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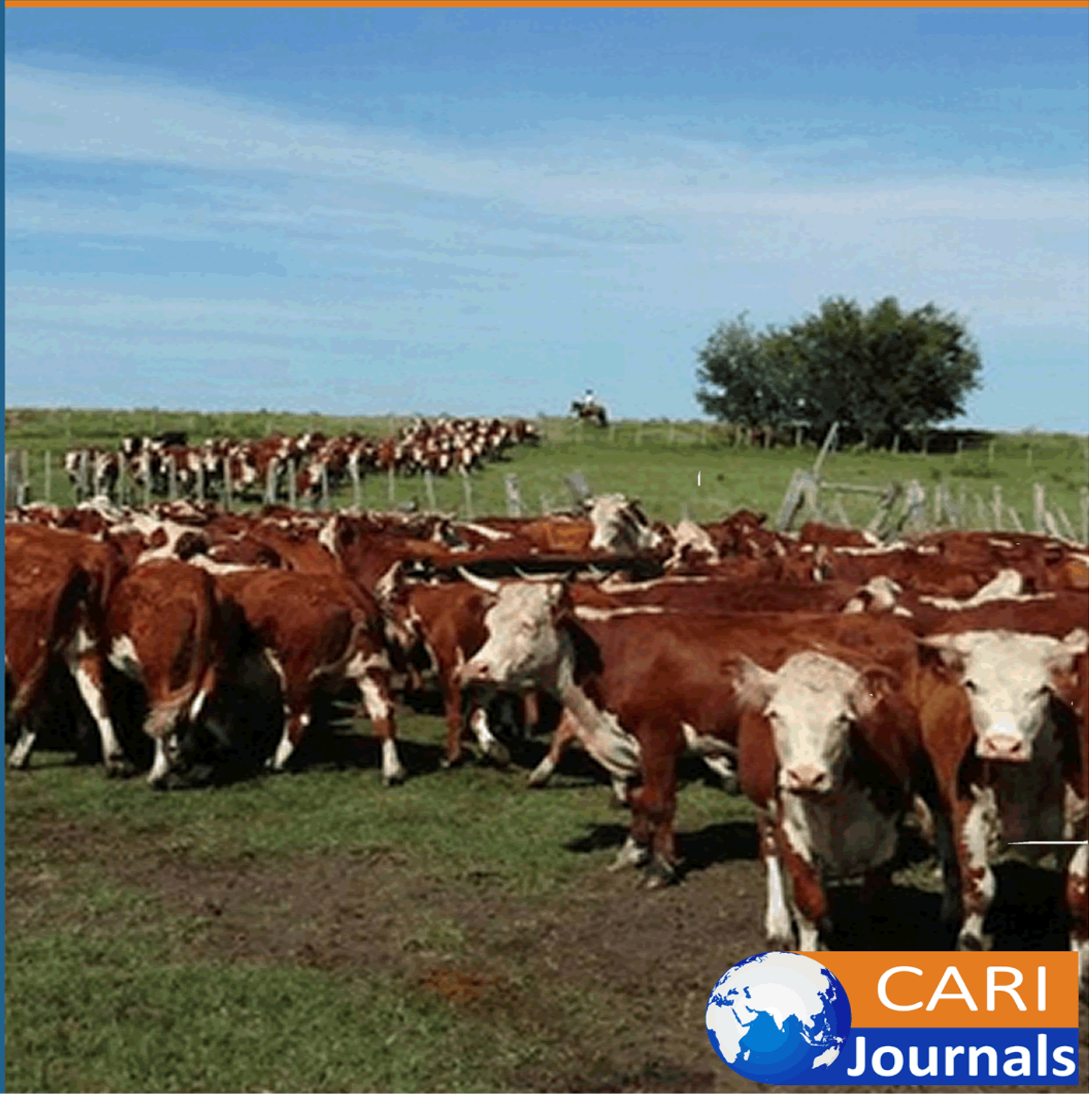

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Potential Effects of Climate Variability on Cattle Farming in Kenya

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Abstract

Purpose: Increase in variability and change in temperature and rainfall patterns are being experienced in many parts of the world including Eastern Africa. Changes in temperature and rainfall extremes are already being experienced in many parts of the world and Kenya is not an exception. The overall objective of this study was to assess the potential effects of extreme climate variability and change on livestock in the ASALs of Kenya.

Methodology: The paper used a desk study review methodology where relevant empirical literature was reviewed to identify main themes and to extract knowledge gaps.

Findings: The study observed that during the period of abnormal wetness, cattle populations were higher than those of the abnormal dryness thus climate affects cattle population. From the projections, the study concludes that there are chances of high negative effect of abnormal dryness for the period 2030-2040 over the study area.

Unique Contribution to Theory, Policy and Practice: Findings from the study can be used in the planning and management of the livestock sector in the ASALs of Kenya and support national sustainable development planning. The information from this study can be used by the policy makers to develop policies that can address the problem of high livestock mortality due to extreme weather and climate conditions in the country. Further studies on the effects of climate change on other aspects of livestock such as forage as well as methodology way to distinguish human factors from climate factors that affect livestock farming should be conducted.

Keywords*: Cattle Farming, Climate Variability, Arid, Semi-Arid*

1.0 INTRODUCTION

1.1 Background of the Study

Increase in variability and change in temperature and rainfall patterns are being experienced in many parts of the world including Eastern Africa. Recent intergovernmental Panel for Climate Change (IPCC, 2013) assessments has indicated that climate change is one of the key challenges threatening the current and future sustainability of the socio-economic systems. Floods/droughts associated with too much or too little rainfall are known to displace and kill people, livestock, destroy property and investments, degrade environment and basic fabrics that support the communities (Huho, J. M., & Kosonei, R. C. 2014). Developing countries like Kenya are more vulnerable to the effect of climate change due to their high degree of low adaptive capacity (IPCC, 2013). Over 80% of Kenyan land mass may be classified as arid and semi-arid lands (ASALs) with livestock being key activity in these areas. Subsistence and commercial farming are the key activities in the high potential agricultural areas.

Agriculture in Kenya accounts for up to 26% of the country's gross domestic product (GDP) and 60% of the export earnings (Chongela, J.2015). Agriculture is extremely vulnerable to extreme climate variability and change as has been witnessed during the years of the major floods and drought. The impacts of climate extremes on livestock and agriculture often affect the rural poor communities who depend on agriculture and livestock for survival (Gukurume, S. 2013). In Kenya, agriculture is the backbone of the economy as 75% of the Kenyan population is dependent on agriculture for food and income. Statistics have also shown that, about one third of the total land area of Kenya is agriculturally productive, including the Kenyan highlands, coastal plains and the lake region (FAO, 2006). About 75% of livestock are found in the ASALs of Kenya, and this sector contributes approximately 13% of Kenya's GDP, 40% to agricultural GDP and it also employs 50% of the labor force (Nyariki, D. M., & Amwata, D. A. 2019; PDNA, 2012).

The arid and semi-arid areas of Kenya are characterized by unreliable, low, variable and poorly distributed rainfall. Orindi et al. (2007) and FAO (2006) indicated that the mean annual rainfall in the semi-arid and arid areas of Kenya is between 300 - 500 mm and that the soils in these areas are shallow and infertile with Lake Turkana region receiving less than 250 mm of rainfall per year. But areas such as Marsabit with an altitude above 1,200 m have fertile soil and receive rainfall up to 600 mm per year (FAO, 2006). Eastern side of Turkana County receives an annual rainfall of

200mm and over 500mm in the western highlands (Omolo, 2010; Mureithi and Opiyo, 2010). Mean annual temperature in the ASALs of Kenya is between 22 °C and 40 °C. The temperature for Turkana County ranges between 26 °C and 38 °C (Opiyo, F. E. 2014).

Northern Kenya's ASALs depend mostly on livestock, which is the major domestic wealth and account for more than two-thirds of mean income (Barrett, C. B., & Carter, M. R. 2013). Zebu cattle is the most common breed for the majority of Kenyans living in the ASALs and constitutes 77% of total cattle population in Kenya (Tully, T. 2014), concentrated mainly in arid and semiarid lands. A study by Nyariki D. M. et al. (2014) showed that cattle are the most important livestock type kept mainly for income, milk, meat and dowry, while goats and sheep are kept for income, meat and skins by the Masaai in the rangelands of Kenya. Floods and drought are key challenges to sustainable livestock development in Kenya.

Floods lead to inundation of grazing land and animal mortality. They are often associated with diseases such as Rift Valley Fever (RVF),_while drought leads to heat stress, lack of water and pasture, death of livestock, and devastation of the livelihoods, among many other miseries (Varenyam A. 2013; FAO, 2006). Studies by IPCC (2007; 2013), Hall A. et al. (2014), showed that climate change, leading to changes in the magnitudes and frequency of extremes, is real.

Since livestock sector has a significant contribution to the formal and informal economy of the country, adaptation in this sector should thus be a significant focus in order for Kenya to respond to the impacts of extreme climate variability and change. This will help in safeguarding the provision of adequate food for a growing population and also for export to generate foreign exchange (Garderen, 2011; GoK, 2013; Tibbo and Steeg, 2013). This study therefore examines the potential impacts of extreme climate variability and change on livestock in the ASATs of Kenya, with specific reference to Turkana, Marsabit, Samburu, and Isiolo Counties.

1.2 Statement of the Problem

Changes in temperature and rainfall extremes are already being experienced in many parts of the world and Kenya is not an exception. IPCC (2013) indicate that climate change is real with the livelihoods likely to be exposed to more climate extremes in the future (Rahman, S., & Kayes, I. 2012). Rainfall variability has also increased, with a decline in long rains season and appositive trend for short rain season (Ouma, J. O. 2015).

Northern Kenya's ASALs depend mostly on livestock (Barrett, C. B., & Carter, M. R. 2013). Floods and droughts are natural events which cannot be controlled (Heazle, M. et al 2013). They are the main extremes of the climate spectrum that have been associated with poor vegetation, diseases, loss of livestock, and devastation of the livelihoods among many other miseries. Drought in particular is a troublesome hazard that has been documented to have adverse impact on livestock and agricultural development. Rangeland degradations have also been caused by over-grazing due to limited resources thus soil erosion (Lal, R. 2015).

Livestock production is adversely affected by drought in terms of quality and quantity of feed which has led to low level of productivity, high mortality, reduced market value and conflicts among the pastoral communities for water and pasture (Shinde, A. K., & Sejian, V. 2013). Extreme climate conditions therefore lead to livestock mortality which is the most severe economic risk faced by pastoralists in Kenya (PDNA, 2012; Chantarat, S. et al., 2013). Little has been done on the impact of extreme climate variability and change to livestock farming in Kenya. This study, therefore, was aimed at assessing the potential impacts of extreme climate variability and change on livestock in the ASALs of Kenya, with specific reference to Turkana, Marsabit, Samburu, and Isiolo Counties.

1.3 Objective of the Study

The overall objective of this study was to assess the potential effects of extreme climate variability and change on livestock in the ASALs of Kenya.

1.4 Significance of the Study

Society is impacted more by changes in extremes than by changes in the means. Risks posed by climate variability are high in Kenya due to lack of coping capacity among large and small sectors of the society. Poor fanners are more exposed to the effect of extreme climate events and are unable to absorb the shocks of climate related hazards due to lack of resources and general coping capacity. Increase in temperature and decline in rainfall as projected by different Global Climate Models (GCMs) are likely to cause several challenges to livestock farming which may lead to increased loss of domestic livestock during extreme events in highly prone areas (Berhane, K., & Samet, J. 2016)

Livestock contributes to food security and diet, poverty reduction, employment and economic growth, financial saving, social security, living insurance and fertilizer. Persistent climate

variability and change will continue impacting this important sector of the economy in Kenya unless action is taken (Ochieng, J., Kirimi, L., & Mathenge, M. 2016). Hence, this study was aimed at assessing the effect past and present climate extremes on livestock and likelihood of future impact of extreme climate variability and change on livestock in the ASALs of Kenya. The four counties were chosen due to the availability of livestock data and the Zebu cattle are the livestock considered in this study.

2.0 LITERATURE REVIEW

2.1 Importance of livestock in Kenya

Cattle's farming remains a central feature of rural populations. Statistics by the African Union indicates that pastoralism contributes between 10% and 44% of the GDP of the African continent (Union, A. (2013). The livelihood of the African continent over time has mainly been livestock domesticated farming. Northern Kenya's ASALs depend mostly on livestock, which account for more than two thirds of mean income (Chantarat, S. et al 2013). They are sold for grains or to meet other domestic requirements. When the pastoralists lose their livestock, they organize social insurance activities that offer informal inter-household transfers of a breeding cow, but the scheme does not cover. Cattle breeds in Kenya comprise of Sahiwal, Boran, Maasai zebu, Kamba zebu, Charolaise, and Simmental and their crosses, Friesian and Ayrshire dairy cattle breeds have also been introduced in some areas of Kenya (Ouma, J. O. 2015). The Zebu cattle are tethered on farm, taken to graze on the roadsides or in communal areas. They are mainly kept for beef and milk (FAO, 2006), and the cows are milked for approximately five months of lactation Most of the dairy fanners in Kenya practice zero grazing, free-grazing or a combination of both (FAO, 2006).

Livestock production in northern Kenya is characterized by low productivity as a result of poor and degraded rangelands due to drought, insecurity, diseases outbreaks, absence of veterinary care and inadequate livestock marketing systems among other factors (Nyangito, M et al 2015). There is need to increase livestock productivity in the ASALs of Africa including Kenya, this is because the demand for livestock products has increased globally. This will lead to changes in livestock production in Africa to meet the increasing demand (Onyango, A. O. (2016)

2.2 Climate extremes affecting cattle farming

Spatiotemporal variability of precipitation in East African affects the livelihood of tens of millions of people in terms of flash floods, droughts, and rainfall variability on intra-seasonal time scales

(Berhane, F. G. 2016). Agricultural production losses due to extreme weather have been documented to have some degree of positive spatial correlation, since weather patterns are generally similar over a large area. Drought in particular, affects both agriculture and pastoralism and its highest impacts are felt by the pastoralists since it results to drying up of water resources and reduction in forage resources for livestock (Opiyo, F. E., & Scheffran, J. 2012). Climate change and variability leads to the spatial distribution of disease outbreaks (Morton, L. C., & Liu, Q. 2013). Seasonal rainfall changes lead to outbreaks of Rift Valley Fever (RVF), Pest des Petits Ruminants (PPR), bluetongue virus, East Coast Fever (ECF), Foot and Mouth disease (FMD), facial eczema and anthrax among others, and they are mainly set off by definite weather conditions. Livestock resistance and immunity to diseases are diminished by drought and are likely to be exposed to new diseases due to rapid increase of pathogens and seasonal variation in disease distribution (Grace, D. (2017). Policy and response in terms of climate change and agriculture over different regions tend to focus more on crops therefore; these need to examine the impact of climate variability on livestock farming.

2.3 Livestock adaptation to climate change

Adaptation is the ability to produce and reproduce by cattle breeds in a given environment or acquiring alternative breeds for a specific environment as defined by Almeida, A. M. D. (2012). IPCC defined adaptation as "the initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects" (Pachauri and Reisinger, 2008; Hoffmann, 2010; 1PPC, 2013). Adaptation behaviors are characterized by low heritability, and one way to adapt to climate change is through the utilization of animal genetic variety (Ma, Y. et al 2019). Ruminants have higher degree of thermal tolerance than mono-gastric species and therefore, there are substantial differences in thermal tolerance between species. Breeds in temperate regions supply bulk product in the market but they don't adapt well to heat stress. Several research have been done on heat stress but still there is need for simulating livestock adaptation to climate change and future impacts of climate change on livestock farming under the changing climate.

Zebu cattle have been reported to sustain low rectal temperatures, low respiratory rates as well as low water intake (Angel, S. P et al 2016). Traditional livestock breeds are likely to play a significant role in adaptation to climate change. It has also been reported that commercial dairy

and beef are more vulnerable to the effect of climate change than small farms (Warburton, M. 2013). Therefore, there is need for more research on the adaptive nature of traditional livestock to different climatic conditions.

Pastoralism in harsh climatic conditions has been the livelihood of many communities in northern Kenya for centuries (Warburton, M. 2013). In case of losses (animal death), the pastoralist borrow money from families and friends in order to restock their animals. They also migrate in response to spatiotemporal variability in water availability and forage. In order for farmers to protect their livestock from the physiological stress of climate change, they need access to capital and technologies otherwise, breed displacement and losses may increase. The Government of Kenya (GoK, 2010) has prioritize livestock as an area for policy support and recommended the creation of special livestock insurance schemes to transfer or spread climate related risk that impacts negatively on the livestock sector mainly on the on northern Kenya Donor agencies and governments have developed and implemented ways of reducing the vulnerability of pastoralists to the impacts of drought.

There are two ways in which climate change adaptation can be considered. These ways are, "How can animals genetic resources cope with and adapt to climate change while continuing to contribute to food security and rural livelihoods?" and "How can the option value of genetic resources be maintained and potential loss of diversity minimized in the event of climate change?"

As the temperature rises, livestock models that consider agro-ecological conditions, production systems and climate change effects have indicated that farmers will change from cattle and chickens farming to goats and sheep. An example is the Sahel region where cattle have been replaced by dromedaries and sheep replaced by goats. They also indicate that livestock in ASALs of Africa will expand at the cost of humid and temperate highlands systems provided that there will be enough rainfall to support vegetation growth. It is also important to note that environmental degradation is likely to worsen the impact of climate change which further leads to increased cost of climate change adaptation.

2.4 Empirical review

Otieno (2019), conducted a study on the effects of climate on agricultural productivity in Kenya. Climate change is a global phenomenon that has greater impacts on productivity through agricultural crop production, livestock production, energy and tourism. Countries all over the

World have put adequate measures in place to combat or reduce its effects. This paper analyzed the effects of climate change on agricultural productivity in Kenya. The paper did answer two specific objectives; to determine the effect of climate change on crop production and to evaluate the effect of climate change on livestock production in Kenya. The study adopted time-series data on all the variables under study. Even though some studies considered the impacts of climate on crop production and on livestock production none actually considered the simultaneous effect on agricultural crop and livestock production. The study employed Ricardian Regression Model to analyze time-series data. A diagnostic research design was employed to carry out the study as it explored secondary sources of data which was analyzed using multivariate regression model and Augmented Dickey Fuller (ADF) was carried out to check the stationary of the data. The variables considered for the study were crop production and livestock production as dependent variables while temperature, rainfall, and relative humidity as independent variables. The data for crop production and livestock production were obtained from economic surveys (KNBS) ministry of agriculture and International Livestock Research Institute (ILRI) while temperature, rainfall and relative humidity from Kenya Metrological Department and World Bank. The results of the study showed that temperature and relative humidity significantly affect agricultural productivity. Relative humidity was found to be positively related to agricultural productivity, temperature has negative relationship and that that rainfall positively related to agricultural productivity.

Wato (2016), conducted a study on the effects of climate variability on livestock production and coping strategies in Maikona Location, Marsabit County, Kenya. Climate change is viewed as one of the greatest challenges facing humanity manifested in form of variation in amount and distribution of precipitation, ocean salinity, wind patterns and aspects of extreme weather leading to droughts and flooding, among others. Pastoral community in Maikona location (Marsabit County) is one such community. The existence of effective coping mechanisms is vital for the survival of these communities. This exploratory study sought to investigate the coping mechanisms that pastoral communities have employed in Maikona Location and their sustainability. The study employed both quantitative and qualitative methods, targeting 145 respondents including 127 Households respondents, 14 Youth and Women group members in FGDs and 4 technical/NGO representatives. Questionnaires, FGDs and key informant checklists were used as the main tools. Data were analyzed both descriptively and inferentially. It is envisioned that the study would give

vital information to pastoral development stakeholders and policy makers on the actual impacts facing the pastoralists, the existing and appropriate coping mechanisms while guiding on the interventions and policy options. The results of the study showed that there had been real and perceived changes both in the rainfall and temperature patterns. Field inquiries indicated a great change in rainfall patterns (94%) between 1980 and 2010 as well as a significant trend of decline from the data of the metrological department. These changes were established to be negatively impacting livestock production and the livelihood of the community in the study area. The local community was found seeking for relief food, buying food on credit and selling livestock asset as the common coping strategies. However, the sustainability of those strategies is in huge doubt since most of the respondents were not even sure of their longevity while others admitted they may not use them for long. Moreover, majority (84%) of the respondents could not tell the consequence of their strategies on the environment. The external supports provided to the communities were largely in response to emergencies and were not seen as sustainable in the long term.

Wachira (2017), did an assessment of economic impacts of climate change on livestocl and crop returns in the coastal regions of Kenya. The overall objective of this study was to assess the economic impacts of climate change on agriculture in Kenya's coastal region. The study was conducted in all the six counties in the coastal Kenya: Kwale, Mombasa, Kilifi, Lamu, Tana River and Taita Taveta. A total of 631 respondents were interviewed to obtain the cross-sectional survey data. The secondary data on temperature, precipitation and evaporation for 40 years was obtained from Kenya Meteorological Department. Using the Ricardian model to analyze the data, both the linear and quadratic effects of change of climate on crops, livestock net revenue and the combination were calculated. The results from the study showed that climate change significantly ($p<0.05$) affects net revenues from crops, livestock and a combination of both livestock and crops. The other socioeconomic variable that were found to also significantly ($p<0.05$) affect net revenue from crops, livestock and a combination of crops and livestock were, access to media, credit services access, farmer to farmer extension services, size of land owned, climate change awareness, education level, age and gender of household head. According to the results, a nonlinear relationship exists between climate variables and net revenues from crop, livestock and agriculture as a whole.

Ngare (2017), conducted a study on farmers' perceptions on the effects of climate variability on dairy farming in Masaba North, Nyamira County in Kenya. Climate variability is an emerging phenomenon that is threatening dairy farming globally. The dairy-climate change dilemma in Kenya cannot be mistaken. However, extensive research into dairy farming and an understanding of the dynamics of climate variability effects is greatly lacking. The study investigated the effects of climate variability on dairy farming in Masaba North Sub-county of Nyamira County, Kenya. The main objective was to determine the effects of climate variability on dairy production in the study area. During the study two sampling techniques were used; purposive and systematic sampling that captured key informants and household information respectively with a targeted sample size of 100 respondents. Further, the findings obtained were analyzed through Statistical Package of Social Sciences and Excel. Data was presented in tables, graphs and pie charts. From the results, a hypothesis was tested using Chi-Square (X2). The null hypothesis on effect of milk production was accepted where, (X2 = 0.087, DF =2, P = 0.001). At least 93% of dairy farmers had basic primary education during the study. The farmers' perceptions on climate variability were set on the Likert scale to determine their magnitudes through total weights. The results from the study showed that temperature had risen by at least +0.50 C in the past 35 years with anomalies of rainfall across the years indicating variability effect in the area. Heat stress affected animal performance with 67% dairy farmers' views hypothetically accepted. 89% of respondents stated that seasons had changed and were unpredictable. From the study, 42% of farmers used crossbreeding to improve animal performance a way of mitigating climate change. The integral recommendations were; improve dairy cattle performance through adoption of modern livestock techniques, growing of fast vegetating fodder crops and harnessing immediate farmers' education to mitigate climate variability effects.

2.5 Research gaps

A knowledge gap occurs when desired research findings provide a different perspective on the issue discussed. For instance, Ngare (2017), conducted a study on farmers' perceptions on the effects of climate variability on dairy farming in Masaba North, Nyamira County in Kenya. The study investigated the effects of climate variability on dairy farming in Masaba North Sub-county of Nyamira County, Kenya. The main objective was to determine the effects of climate variability on dairy production in the study area. During the study two sampling techniques were used;

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In addition to that, a methodological gap can be identified as the above researchers for example Wachira (2017), did an assessment of economic impacts of climate change on livestock and crop returns in the coastal regions of Kenya. The overall objective of this study was to assess the economic impacts of climate change on agriculture in Kenya's coastal region. A total of 631 respondents were interviewed to obtain the cross-sectional survey data. The results from the study showed that climate change significantly ($p<0.05$) affects net revenues from crops, livestock and a combination of both livestock and crops. Our current study adopted a desktop literature review method.

3.0 METHODOLOGY

The study adopted a desktop literature review method (desk study). This involved an in-depth review of studies related to the potential effects of climate change and variability on livestock in arid lands of Kenya. Three sorting stages were implemented on the subject under study in order to determine the viability of the subject for research. This is the first stage that comprised the initial identification of all articles that were based on potential effects of climate change and variability on livestock in arid lands of Kenya. The search was done generally by searching the articles in the article title, abstract, keywords. A second search involved fully available publications on the subject on potential effects of climate change and variability on livestock in arid lands of Kenya. The third step involved the selection of fully accessible publications. Reduction of the literature to only fully accessible publications yielded specificity and allowed the researcher to focus on the articles that related to potential effects of climate change and variability on livestock in arid lands

of Kenya which was split into top key words. After an in- depth search into the top key words (cattle farming, climate variability), the researcher arrived at 4 articles that were suitable for analysis. This were results from;

Otieno (2019), who conducted a study on the effects of climate on agricultural productivity in Kenya. The study adopted time-series data on all the variables under study. A diagnostic research design was employed to carry out the study as it explored secondary sources of data which was analyzed using multivariate regression model and Augmented Dickey Fuller (ADF) was carried out to check the stationary of the data. The variables considered for the study were crop production and livestock production as dependent variables while temperature, rainfall, and relative humidity as independent variables. The results of the study showed that temperature and relative humidity significantly affect agricultural productivity. Relative humidity was found to be positively related to agricultural productivity, temperature has negative relationship and that that rainfall positively related to agricultural productivity.

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4.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

It is evident from the study that both maximum and minimum temperatures are increasing at all study locations as has been observed at many locations worldwide. The highest increase in seasonal mean of surface air temperature ranging from 0.33-1.45°C was observed for June-August season. Results from rainfall analyses did not delineate homogenous changing patterns at all locations and seasons, however increase in drought risk was evident at most locations within the study area when recent mean rainfall (1991-2013) was compared with the means of 1901-30, 1931-60, and 1961-90. Some changes in the pattern of temperature and rainfall extremes were also evident from the patterns of higher order time series moments which included skewness and kurtosis. It was observed that the recurrences of extremes were centered on 2.3, 3.5, 5.5, and 9-10 years which were attributed to different climatic systems.

The study observed that during the period of abnormal wetness, cattle populations were higher than those of the abnormal dryness thus climate affects cattle population. From the projections, the study concludes that there are chances of high negative effect of abnormal dryness for the period 2030-2040 over the study area. An ensemble of the models was found to have a better skill in replicating the observation and hence was used for analysis of future climate. The extremes in rainfall and temperature were projected to increase in the future with a significant change in the mean of temperature in all the scenarios used in this study. Cattle farming are likely to be affected by high temperature resulting to severe thermal heat comfort thus cattle that can adapt to high

temperature are recommended in the arid and semiarid lands of Kenya. Cattle that can adapt to these projected temperature, abnormal wet and dry conditions should adopt in the ASAT.s of Kenya.

4.2 Recommendations

Findings from the study can be used in the planning and management of the livestock sector in the ASALs of Kenya and support national sustainable development planning. The SPI tool can be adopted by the livestock sector for monitoring and forecasting abnormal wetness and dryness of a region to improve the timely identification of the emerging extreme conditions to be action by the government.

The information from this study can be used by the policy makers to develop policies that can address the problem of high livestock mortality due to extreme weather and climate conditions in the country. Further studies on the effects of climate change on other aspects of livestock such as forage as well as methodology way to distinguish human factors from climate factors that affect livestock farming should be conducted.

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