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Analysis of Climate Trends and Livestock Disease Occurrence in Kajiado County

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Authors' contributions

This work was carried out in collaboration among all authors. Author AJY conceptualized the study, arranged resources, managed the project administration, made Investigation, methodology, formal analysis, prepared the original draft, has written the review and done the editing. Author OJO performed the data curation, preparation, formal analysis, project administration, supervision, written the review and done the editing. Author OWO supervised the manuscript and made review and editing. Author OGO done overall supervision, writing-review and editing. Author OSO done the supervision and writing-review and editing. All authors read and approved the final manuscript.

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ABSTRACT

Climate change is argued to have a major impact on livestock production systems as it does not only affect livestock productivity but it also affects the incidence and distribution of livestock diseases. With the changing climate, pastoral production systems are likely to experience even a higher impact on their sources of livelihoods. The objective of the study was to analyse climate

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trends and livestock disease occurrence in Kajiado County. The study used a cross-sectional design with primary data being collected through focus group discussions (FGD), key informant interviews (KIIs), and expert opinion interviews (EOIs), while secondary data was collected from the Kenya Meteorological Services and County Veterinary Services. A total of 10 FGDs, 25 KIIs, and 12 EOIs were conducted in selected areas within the five sub-counties of Kajiado. Quantitative data were analyzed through descriptive and inferential statistics while qualitative data was analyzed through Kruskall Wallis non-parametric method and content analysis. The findings show that there was an increase in variability in rainfall amounts and temperature between 1970 and 2015. For rainfall, the coefficient of variation rose from 21.6% (1970 to 1993) to 32.02% (1994 to 2015) while for temperature, the increment was from 2.6% (1970 to 1993) to 4.04% (1994 to 2015). There was no significant change in the average annual temperature and rainfall amounts between 1970 and 2015 ($P > 0.05$). Among livestock diseases, trypanosomiasis and helminthiasis reportedly had higher occurrences according to records obtained from the Veterinary department but according to pastoralists, East coast fever, Foot and mouth disease, anthrax, black quarter, pestes des petits ruminants and contagious caprine pleuropneumonia were the diseases that were significantly affecting the livestock ($Z > 1.96$). In conclusion, the study showed that there was evidence of climate variability with livestock diseases impacting significantly on livestock production which is a major source of livelihoods for pastoralists.

Keywords: Climate change; climate trend; climate variability; livestock production; livestock diseases.

1. INTRODUCTION

There is overwhelming evidence that climate change is real and that the changes are expected to worsen with time [1]. A general increase in the average global temperature has been observed [IPCC 2] and this warming has resulted in frequent and more intense storms, floods and droughts [3]. This change on the earth's global climate has occurred through shifts of weather patterns averagely for over thirty years or more [4]. The global warming is further being accelerated by human activities such as overexploitation of water for production of energy and water supplies. These are for consumption, industrialization, food security concerns, human health and ecosystems with the influences differing from region to region [5]. More recent IPCC reports have indicated that human activities are estimated to have caused global warming of a range of 0.8°C to 1.2°C with global warming likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate [6].

Climate change has become the largest threats to the world with poor continents such as Africa more likely to be affected most due to high poverty levels, inadequate resources and low capacity to respond to the effects of climate change [7,8,9]. Africa has been found to be highly vulnerable to climate change due to the impacts of climatic changes on its water resources [10]. For example, the northern part of Africa is projected to have a temperature increase of 3.2°C and precipitation increase of 7% during the period 2080-2090 with the pattern likely to lead to poor successive rains, increment in drought-related shocks and sometimes heavier but unpredictable rains [1]. Globally, climate change therefore presents a very worrying challenge to humanity in the 21st Century globally [1].

Pastoral production systems are facing several challenges arising from climate change that is currently being experienced globally. Pastoralism is a traditional livestock production system where livestock is reared for the provision of food, financial capital and a description of wealth among the pastoralist communities. It depends on the quality and quantity of pasture and water availability. All these factors are components of the natural resources that are dependent on climatic conditions. This dependence on natural resources makes pastoralism vulnerable to any changes in climatic conditions [11]. The frequent incidences of drought and floods are destroying the regenerative capacities of the environmental systems, leading to inadequate pasture for grazing and water availability and hence low livestock productivity in pastoral areas. The low productivity is also partly due to long-distance movements of livestock to other areas in search of pasture and water during the dry periods [12].

About one-third of African populations including the pastoral communities are living in areas that are prone to droughts. About 220 million people living in these areas are therefore being exposed to drought virtually every year [13]. Pastoralism being a source of livelihoods for millions of

inhabitants in many rural areas of Africa, climate change has become a key developmental issue in discussions concerning the future of pastoralism in Africa as well as other areas in the world where pastoralism is being practiced [14]. The predicted impacts of climatic changes are already raising questions on the sustainability of pastoralism as a viable livelihood system for the pastoral areas.

Birch and Grahn [15] recognized that pastoral adaptations and climate-induced innovative coping mechanisms are strategically embedded in the indigenous social structures and resource management value systems The global climate change, expressed in terms of increased temperature and shifts in patterns of precipitation, is a new challenge to the world of pastoralism overriding even the indigenous social structures that have been used as the basis for resource management in the pastoral areas [14]. In the Greater Horn of Africa region where pastoralism is being practiced as a production system, the pastoralists are occupying vast arid and semi-arid zones that have very high spatial and temporal variability in rainfall [16].

In terms of livestock diseases, climate change has affected and would continue affecting prevalence, occurrence and distribution of livestock diseases [17]. The spatio-temporal scales of climate variables such as rainfall and temperature define climatic changes that affect the incidence of livestock diseases [18]. Climate change has direct and indirect effect on animal health but the increment in temperatures would more severely affect the health of the animal [11]. The direct or indirect effects could include increment on disease prevalence and interference with productivity and profit arising from the sector [19]. The factors that would affect occurrence and distribution of livestock diseases under the influence of climate change include farming practice, land use, the disease causing-pathogen, vectors that transmit the diseases, environmental changes, new microenvironments and microclimates [17]. Livestock diseases do not only affect the health of the animal but also the livelihoods of livestock-dependent communities [20].

With climate change, national, regional and global early warning systems need to be strengthened. Th the research programmes and intervention measures need to be well coordinated to enable proper planning through appropriate adaptation strategies by the pastoral communities for the changing climatic conditions [21]. The study looked at the climate trend and how the trend was affecting livestock disease occurrence in Kajiado County. The majority of the population in Kajiado depends on pastoralism as a livelihood source. The traditional pastoral production system in Kajiado is already facing challenges as a result of climatic changes [22]. The findings of the study are useful for policymakers when developing community-sensitive climate change response strategies that could support extension and livestock disease management services within Kajiado and similar pastoralists' setups since livestock diseases have major impacts on the pastoral production systems.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Kajiado County which is located in the southern part of Kenya. It is situated between Latitudes 1° 0' and 3° 0' South and Longitudes 36° 5' and 37° 5' East with an area coverage of 21,900.9 Km^2. The County borders Nakuru and Kiambu counties to the North, Narok County to the West, Machakos and Makueni Counties to the East, Nairobi County to the North East, Taita Taveta County to the South East and the United Republic of Tanzania to the South West. The County is characterized as semi-arid and high-altitude pastoral ecosystem that is mainly used for animal husbandry system [22]. The County is composed of five administrative sub-counties namely Kajiado South, Kajiado East, Kajiado West, Kajiado Central and Kajiado North with each sub-county further divided into five administrative wards. There are four livelihood zones that include pastoral, agro-pastoral, marginal mixed farming and mixed farming, distributed among the five sub-counties. The majority of the population is the Maasai pastoral community who are mostly found within the rural areas of the County with pastoralism as the main source of livelihoods. A Cosmopolitan population is mainly found in the urban centres. Horticultural and crop farming are also undertaken in some parts of the County depending on the ecological zone [22].

The County's seasonal rainfall calendar is bimodal. The long rains are usually observed between March-May with the peak season being April while the short rains are between October-December and the peak season being December [22]. Recurrent droughts, flashy floods and environmental pollution and degradation are

some of the climate change-related disasters that have been observed during the current situation in the County. The human activities that have been observed to be attributing to serious environmental degradation thus predisposing the County to adverse weather conditions included tree cutting for charcoal burning [22]. Fig. 1 shows the Map of Kenya and Kajiado County.

2.2 Study Design

Before the start of the data collection, meetings were organized through the assistance of village elders, extension workers and chiefs who were familiar with the study area to familiarize with the study area, to make contacts with the study participants and other stakeholders and introduce the study objectives. During these meetings, participants were given an assurance that the study was being undertaken mainly for academic purposes, participants could only take part in the study voluntarily, the respondents had the freedom to decline to participate in the study or freedom of withdrawing from the research at any time during the research period and there was no coercion to participate in the study. Furthermore, assurance was given to the respondents and participants that their privacy would be strictly protected according to ethical considerations in any given academic research while also ensuring that the respondents or participants involved in the study consented to participate voluntarily [23]. All the 5 sub-counties in Kajiado County were first purposively selected with the presumption that pastoralism is being practiced in the whole of County but the selection also took into consideration the livelihood zones (mixed farming system, marginal mixed farming system, agro-pastoral system, and pastoral). Selection of the sub-counties was then followed by the random selection of two wards from each sub-county through a lottery method where all the twenty five wards were first listed down on different papers, papers folded and placed in different boxes for each sub-county. The cross-sectional study Maninder [24] was conducted between June 2016 and August 2019. The data collected was mainly on climate variables (temperature and rainfall), livestock disease prevalence, incidence and intervention.

2.3 Selection of the Study Subjects

The groups for focus group discussions were systematically selected within the selected wards. The mobilization of the study participants who took part in the focus group discussions was guided by the research team through the assistance of village elders, extension workers and chiefs who were familiar with the study area. The mobilized participants were people who had lived within these wards for several years and were therefore conversant with Maasai language, culture, and their major production system (pastoralism). Recruitment for FGDs was done according to FGD guidelines of between 6-12 participants [25]. The number of people per group was between 6 and 16 and the participants comprised of both males and females. For triangulation of the information on livestock diseases, veterinary personnel from within these localities (wards) were also recruited to be part of the participants to assist during focus group discussions at the same time serve as key informants during the study. FGDs were held in homesteads, the community's makeshift structures of worship or schools that had been identified by the chiefs or village elders through consultation with research participants.

Key Informant Interviews (KIIs) were conducted with chiefs, opinion leaders, village elders and the staff from Non-Governmental Organization (NGO) and the Department of Veterinary Services. Expert opinion interviews (EOIs) were conducted with experts drawn from technical departments. The KIIs and EOIs were face-to-face [26]. Focus group discussions, key informant interviews and expert opinion interviews were guided by semi-structured interview schedules and open-ended questions. The questions elicited responses and generated reasonable amount of discussions and opinions among participants [27]. The secondary data were obtained from the records from Department of Meteorological Services, the Department of Veterinary Services and other publications.

2.4 Data Collection Methods

Ghauri and Gronhaug [28] described research methodology as a data collection method that is systematic, focused and orderly purposely to get relevant information to assist in the solution of research questions and objectives. Both primary and secondary data was collected. The FGDs were conducted in 10 areas within the selected wards. The qualitative approaches (expert opinion, key informant interviews and focus group discussions) used during the data collection gave an insight into the respondents' ideas, opinions and experiences on the problems being investigated [29]. The Key informant interviews were conducted with participants with deeper knowledge on what was going on in the

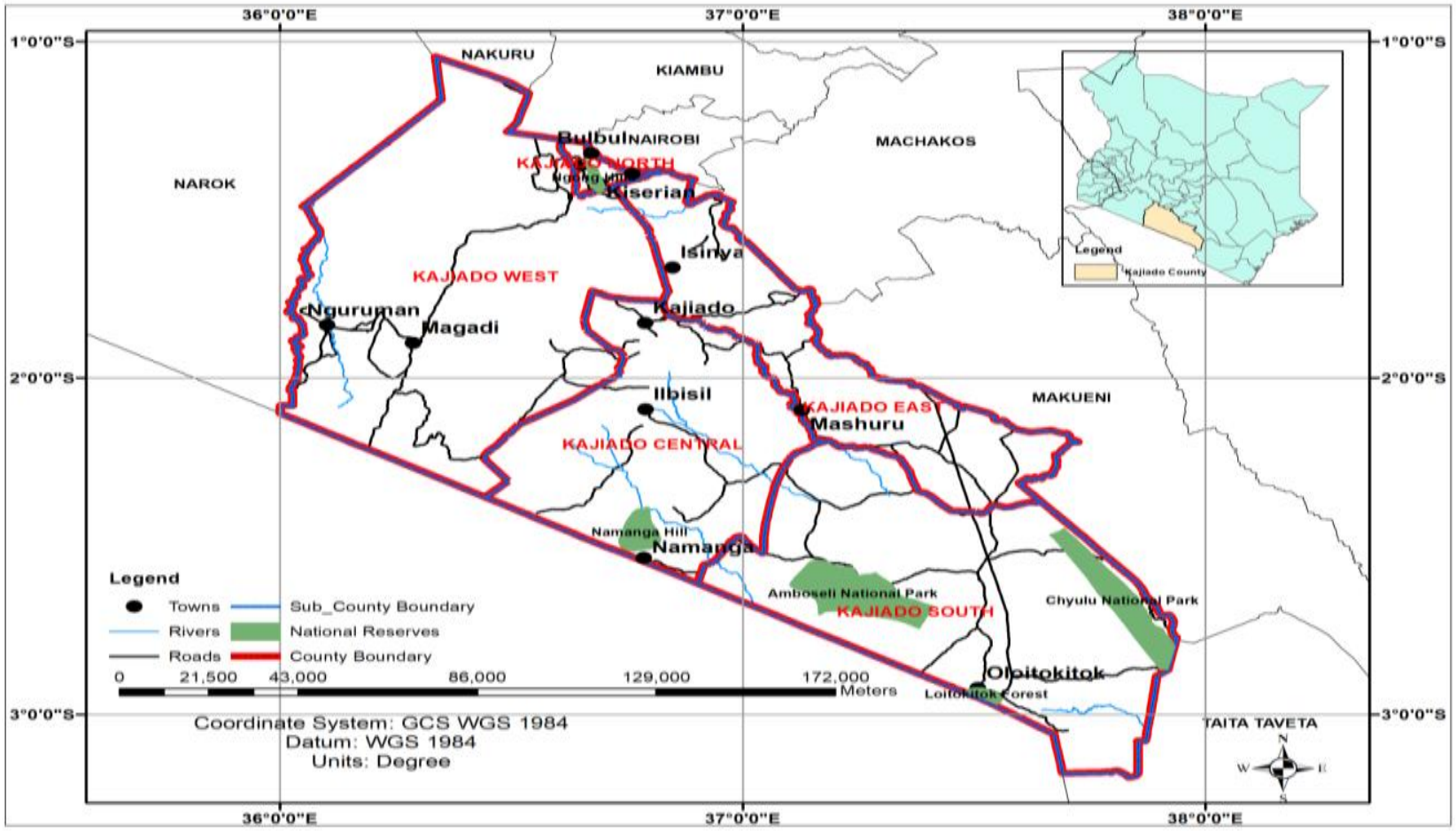

Fig. 1. The map of Kenya and Kajiado County administrative units
Source: Physical Planning Department, Kajiado County

community and these people included community leaders, professionals and pastoralists themselves [26]. Experts with specialized knowledge in relation to professional field of specialization such as technical or social field were interviewed during EOIs [30].

The FGDs were conducted in 10 areas within the selected wards. Two focus group discussions were conducted in each of the wards giving a total of 10 FGDs across the five sub-counties. Published participatory data collection methods that included listing, simple ranking and pairwise ranking and probing were used during the collection of primary data on livestock disease prevalence [31,32].Twenty five KIIs were conducted; six were conducted with the community's opinion leaders, five with village elders, six with chiefs, six with staff from the Veterinary Department and two with staff from an NGO within the County.

Twelve expert opinion interviews (EOIs) were conducted with experts drawn from technical departments; one expert each was interviewed from the Department of Meteorological Services and National Drought Management Authority (NDMA), two from the Department of Agriculture and eight from the Departments of Veterinary Services and Livestock Production. For the livestock disease prevalence, the participants identified and listed the common livestock diseases that affected cattle, sheep and goats based on their prevalence in relation to climate change. The pastoralists applied the usage of local names that the diseases were being identified by within the County and where necessary there was probing to establish if the disease had been identified correctly. Where the pastoralists could only identify the disease using syndromes rather than the specific name of the disease, probing was done to get clarity on the identified disease but final validation of the actual disease in reference was later done through the assistance of technical staff from veterinary office on such diseases. Simple ranking was done with the participants to establish a simple relationship between the diseases by giving a ranking number. The pairwise ranking was then further used to rank the diseases in pairs. The rankings from both simple and pairwise rankings were computed into scores.

The secondary data on rainfall and temperature were obtained from the Department of Meteorological Services for a period of over 30 years and livestock disease incidence and intervention measures were obtained from the County Department of Veterinary Services in Kajiado. Other information on secondary data was obtained from published research papers, journals, books, and other online publications.

2.5 Data Management and Analysis

Data collected on climate variables (rainfall and temperature), livestock disease incidence and interventions were recorded in notebooks and then entered into a database. The data were then analyzed through content analysis, appropriate conclusions drawn based on the questions and objectives of the study. The results were reported as community's perception on climate trend and livestock disease incidence and interventions. The scores on livestock disease prevalence obtained through simple and pairwise rankings by the participants were analyzed using the Kruskall-Wallis test to determine whether the average scores obtained for the diseases showed any significant difference from zero score [33].

For quantitative data on temperature and rainfall, the study period was divided into two: Period A (1970 to 1993) and Period B (1994 to 2015). The data was first entered into Statistical Package for Social Sciences (SPSS version 20.0) then analysis done through descriptive and inferential statistics. With descriptive statistics, there was a computation of mean, median, and coefficient of variation that gave the climate trend. To determine the differences in the mean of climate variables (temperature and rainfall amounts) between the two periods (A and B), inferential statistical analysis was used through the use of unpaired t-test, with 5% level of significance. This was done to establish if there was a significant variation in values between rainfall and temperature within the two periods. The results were presented in tables and graphs. Quantitative data on livestock diseases and intervention was analyzed by computing disease frequency based on reported clinical cases, and results presented as bar graphs.

3. RESULTS

3.1 Description of Climate Trends

3.1.1 The community perception on climate trends

Community's perception was that rainfall amounts have declined and unpredictable, erratic, and of shorter duration, while temperatures were becoming very high or too

low. Dry seasons and incidences of droughts had become unusually prolonged. The incidences of drought was increasingly becoming more severe over a period of time with the water resources drying up, loss of vegetation cover and livestock pasture was becoming scarce due to the prevailing and observed climatic changes. These changes in climate were reportedly interfering with the community's cultural calendar of climate predictions through their indigenous knowledge.

3.1.2 Climate trends from the data of the department of meteorological services

For climate trend analysis, the study period was divided into two: Period A (1970 to 1993) and Period B (1994 to 2015). The average annual amount of rainfall for period A (1970-1993) was 793.70 mm while that for period B (1994-2015) was 765.17 mm. The minimum recorded average annual rainfall amount for period A was 438 mm while for period B, the minimum recorded average annual rainfall amount was 450 mm. The maximum recorded average annual rainfall for period A was 1,107 mm while for period B, the maximum recorded average annual rainfall was 1,174 mm. The variability in rainfall amount was shown by the increase in the coefficient of variation from 21.6% (period A) to 32.02% (period B) as shown in Table 1. For temperature, the average annual temperature for period A was 19.6°C while for period B, it was 19.8°C. The minimum recorded average annual temperature was 18.4^0C for period A and 16.4°C for period B while the maximum recorded average annual temperature was 20.4°C for period A and 20.6°C for period B. The variability in temperature was indicated by the increase in the coefficient of variation from 2.6% (period A) to 4.04% (period B) Inferential analysis to determine differences in mean in temperature and rainfall between the two periods (A and B) was done through an unpaired t-test. Within the two periods (A and B), the mean annual rainfall did not show any significant difference since the mean for the two periods was within the range of 700 mm of rainfall. Likewise, the mean temperature within the two periods, were not significantly different (Table 2).

3.2 Incidences of Livestock Diseases and Interventions on Livestock Diseases

3.2.1 Occurrence of livestock diseases from veterinary office records

The following livestock diseases reportedly occurred on farms within the County according to records from the Veterinary office: Helminthiasis, trypanosomiasis, anaplasmosis, East Coast fever (ECF), and pneumonia. The results showed that helminthiasis had the highest number of cases followed by trypanosomiasis. Other diseases that were reported to have occurred on the farms included Foot and mouth disease (FMD), anthrax, black quarter (BQ), rift valley fever disease (RVF), pestes des petits ruminants (PPR), sheep and goat pox disease, contagious bovine pleuropneumonia (CBPP), contagious caprine pleuropneumonia (CCPP) and lumpy skin disease (LSD). The results of the incidence of livestock diseases are shown in Fig. 2.

3.2.2 Intervention on livestock diseases from veterinary records

Livestock disease interventions especially vaccination, showed that diseases such as Rift valley fever, black quarter, anthrax, contagious bovine pleuropneumonia, contagious caprine pleuropneumonia, sheep and goat pox disease, pestes des petits ruminants and foot and mouth disease had low occurrence following the interventions (Fig. 3).

3.3 The Prevalence of Livestock Diseases in Kajiado

The pastoralists listed a total of 12 livestock diseases that affected cattle, 8 that affected sheep, and 8 that affected goats with higher prevalence rate. According to the pastoralists, livestock diseases more prevalent in the County were anaplasmosis, babesiosis, black quarter/anthrax, contagious bovine pleuropneumonia, East coast fever, Foot and mouth disease, heartwater, helminthiasis, lumpy skin disease, mastitis, pneumonia, trypanosomiasis, pestes des petits ruminants, coenurosis, enterotoxaemia, sheep and goat pox, rift valley fever, blue tongue and contagious caprine pleuropneumonia. There were reportedly increase incidences of these diseases and the increase was being associated with the observed changes in climate. There was an observation by the pastoralists that these diseases have a very high impact on livestock productivity thus greatly affecting their livelihoods.

The results of obtained scores for each of the diseases that affected cattle, sheep, and goats in the County as ranked by the pastoralists are shown in Tables 3, 4, and 5. According to the pastoralist, the cattle disease which frequently occurred in herds included, black quarter,

Table 1. Descriptive summary of average amount of rainfall (mm) and temperature ((°C)) between 1970 and 2015 in kajiado county

	Period A (1970- 1993)					Period B (1994-2015)				
Type of climatic parameter	**Mean**	**SD**	**Minimum**	**Maximum**	**CV%**	**Mean**	**SD**	**Minimum**	**Maximum**	**CV%**
Rainfall amounts mm per annum (n= 21)	793.70	171.36	438.23	1107.43	21.60	765.17	245.01	450	1174.13	32.02
Average annual temperatures (n=21)	19.60	0.50	18.40	20.40	2.60	19.80	0.80	16.40	20.60	4.04

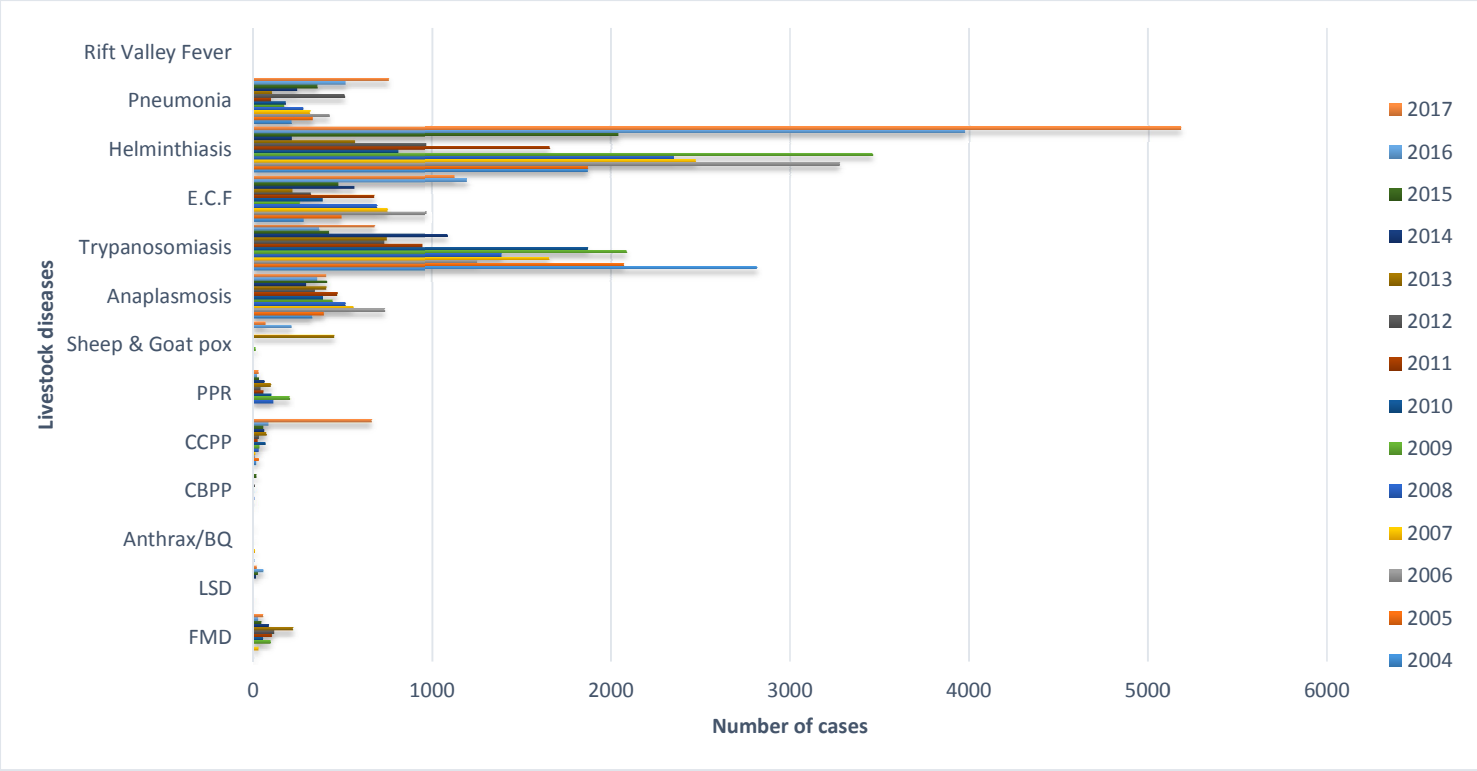

Fig. 2. Incidence of livestock disease trend in Kajiado County

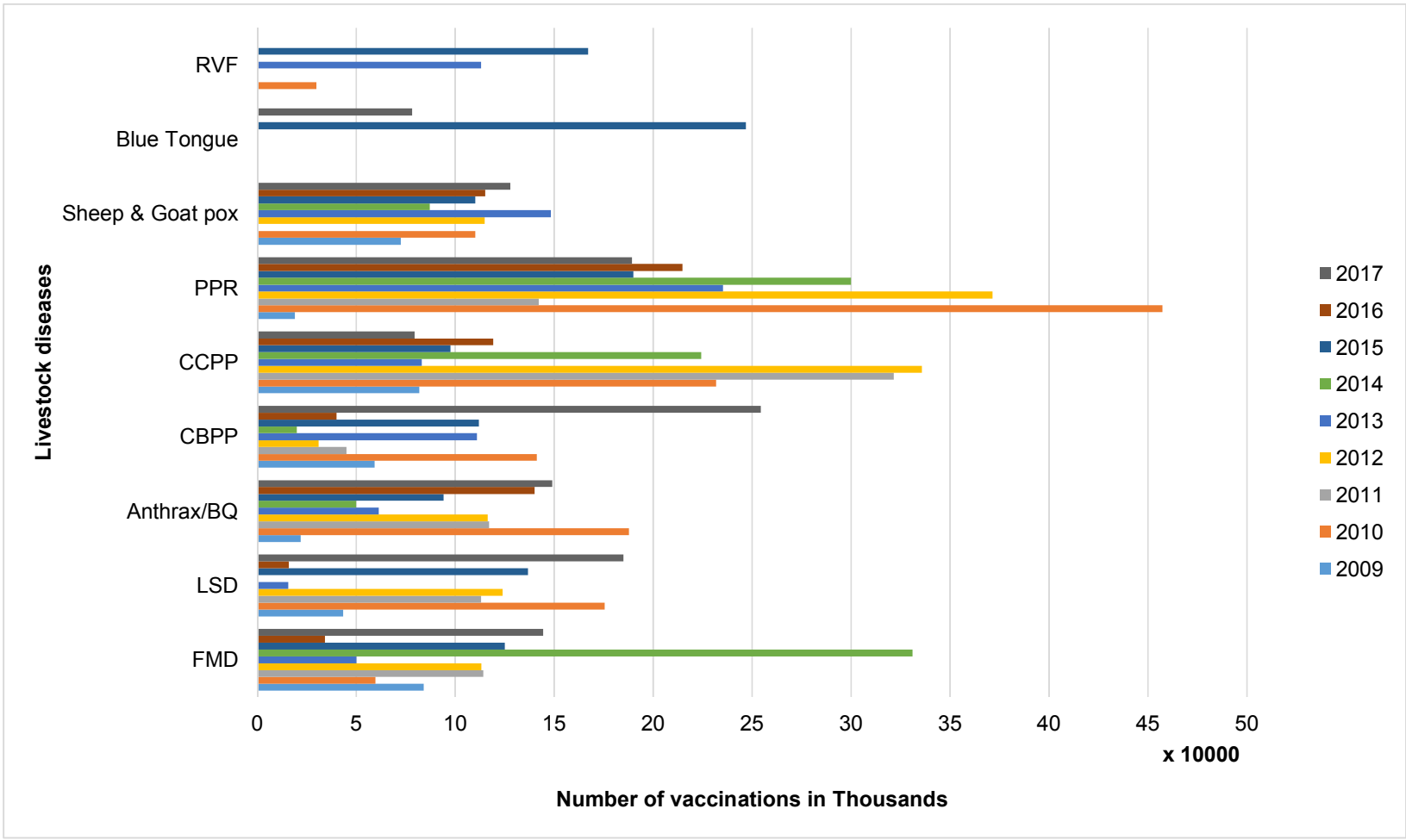

Fig. 3. Livestock disease intervention trend in Kajiado County

Table 2. Comparison of average annual rainfall and temperature in Kajiado County between 1970 and 2015

Description of climatic parameters	Period A	Period B	*P*-value
Average amount of rainfall (mm)	793.70	765.17	0.65
Average annual temperatures (°C)	19.6	19.8	0.20

Table 3. Prevalent diseases of cattle that affect production under a pastoral production system in Kajiado

List of cattle diseases	Median rank	Average rank	Z score
Black quarter/anthrax	0.21	50.8	2.71
Foot and mouth disease	0.25	50.8	2.71
East coast fever	0.14	45.5	2.01
Lumpy skin disease	0.16	34.5	0.53
Anaplasmosis	0.05	32.8	0.31
Helminthiosis	0.07	30.6	0.01
Contagious bovine pleurapneumonia	0	25.2	-0.71
Babesiosis	0	24.0	-0.87
Mastitis	0	20.0	-1.40
Heartwater	0	18.9	-1.55
Pneumonia	0	18.9	-1.55
Trypanosomiasis	0	14.0	-2.21

H = 31.98 (adjusted for ties) with 11 df, Probability > 31.98 = 0.0008

Table 4. Prevalent livestock diseases of sheep that affect production under a pastoral production system in Kajiado

List of sheep diseases	Median rank	Average rank	Z score
Pestes des petits ruminants	0.33	35.3	2.22
Coenurosis	0.20	31.5	1.53
Enterotoxaemia	0.10	25.1	0.38
Sheep and goat pox	0.07	22.2	-0.14
Blue tongue	0.0	21.5	-0.42
Rift valley fever	0.0	19.3	-0.67
Pneumonia	0.0	18.2	-0.87
Helminthiosis	0.0	12.5	-1.90

H = 12.73 (adjusted for ties) with 7 df, Probability > 12.73 = 0.0791

Table 5. Prevalent livestock diseases of goats that affect production under a pastoral production system in kajiado

List of goats diseases	Median rank	Average rank	Z score
Contagious caprine pleuropneumonia	0.33	31.3	2.21
Coenurosis	0.27	29.7	1.88
Heartwater	0.20	21.9	0.29
Rift Valley Fever	0.13	20.5	0.00
Pestes des petits ruminants	0.07	20.1	-0.08
Pneumonia	0.0	16.4	-0.84
Blue Tongue	0.0	13.6	-1.41
Helminthiosis	0.0	10.5	-2.04

H = 15.08 (adjusted for ties) with 7 df, Probability > 15.08 = 0.035

anthrax, Foot and mouth disease and East coast fever (Z > 1.96). The disease which significantly affected sheep was pestes des petit ruminates while goats were affected by contagious caprine pleuropneumonia.

4. DISCUSSION

The findings showed that there was an increase in variability in average amounts of rainfall and temperature. The coefficient of variation for the

average amount of rainfall had increased from 21.6% (1970 to 1993) to 32.02% (1994 to 2015) while the coefficient of variation for average temperature had increased from 2.6% (1970 to 1993) to 4.04% (1994 to 2015). But, there was no evidence that the average annual temperature and rainfall had changed significantly between these periods of study ($P > 0.05$). According to IPCC [1], climate change expectedly would become worse with pastoralists more likely becoming more vulnerable to climatic changes. Future climate-related risks would depend on the rate, peak and duration of global warming [6]. Climate change and variability were being experienced by the pastoralists through unpredictable rainfall, prolonged droughts, and high temperatures. According to a study carried out by Kimaro et al. [34] in Northern Tanzania, pastoralists were well aware of the general climate trends in their location, its variability and the impacts of extreme weather events on cattle production with the main climate changes perceived by pastoralists including more erratic and reduced amounts of rainfall, rise in temperature and prolonged and frequent periods of drought. This study reportedly found that the situation in Kajiado had been worsened further by the fact that variability has interfered with the community's cultural calendar as they could no longer use their cultural calendars through the indigenous knowledge to predict weather conditions preciously as before. This was in consistent with the study conducted by Ingrid [12] in the pastoral communities of Somaliland where the findings showed that there were changes in the weather patterns in comparison to the past, especially changes in temperature and rainfall levels with the resultant change in the traditional weather forecasting to the extent that the predictions were no longer practiced and considered valid by the communities.

These climatic changes have led to drying up of water sources, loss of vegetation cover, scarcity of pasture for livestock, the emergence of or increased livestock diseases, massive livestock deaths and poor livestock productivity greatly impacting on their livelihoods. Globally, livestock is likely to face serious effects of climate change and variability including the risk of extinction of between 20-30 percent of all animal species. Climate variability has severe impacts on the environment, more so on water availability, agriculture and food security, human health and biodiversity [35]. Massive livestock deaths and low livestock productivity was being associated with severe and prolonged droughts. This was found to be impacting negatively on pastoralism which is the main economic activity and source of livelihood for the pastoralist community in the County. These results agree with reports from UNFCCC [13] and WSPA [36] that stated that climate change and variability is expected to have far-reaching consequences in ASALs for dairy and meat production where the production systems are vital for nutrition and livelihoods. The findings of this research are in further agreement with a study conducted by Gardner [20] among pastoralist community in Tanzania where it was found that East African pastoralists whose livelihoods depend upon their livestock were seriously threatened by climate change impacts on water, pasture, and disease dynamics.

The livestock diseases are posing a serious challenge to the pastoral production system in the County with expected serious disruption on the pastoral livelihoods in the County as was indicated by the results from the records obtained from Veterinary office where there were reportedly high incidence of diseases such as helminthiasis, trypanosomiasis, anaplasmosis, East coast fever and pneumonia but with trypanosomiasis and helminthiasis reportedly occurring at high frequency compared to the rest of the diseases. In a study conducted by Kimaru et al. [37] in northern Tanzania on climate change and cattle vector-borne diseases, the incidence of livestock diseases followed the same pattern as East coast fever and African animal trypanosomiasis were among the highly rated livestock diseases in occurrence.

However from the pastoralists' perspective, the livestock diseases that affecting their livestock (cattle, sheep and goats) were included anaplasmosis, babesiosis, black quarter/anthrax, contagious bovine pleuropneumonia, East coast fever, Foot and mouth disease, heartwater, helminthiasis, lumpy skin disease, mastitis, pneumonia, trypanosomiasis, pestes des petit ruminants, coenurosis, enterotoxaemia, sheep and goat pox, rift valley fever, blue tongue and contagious caprine pleuropneumonia but the diseases with the highest prevalence included East Coast fever, Foot and mouth disease and anthrax and black quarter, pestes des petits ruminants and contagious caprine pleuropneumonia ($Z > 1.96$). Climate is one of many factors with the potential to alter disease frequencies and is expected to exert an overwhelming negative effect on the health of humans and animals [38]. During 2006 when the

lowest amount of rainfall was recorded in Kajiado, the most reported livestock diseases were included helminthiasis, trypanosomiasis and tick-borne diseases including East coast fever and anaplasmosis while the diseases which were reported to have occurred at higher frequencies during the El Nino year (2017) included helminthiasis, East coast fever, pneumonia and trypanosomiasis. The occurrence of helminthiasis appeared to have been highest in 2017. The occurrence of these diseases during drought period (2006) and El Nino period (2017) did not seem to have a direct relationship with variability in rainfall and temperature since they were equally reported during drought and floods. This seems to conform to the observations made by Bett et al. [18], that investigation on climate change and disease occurrence would show a lot of uncertainties and specification biases and by Gale et al. [17] that climate change would affect the occurrence, distribution and prevalence of livestock diseases. A series of studies have described a greater risk of mortality during the hottest months Vitali et al. [39] and an increased death rate during extreme weather events [40,41]. It should be noted that factors leading to the effects of climate change on health are extremely complex, involving not only environmental forces, but also ecological and social aspects, economical interests, and individual and community behaviors [42]. Some of the livestock diseases that were considered by pastoralists to be of economic importance to livestock production system in Kajiado but were reported to have low occurrence due to interventions undertaken by County Government included Rift valley fever, CBPP, CCPP, Blackquarter/Anthrax, FMD, PPR and Sheep and Goat Pox. Intervention especially vaccination were considered by pastoralists to be very important in reducing the impact of these diseases on livestock production as the results indicated in the low occurrences. The negative effects of climate change on animal health and welfare will be consequence of combined changes of air temperature, precipitation, frequency and magnitude of extreme weather events and may be both direct and indirect [43]. The direct effects of climate change on health include temperature-related illness and death. Indirect impacts follow more intricate pathways and include those derived from the influence of climate on microbial density and distribution, distribution of vector-borne diseases, food and water shortages, or food-borne diseases [44].

5. CONCLUSION AND RECOMMENDATIONS

The results have shown that there was variability in rainfall and temperature with the coefficient of variation for the average amount of rainfall increasing 21.6% to 32.02% between 1970 and 2015 and the coefficient of variation for average temperature increasing from 2.6% to 4.04% between the same periods. There was no clear evidence to show that the average annual temperature and rainfall had changed significantly between these periods of study ($P > 0.05$). Trypanosomiasis and helminthiasis reportedly were the livestock diseases with the highest incidence of occurrence according to records obtained from the county government veterinary office but according to the pastoralists, livestock diseases that had a significant effect on livestock were included pestes des petits ruminants, contagious caprine pleuropneumonia, east coast fever, anthrax, foot and mouth disease and black quarter ($Z > 1.96$).

These livestock diseases are posing a serious challenge to the pastoral production system as they cause livestock deaths and reduction in livestock productivity. This was attested to during the 2006, 2008, and 2009 droughts where there were reported livestock deaths above 70% in most parts of the County. Where proper livestock disease interventions through vaccinations have been applied, it was observed that the occurrence of diseases had been reduced.

In conclusion, there is evidence of increased climate variability in the area as shown by increase in the coefficient of variation for rainfall amounts and temperature. Livestock diseases that occurred with increased frequency in the area included ECF, Anaplasmosis, helminthiasis and trypanosomiasis and there were no intervention measures applied against these diseases by the county government of Kajiado. Most of the intervention measures targeted diseases like pestes des petit ruminates, contagious caprine pleuropneumonia, lumpy skin disease, contagious bovine pleuropneumonia, anthrax and black quarter, sheep and goat pox and rift valley fever.

The study recommends the formulation and implementation of appropriate plans and policies that could assist in management of pastoral production systems with the advent of climate change and variability to support the resilience of the pastoral community in Kajiado. Among the

areas, the policy or plan should address is proper management of livestock diseases to reduce their impact on livestock production and Early Warning System as a timely surveillance system to collect data on expected hazards or disasters that triggers prompt and appropriate interventions to minimize impacts of climate hazards or disasters that could be associated with climate change and variability, especially on livestock production. The early warning should provide on the impending drought or erratic rainfalls and the impacts that might accompany the incidences of drought or excessive rainfall that results in flooding. Other areas that should be considered in the policy or plan are the provision of monthly and seasonal weather forecasts, dissemination of climate-related information to pastoralists, development of Disaster Risk Management Reduction (CMDRR) for disaster risk analysis, hazard identification, ranking of hazards, vulnerability assessment, characterization of hazards, rapport building and introduction of Pastoral Field Schools as platforms for community's capacity building on disaster preparedness, vulnerabilities and capacity to identify climate change adaptation strategies.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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