value Chain in Isiolo County, Northern Kenya

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**Abstract:** Dryland areas in northern Kenya experience challenges due to various factors, including environmental degradation associated with unstable weather conditions and climate change. These and related risks and stressors are threats to the sustenance of camel milk production for many of Kenya's northern communities. We conducted a study among the pastoral communities in Isiolo County whose principal source of livelihood is dependent on camel production. In this paper, we discuss the drivers of the environmental factors influencing the resilience and sustainability of the camel milk value chain in Isiolo County, northern Kenya. We analyzed (i) the internal factors that influence the system, which includes: the categories and economic contributions of livestock-based value chains, the occupation of the camel milk value chain micro players, and land-use practices in Isiolo County, and (ii) the external factors influencing the system: the climatic variability (2014–2017) and its effect on the camel milk value chain, and the vegetation condition index (VCI) indicating drought trends for Isiolo County (2002–2020). The study adopted a field survey through interviews with randomly selected households involved in the camel milk value chain by using a survey questionnaire and a survey guide for focus group discussions (FGD) and key informant interviews (KII). The results from the study showed camel milk as a dominant value chain among the livestock-based value chain products in Isiolo County, the variations in quantities of camel milk supplied due to changes in seasonality, and we show that the current system is not sustainable. We conclude with recommendations to establish a modernized camel milk value chain based on improved natural resources management for a resilient and sustainable system.

**Keywords:** camel milk; environment; value chain; natural resources; Isiolo; northern Kenya



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## 1. Introduction

### *Background*

Globally, the population of camels has been steadily increasing over the past four decades to over 35 million in 2018 [1,2]. Currently, about 82.5% of the world's total camel population are found in the arid and semi-arid areas of sub-Saharan Africa. The horn of Africa is home to 60% of this population, where they are kept mainly for milk production and transport purposes [3]. Although there is high growth potential for a camel-based food system in the Sahel and Horn of Africa, climate change and variability are major factors affecting livestock production systems [4,5]. These areas are also prone to land degradation due to inappropriate land uses and conflicts, resulting in a weak value chain in the livestock industry [6,7].

In Kenya, camels are found in the drier parts of the country, which account for 84% of the land surface holding over 50% of the country's total livestock population [6,8,9]. Overall, the livestock sub-sector contributes 17% of the country's gross domestic products (GDP) and supports over 30% (14 million) of the population [10,11]. The camel population in the

country is estimated to be 3 million (6% of the Africa's camel population) but contributes 29% of the world's total camel milk production, which is indicative of a high growth potential of the value chain. Although the camel is an important source of nutrition, it has not solved the food insecurity and extreme poverty of some 820 million people who are dependent on it for their livelihoods [12]. This is probably due to unsustainable practices in the local camel milk value chains and is exacerbated by degraded landscapes and climate change increasing the risks to human health and well-being. There is a need to contextualize the drivers of threats and develop interventions that enhance system resilience in this value chain. In Kenya, camel milk is a major source of food and income and provides the basic livelihoods of the pastoral communities in northern Kenya [13].

In Isiolo County, the estimated total population of camels is 148,859 (9% of Kenya's total camel population), with the camel milk value chain contributing 58.7% of the total county revenue [14,15]. The value chain attracts diverse actors involved in milk marketing processes. Currently, there are two main local camel milk cooperative societies that were established, namely, Anolei and Tawakal, to handle and cushion the low productivity in the milk processing and marketing systems that is being experienced in the county. The challenge is that the camel milk production system heavily relies on the uncertainties of weather conditions, which cause fluctuations in milk supply and prices. These climatic variability and rainfall seasonality accentuated by oscillating weather conditions disrupts the proper functioning of the system. The resultant effect is pastoralists migrations from one area to another, and these have become more prevalent in many parts of the arid and semi-arid regions in Kenya, including Isiolo County in northern Kenya [16,17]. This contributes to an inconsistent supply of camel milk in terms of milk production, processing capacities, and networks among the actors, hence, an informal milk marketing infrastructure. The Isiolo County Integrated Development Plan, 2018–2022, also indicates that the camel milk value chain supports the livelihoods of these pastoral communities either directly or indirectly. However, although the support is significant, the sustainability of the system has not been well understood in relation to the environmental factors influencing the sustainability of the camel milk value chain in Isiolo County in northern Kenya. The literature reviewed from a study by Harison, K., Mark B., & Imwati, A. (2017) reveals that the high levels of poverty and low incomes among the pastoral communities in Isiolo County are due to increasing vulnerability accruing from climate shocks and stresses—especially drought and poor land-use systems.

The purpose of this study, therefore, was to analyze the environmental factors influencing the sustainability of the system. We provide results according to the objectives, discuss the findings, and provide recommendations not only for improving the productivity of the camel milk value chain through improving milk marketing systems, but also in planning camel production policies to enhance a sustainable and resilient system in Isiolo County and other parts of the world with similar environments.

## 2. Literature Review

The global Intergovernmental Panel on Climate Change (IPCC) has indicated that the major impacts that accrue from environmental risks include, changes in rainfall patterns, floods, droughts, a reduction in biodiversity, and increases in resource use conflicts [17–21]. Today, warnings of these disaster-related scenarios are most evident all over the world. There is also growing evidence that the frequency and extent of droughts have increased as a result of climatic variations and overall global warming [22]. A global analysis also shows that changes in climate change impact the overall productivity and environmental services that support pastoral livelihoods, therefore, complicating the pastoral production systems [23]. This is evidenced by abrupt changes in weather conditions necessitating unreliable weather patterns that have strong negative impacts on livestock production, vegetation index cover, and natural resources management [24]. Sub-Saharan Africa (SSA) is among these regions in the world where the effects of climate change and climatic variability are being felt hard [25,26]. These environmental challenges are likely to affect

more of the pastoralist communities whose main livelihoods are dependent on livestock production [27,28]. These constraints are anticipated to affect the viability of the camel milk value chain in the region. Hence, although there is potential for the camel milk value chain in the arid and semi-arid regions of Africa, particularly the drylands of the Sahel and Horn of Africa, there are barriers to its sustenance. The major threats are realized in camel milk production and market channels due to climate change and climatic variability that affect the overall livestock production systems [7]. Other studies also indicate that climate change and climatic variability predispose frequent droughts that exacerbate inappropriate land-use systems [23,29–31]. These inappropriate land-use systems further exacerbate a pastoral migratory pattern that ultimately threatens the system and contributes to low productivity and high environmental degradation, resulting in weak value chain products to meet global market standards [6].

In recent decades, changes in the socio-economic situation and increasing climate variability have led to a need to enhance adaptation by building the resilience of local food systems, including economic diversification and the sustainable management of natural resources [32]. These diversifications, both internal and external, will stimulate changes in policy matters needed to support rational camel milk production, market access, and income generation without compromising environmental integrity. Although nomadic pastoralism and traditional camel keeping practices are anticipated to provide a significant contribution of the revenue—not only to the County Government of Isiolo but also to the overall national economic development—there are no sustainable natural resources management measures that are put in place to support a resilient pastoralist's livelihood [33]. It is, therefore, imperative to note that nomadic pastoralism has come increasingly under pressure in a downward spiral of resource depletion and diminishing resilience against climate and non-climate changes.

The Kenya National Climate Change Policy (2014) gives a focus for finding out the mitigation measures of the consequences implicated with climate change through support for the development of integrated institutional frameworks between the National and County levels. The overall implication is that there is increasing demand for livestock products and by-products both at the international and regional level that will seriously challenge the livestock production and marketing systems, as this will demand the mechanisms to increase the productivity of the camel milk value chain to meet the requirements for the external markets [15]. The main concern, therefore, is that the system currently faces challenges of resilience to existing environmental stressors affecting the system. The ten-year plan Kenya Compact for the Ending Drought Emergency (EDE) linked to the UN Sendai Framework for climate actions (2015–2030), which intends to end extreme climate anomalies, such as drought emergencies, by 2022 recognizes that environmental risks are driven by climate change and climatic variability and the socio-cultural practices leading to land degradation and reduced livelihood performance [10]. This framework stipulates the need to build capacities in the pastoral communities towards the resilience of livelihoods in the arid and semi-arid regions. The framework emphasizes enhancing the productive potential of the livestock value chains and the need for development of a multi-sectoral and multidisciplinary approach to enhance effective risk management for sustainable livestock value chains such as camel milk [34]. We, therefore, attempt to fill this gap by analyzing the environmental factors influencing the sustenance of the camel milk value chain along the various processes in the chain and we provide recommendations for an enhanced system.

## 3. Methodology

### *3.1. Background of the Study Area*

We carried out a survey between January and December 2019 within the three sub-counties of Isiolo County (Isiolo central, Garbatulla, and Merti), which are located between Longitudes 36°50″ and 39°50″ east and latitude 0°05″ south and 20 north of the equator. Isiolo County is a typical arid and semi-arid region with a bimodal rainfall pattern, characterized by long rains from March to May and short rains from October to December [2].

It has an estimated land area of 25,350.6 km$^2$ (Figure 1) with a total camel population of 148,859 [14]. About 95% of the county is classified as arid or very arid, while only 5% is semi-arid—generally receiving an average annual rainfall below 300 mm (12 inches), which is also unevenly distributed [2,9]. The temperatures are high throughout the year, ranging from a mean minimum of 27 °C and a maximum of 30 °C in almost all parts of the county [2]. Generally, this type of climatic condition supports grassland, dry land trees, and shrubs. This vegetation type makes it more conducive for livestock keeping than crop farming. The majority of the land is communally owned (80%); public land and wildlife conservancies account for 19%, and only 1% of the land is under private ownership [15].

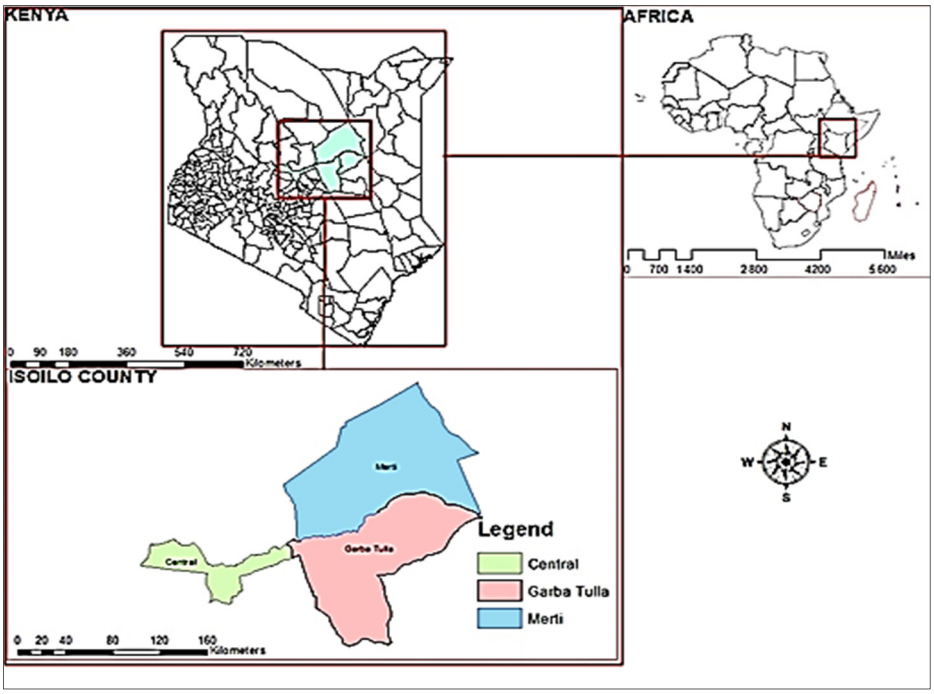


**Figure 1.** The Location of the Study Area in Kenya.

### *3.2. Data Collection Method*

Our study adopted the field survey design method within the Isiolo central, Garbatulla, and Merti sub-counties. We adopted the research design used by Simiyu (2012) for acquiring representative samples from the geographical areas of interest that happen to be large. It involves mixed methods (quantitative and qualitative) approaches that strive to find information that can be subjected to statistical analysis. Both primary and secondary data were collected from the camel milk value chain actors and support services providers. We conducted a survey using a questionnaire for collecting primary data from the selected households involved in the camel milk value chain. Using the simple random sampling method with the aid of the Raosoft sample size calculator for the determined target population, 316 households were randomly selected for interviews. We conducted the interviews at the village level with selected households. A household head was considered to take part in the interview if the individual was 18 years or older. In the cases of those who had a low population (<30) to be part of the study, we subjected them to FGDs and KIIs for information collection. Hence, they were not included in the statistical data. We recruited trained local enumerators who spoke the language of the respondents and conducted pre-testing of the questionnaires for data collection to remove errors to assure data quality. We collected primary data using a semi-structured questionnaire to collect information among the selected households for the study. This information includes the occupational categories of camel milk micro-actors and land-use practices. The information on land-use was based on the purpose of current settlement areas and the reasons for migrations from

the past and into the present areas of settlement. We collected data on milk sales from Anolei and Tawakal cooperative societies and we adopted a statistical analysis method to determine the significant differences in the quantities of camel milk sold over a 4-year period (2014–2017) between the wet and dry seasons.

We collected secondary data using a desk study. This included information on livestock-based value chains currently practiced in the county that contribute to the county revenue base and used records from the department of livestock development to identify the most potential value chain in the county. We also collected data on the external factors influencing the system, which include: the interannual rainfall variations (2014–2017) and the vegetation condition index (VCI) and drought trends (2002–2021) associated with these effects. The projection for the interannual rainfall variations was determined using the PRECIS tool. This tool uses the Normalized Difference Vegetation Index (NDVI) model to evaluate the severity of drought for the last few decades. The National Drought Management Authority (NDMA) provided a summary of the information on the analysis of VCI trends from 2002–2021. The method of analysis of drought episodes included the retrospective analysis of NDVI obtained from satellite imagery. The results are thereafter presented in a matrix form to indicate the vegetation condition and drought trend. We used information collected from FGDs and KIIs for the triangulation of the environmental factors that affect the camel milk value chain in the county. The study used snowballing to identify key informants based on their knowledge of the value chain and historical experiences related to past and present land uses. We also used a desk study for the review of the existing literature documents, such as published departmental reports and materials (e.g., journals, students' theses) and field observations. Where there was a gap in the face-to-face interviews, we followed up with telephone calls for clarification of certain information during field observations.

### *3.3. Data Analyses*

We carried out comparative descriptive and inferential statistical analyses of the camel milk supplied over the 4-year period to test for any significant differences in the means of the test parameters. The data were coded and entered and we computed the data using the IBM SPSS Statistics for Windows Version 23.0.0 software. We used the Fisher's LSD test at a 5% level and ($p < 0.05$) to differentiate the means.

## 4. Results

### *4.1. Internal Environmental Factors Influencing the Sustenance of the Camel Milk Value Chain in Isiolo County, Northern Kenya*

We identified the human-based activities that accrue from the camel milk micro-players in the different stages of the value chain as the main internal factors influencing the system. These include the economic and occupational activities and land-use practices. Specifically, we provide results for 136 female household-headed, 49 male-headed, and 99 youth household-headed respondents in their different roles in the value chain. The study shows an overall response rate of 94% of the respondents.

#### 4.1.1. Categories of Livestock-Based Value Chains in Isiolo County, Northern Kenya

The results indicate that the current livestock-based value chains that make up the main economic activities of the pastoralist communities in Isiolo County in northern Kenya were: beef (16.7%), goat meat (3.9%), mutton (2.7%), camel meat (10.7%), camel milk (58.7%), poultry (4.4%), hides 0.3%), and skins (2.5%) (Table 1). Among these, the camel value chain products form about 69.4%, while camel milk alone contributes 58.7% of the total county revenue that accrues from livestock-based value chains (Table 1). Isiolo central sub-county supplies over a half (53%) of the total milk delivered to milk processing centers, and Garbatulla sub-county (26.5%) and Merti sub-county have the lowest (20.6%) camel milk supplied to the processing centers (Table 1).

**Table 1.** Summary of total revenue earned from livestock-based value chains in Isiolo County (US$)—2018.

| Value Chain | Isiolo Central | Garbatulla | Merti | Totals |
|---|---|---|---|---|
| Beef | 139,293.2 | 120 | 720 | 140,133.2 |
| Meat goat | 23,940 | 5938 | 3036.4 | 32,914.4 |
| Mutton | 3448 | 14,347 | 4418.4 | 22,213.4 |
| Camel meat | 84,377.6 | 5026.4 | 0 | 89,404.0 |
| Camel milk | 259,200 | 129,600 | 100,800 | 489,600.0 |
| Poultry | 15,205.5 | 13,270.5 | 8318 | 36,794.0 |
| Hides | 1747.2 | 404.8 | 404.8 | 2556.8 |
| Skins | 1898.1 | 9111.5 | 9870.5 | 20,880.1 |
| | | | TOTAL | 834,495.9 |

Source: Isiolo CIDP (2018).

#### 4.1.2. Occupational Categories of the Micro Players Involved in Camel Milk Value Chain in Isiolo County

The analysis of the occupational categories of the respondents shows 85% pastoral production practices, 6.5% casual labor, 4.7% salaried or employed, 3.4% crop farming, and only 0.9% involved in contractual employment (Figure 2). We find that pastoralism is the dominant economic activity among the camel milk value chain players, while categories of those players in formal employment (casual labor, salaried, and contractual employment) only form a total of 12.1% in Isiolo County, northern Kenya (Figure 2).

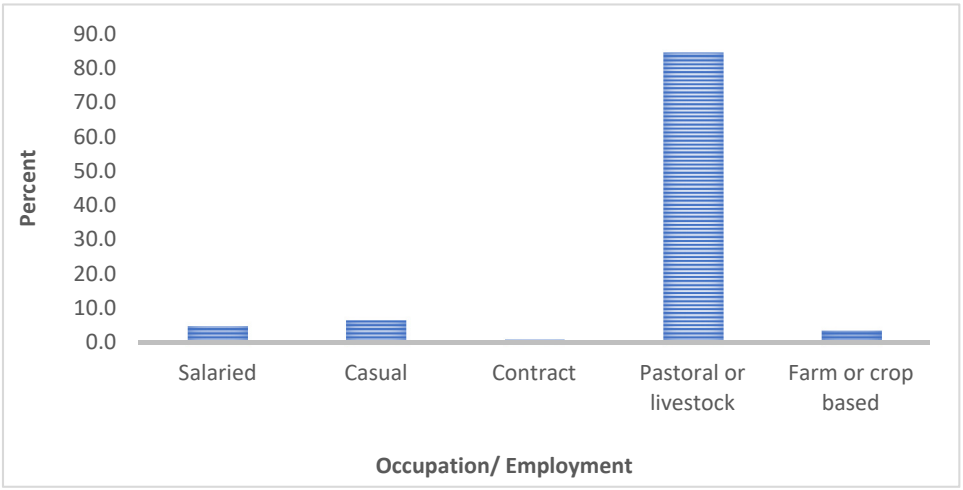


**Figure 2.** Analysis of occupational categories of respondents involved in camel milk value chain in Isiolo County.

#### 4.1.3. Land Use System

Our study shows that 85% of the total land coverage in the county is under communal land-use practices with only 2% registered under private ownership. The rest of the land (13%) is under crop production, public land, and community conservancies. We report that there have been increases in migrations into new settlements between 1971 and after 2010 (Figure 3). Specifically, high levels of sedentarization were realized between 2001 and 2010, accounting for 28.7 percent. However, before 1970, the percentage of those who migrated into Isiolo County was only 6.1 percent. These findings also indicate that there was a significant drop in migrations into new settlements from 28.7% between 2001–2010 to 4.3% from 2011 to 2019 (Figure 3).

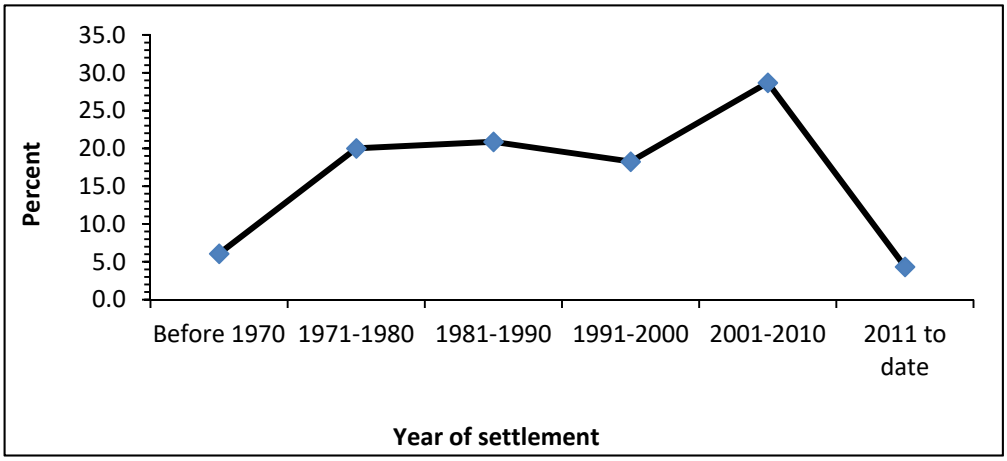


**Figure 3.** Household migrations into present residence area between 1970 and 2019.

The reasons for settlement into present areas of residence were examined and established that about 43.5% have settled in the present residential areas due to the belief that it's their ancestral homeland, 38.2% due to livestock rearing, 14.5% for crop production, 3.1% for commercial purposes, and only 0.8% have settled for security reasons (Figure 4).

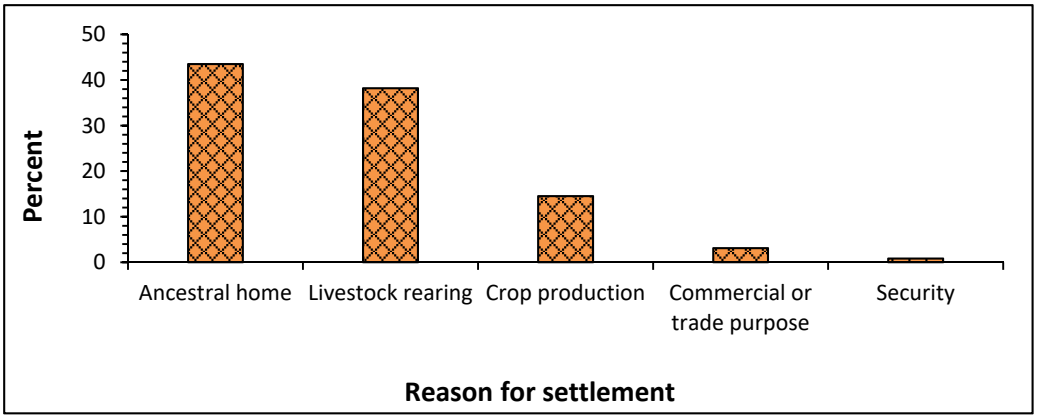


**Figure 4.** Reasons for settlement of the households interviewed in the present area of residence.

### *4.2. External Environmental Factors Influencing the Sustenance of the Camel Milk Value Chain in Isiolo County, Northern Kenya*

Here we present the external factors influencing the camel milk value chain system.

#### 4.2.1. Rainfall Variability and Its Effect on Camel Milk Value Chain in Isiolo County

The results on the interannual variability in the quantity of milk sold over the 4 years showed a significant ($p < 0.05$) difference after using a Fisher's LSD test at a 5% level. There were more quantities of milk sold during the year 2017 than the rest. While the year 2016 was slightly different in terms of the quantity of milk sold, there was much more similarity between 2016 and 2014. However, the lowest milk supply was realized during the year 2015 when compared to the others. The variation in the quantity of milk sold between 2014 and 2016 was ±2728.6 (Figure 5). The results on the quantity of milk sold during the dry and wet seasons showed a significant ($p < 0.05$) difference. The quantity of milk sold in 2017 (89,620) was significantly higher ($p < 0.05$) than that observed in 2016 (74,369), in 2015 (66,664), and 2014 (65,432). The mean quantity of milk sold during the dry season was 65,592 L while that sold during the wet season was 74,021, which gave a variation of ±2570.8 over the four years. The mean quantity of milk traded during the wet season was higher than the dry season, which concurs with $P_{(0.05)} = 0.025$

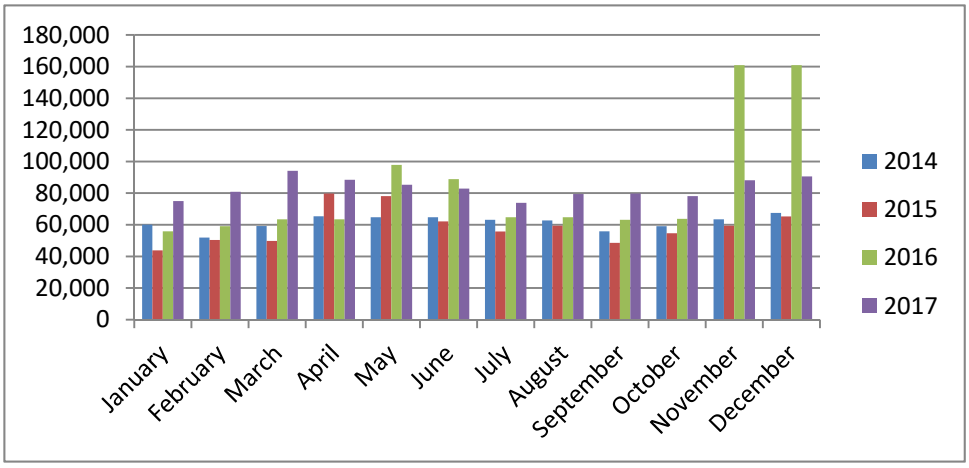


**Figure 5.** Effect of interannual rainfall variability on camel milk value chain (2014–2017).

#### 4.2.2. An Assessment of Rainfall Variability and Vegetation Cover Index and Its Implications on Camel Milk Value Chain for Isiolo County (2002–2020)

The camel value chain is highly dependent on natural vegetation conditions that fluctuate due to the rainfall variability and intensity between and within seasons. Here we present the effect of drought on its intensity on the vegetation cover index for Isiolo County (Figure 6). The scale zero (0) is considered a moderate vegetation deficit following a normal rainfall pattern. The scale of one (1) is an indication of normal vegetation greenness while the scale of two (2) is an indication of very good vegetation conditions, mainly due to prolonged rainfall. A negative one (−1) indicates a severe vegetation deficit associated with a poor distribution in terms of time and space, which leads to partial or poor regeneration of vegetation. This phenomenon predisposes an irregular and poorly distributed rainfall and vegetation cover. It's imperative, therefore, to deduce that the period between 2002–2020 has experienced, in general, a below normal rainfall that contributes to reduced vegetation condition regeneration, hence negatively impacting the camel milk value chain that is dependent on the available natural resources.

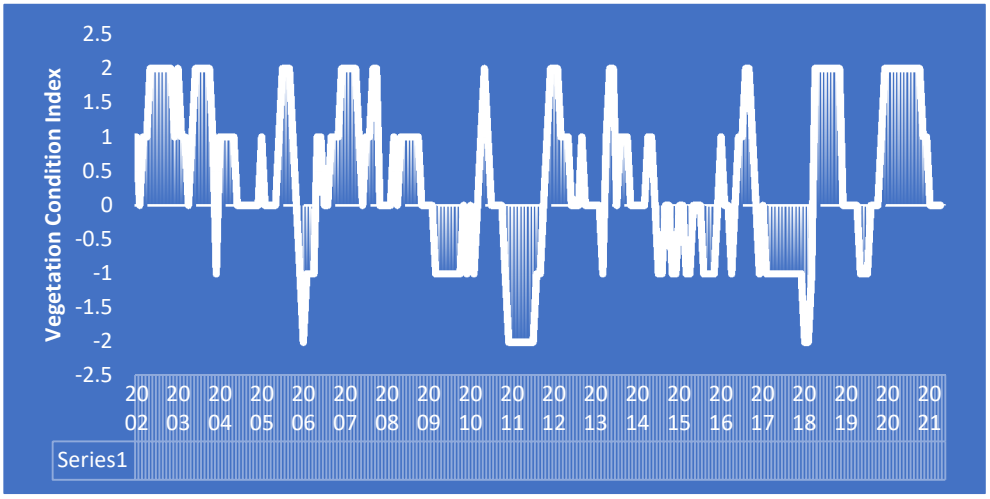


**Figure 6.** Vegetation condition index (VCI) indicating drought trends for Isiolo County (2002–2020). Source: NDMA, 2021.

## 5. Discussion of Results

### *5.1. Contribution of Camel Milk Value Chain in Relation to Other Livestock-Based Value Chains*

Results show that Isiolo central sub-county supplies over a half (53%) of the total milk delivered to milk processing centers, and Garbatulla sub-county (26.5%) and Merti

sub-county have the lowest (20.6%) camel milk supplied to the processing centers (Table 1). Among these, the camel value chain products form about 69.4%, while camel milk alone contributes 58.7% of the total county revenue that accrues from livestock-based value chains (Table 1). The analysis of the occupational categories of the respondents shows 85% are involved in traditional camel production practices, and pastoralism is the dominant land-use system. Overall, the camel milk value chain is the highest revenue earner in the county compared to other livestock-based value chains, but the chain is not well connected (Table 1). We find that although pastoralism is the major land-use activity it's facing great challenges that accrue from extreme environmental risks exacerbated by long and frequent drought episodes caused by poor rainfall and distribution patterns.

### 5.2. Climatic Variability, Seasonality and Drought Trends

The rainfall amounts have increasingly been decreasing over the last few decades (Figure 6). In normal circumstances, a culmination of several failed seasons sums up into droughts episodes resulting in poor and prolonged range conditions. The drought episodes are exacerbated by highly irregular rainfall patterns coupled with a poor distribution regime. This is evidenced by an interannual rainfall variability with ±2728.6 of milk sold between wet and dry seasons. The coefficient of variation for milk sold between 2014–2017 shows a variability of ±3967.3 at $P_{(0.05)} < 0.001$. The statistical analysis conducted on the quantity of milk supplied during wet and dry seasons also indicated a high significant difference at $P_{(0.05)} < 0.025$. This is attributed to conditions of low vegetation regeneration and environmental degradation due to overgrazing, which causes further scarcity of grazing resources already under threat by climatic variability and climate change effects. This study, therefore, concurs with other studies that indicated there is growing evidence in the frequency and extent of droughts, which are increasing as a result of climatic variations and overall global warming [17,19]. We also agree with other studies conducted that indicated that drought severity and related climate extremes have a greater impact on general livestock production, market access, and price stability [23,25]. Drought is the outcome of climate variability (rainfall & temperatures, specifically), which contributes significantly to the increasing instability of production and ecological resilience, hence affecting the market prices of camel milk products. This, coupled with an uncontrolled communal grazing system, is a threat to a sustainable system.

The extensive or communal grazing systems have greater implications for the sustainability of not only the camel milk value chain but also the entire livestock value chains practiced in the county. This is because poor grazing systems are predisposed to environmental degradation and inadequate and low-quality foraging—thus, affecting the quantities and quality of the products supplied. Climatic variability is also attributed to inadequate access to water and pasture resources required for a resilient and sustainable system. Although nomadic pastoralism is an alternative land-use practice that contributes significantly to the county revenue base, there are no reliable control measures put in place by the county to sustain the system. The assessment of drought trends and the vegetation condition index reveals that there has been an upsurge of unusual drought episodes over the last few decades (Figure 6). The main cause of drought is due to unreliable and poorly distributed rainfall patterns. This necessitates competition for scarce resources, thereby stimulating frequent frictions and conflicts over grazing resources (pastures and water) among the camel producers. Currently, we observe that there are much more frequent movements of camels from one place to another, causing an inconsistent supply of milk. The FGDs and KIIs perceptions on land-use have also pointed out that the National Government has failed to provide security in the interior grazing areas, which are considered major camel production and grazing zones. This can cause an inadequate enabling environment for the camel milk value chain and other livestock-based products. The county also lacks land-use plans to enhance the sustainable utilization of natural resources. The inadequate capacities of the camel milk micro actors, weak networks, and poor partnerships among

the service providers are a clear indication of weak institutional arrangements concerned with the camel milk food industry.

The findings also agree with the recommendations of [21], which noted that, to cope with these challenges, there is a need for an increasing transformation in food systems technologies and the environment in many ways on an unprecedented scale that influences the well-being of society. It is, therefore, imperative to not underestimate the need for the inclusion of potential value chains transformations and enhanced productive ecosystem services during policy decision making. The Isiolo County Integrated Development Plan (CIDP, 2017–2022) envisages the support of the livestock sub-sector through the commercialization of livestock and livestock-based products, mainly the camel milk value chain, to improve the livelihoods of her citizens and county revenue base. The CIDP is anchored on the existing national and county policies supported by multi-sectoral departmental plans. However, these policies and the sectoral plans of the relevant departments for livestock sub-sector development in the county have not been aligned effectively to mitigate the current challenges that accrue from environmental factors influencing the camel milk value chain. The CIPD brings out certain challenges that influence the system, such as the cultural practices in livestock production and some local adaptation mechanisms under the prevailing climatic conditions.

However, we observe that more studies have been conducted on the assessment of dry spells analysis in relation to crop growing periods than livestock value chains. In the Sub-Saharan African (SSA) and East African regions, where livestock production is the main economic activity and the production system is dependent on prevailing weather conditions, the effects of climate change and climatic variability are high, thereby exacerbating high risks and vulnerability [26,30]. Climate change has already had negative impacts on food production in some of these regions. Some of these impacts include changes in rainfall patterns that directly impact the availability of livestock forages and other grazing resources and unusual and often recurring droughts, which are predisposed to resource use conflicts among others [31]. Warning of disaster-related scenarios in advance is also becoming feasible from weeks to seasons due to these anomalies. Hence, regular assessments on the interpretation of climate variability and climate alert systems are major requirements to enhance the balance between the environmental support systems and livestock-based economies.

## 6. Conclusions

Our study analyzes some of the environmental factors that influence the camel milk value chain among the pastoral communities whose principal source of livelihood is dependent on camel production in Isiolo County, northern Kenya. We carried out the study among the selected households in the three sub-counties namely Isiolo central, Garbatulla, and Merti. The study was based on the socio-economic characteristics of value chain actors, land-use systems, and drought implications for a sustainable system. The results from the study show 85% pastoral production practices, 6.5% casual labor, 4.7% salaried or employed, 3.4% crop farming, and only 0.9% involved in contractual employment, with about 57% of the respondents without formal education. The results also show that there is variability in the quantities of camel milk supplied to the local processors, leading to the low processing of camel milk products—mainly due to prolonged dry spells coupled with inappropriate land-use systems. This is caused by the prevailing unpredictable weather conditions that also results in inadequate natural forages. The drought trends observed indicate that the drought episodes are exacerbated by highly irregular rainfall patterns coupled with a poor distribution regime. This is evidenced by the interannual rainfall variability with $\pm$2728.6 of milk sold between wet and dry seasons. The impact has been the reduced milk quantities within and between seasons, low-quality products, and inconsistent accessibility of required camel milk volumes due to the migratory nature of pastoral communities with their camels in search of natural forages. These conditions affect the supply chain from production, transportation, processing, and distribution to the final consumption of the

products. These present large challenges in a viable camel milk value chain system and in maintaining a sustainable land-use system.

We observed that the camel milk value chain is operating in delicate environmental conditions that need to be studied to come up with a possible solution to a sustainable system. The study limitations included diverse actors spread out in a vast area with poor infrastructure that affects the ease of accessibility. While the camel milk producers experience many challenges from environmental risks, such as drought coupled with unevenly distributed rainfall patterns, we recommend future lines of research in understanding the complex systems and ecological interactions that influence the camel milk value chain. There is also a need for establishing a county land-use plan with strong local-based institutional frameworks for implementation and enforcement for the adequate utilization of grazing resources, such as pasture and water. This will help reduce resource use conflicts and the current intermittent insecurity.

*Towards a Sustainable Camel Milk Value Chain in Isiolo County*

In this section, we present a model for a well-regulated camel milk value chain in Isiolo County to satisfy the current environmentally challenged camel milk value chain system. The outcome is a sustainable camel milk value chain determined by increased productivity, enhanced capacities of the value chain actors with strong networks, increased market access, strengthened institutional arrangements, and effective regulatory mechanisms (Figure 7). At the county level, the model recommends the development of a camel policy that puts in place strong institutional arrangements with the establishment of a camel dairy board to guide the camel milk marketing legislation. This board will also establish coordination mechanisms aligned with the national livestock policy and food systems strategies. The model recognizes the need for coordination and knowledge transfer to various value chain actors through capacity building that will ultimately trigger transformative innovations in the system. To determine the sustainability of the system, the model recommends the camel milk value chain in the county be anchored on national frameworks such as KEBS quality and safety standards and the national environmental frameworks that include the climate change policy and the EDE's strategies. At the regional level, the value chain is recommended to align with regional agreements such as IGAD, COMESA, and EAC, for compliance in terms of, as well as in adherence to, environmental integrity. Finally, we recommend all these frameworks are aligned to the global food system policies and agreements, such as the SDGs, climate change frameworks, and WTO standards, to achieve a sustainable camel milk value chain in Isiolo County and other areas with similar value chains in Africa.

The county should also put in place an effective county drought risk management policy (DRMP) to mitigate the current drought anomalies. The policy should be aligned with the regional Ending Drought Emergency (EDE) 2020 framework and the National climate change policy (2017). We recommend that the county develop a local-based drought management authority framework that will work in collaboration with the National Drought Management Authority (NDMA), National Environment and Management Authority (NEMA), and other relevant stakeholders. The creation of an internal drought management authority will guarantee the sustenance of the system and enable the county to benefit from the Global and National climate change funds. These regulatory mechanisms will finally strengthen the institutional arrangements and improve coordination to help improve the capacities of various levels of value chain actors through diverse knowledge-sharing platforms.

With livestock being the greatest user of natural resources, especially camels, there is a need for further research to understand the complex ecosystems and ecological interactions in the county, which is almost 95% arid and semi-arid based. The systems are further complicated with the current and new community lands Act, 2016, which requires new approaches to community land use and management systems.

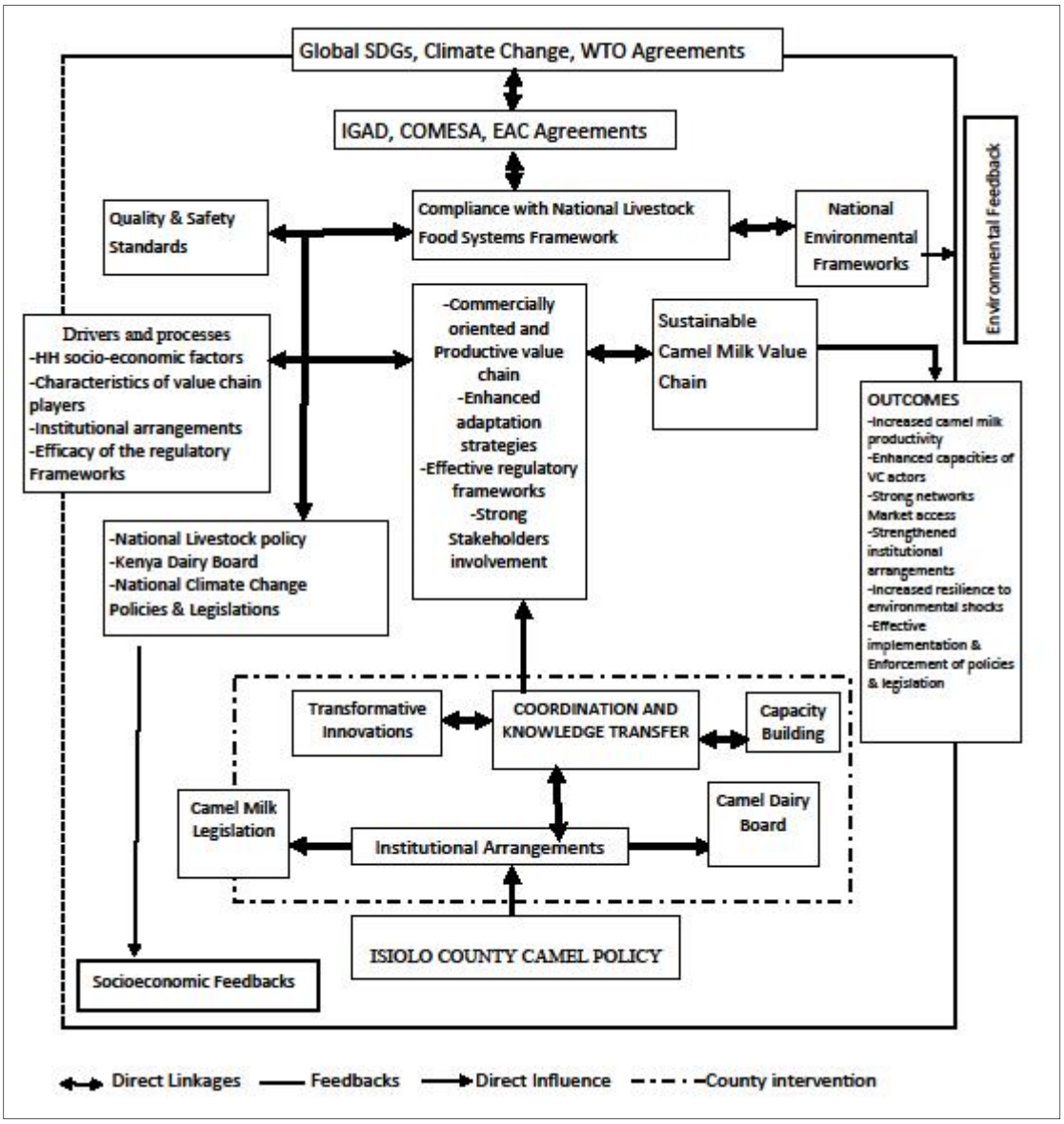


**Figure 7.** Model for Sustainable Camel Milk Value Chain in Isiolo County, Northern Kenya. Source: Machan, S. N., Agwata, J. F., & Oguge, N. O. (2022). Journal of Agriculture, Food Systems, and Community Development ISSN: 2152-0801 online https://foodsystemsjournal.org (accessed on 16 February 2022). Copyright © 2022 by the Authors. Published by the Lyson Center for Civic Agriculture and Food Systems. Open access under CC-BY license. Note: IGAD (Intergovernmental Authority on Development), COMESA (Common Markets for Eastern and Southern Africa), KEBS (Kenya Bureau of Standards).

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