The Trend of Climate Variability Effects on Dairy Farming in Masaba North, Nyamira County Kenya

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Abstract

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 cattle breeds in Masaba North, Kenya. The objective for the study were to determine the trend of climate variability and its effects on dairy farming. 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. The findings showed that temperature had rose by 0.8^0 C in the past 30 years with anomalies of rainfall across the years indicating variability effect in the area. From the study, 89% of farmers respondent on effect of climate variability to dairy cattle. The integral recommendations were; improve dairy cattle performance through adoption of modern livestock techniques and harnessing immediate farmers' education to mitigate climate variability effects.

Keywords: Dairy farming, Climate change, Climate variability; Temperature, Precipitation

1. Introduction

Predisposing factors of climate variability are important in studying its vulnerability to dairy farming. Climate variability is a characteristic of climate change. It is projected to greatly impact the world progress towards addressing hunger and attaining global hunger free goal towards world food security. One of the greatest challenges in the world today is tracking global hunger that continues to increase each day due to climate change phenomenon (Wheeler and Von, 2013). Dairy farming will be affected greatly as different animal breeds globally will respond differently to heat extremes, shift of rainfall patterns and impact of climatic changes to fodder quality thus reductions of milk production (Renaudeau *et al.,* 2012). Through modelling, different climate change scenarios are being observed all over the world as this affects both livestock rearing and crop farming across the continent (O'Loughlin *et al.,* 2012).

This focused on the predisposing factors exercabeted by climate variability that affect dairy farming in as a whole. Temperature and precipitation were used as variables to account for variability trend in Masaba North in the past 30 years. Gender was used to determine the understanding of climate variability with high, severe, alternating and delayed used as intervening variables where dairy production was a dependent variable. Both exotic (*Bos taulus*) and indigenous breeds (*Bos indicus*) were assessed through predisposing climate variability effect on their performance. Different studies have accredited that, dairy farming contributes to GHGs emissions to the atmosphere. A study by FAO, 2010 concluded that globally, dairy farming contributes to 4% (CO_2) anthropogenic GHGs emissions to the atmosphere. Therefore, it is imperative for sustainable dairy waste management like manure, fodder and leachate that are rich in release of methane (CH_4) that is listed among the Greenhouse gases globally.

The variations in the mean state and other statistics like standard deviations and the occurrence of extremes of the climate on all temporal and spatial scales beyond that of individual weather events causes variability (UNEP, 2001). Climate variability can occur due to internal or external anthropogenic forcing. Livestock keeping systems vary in East Africa, ranging from dominating pastoral systems, substance production in small scale that is commercially oriented (McDermott *et al.,* 2010). The United States Department of Agriculture (USDA) through its report. It projects that climate variability will increase the daily average temperatures and frequency of heat waves. This exposes livestock to heat stress, a challenge to cattle rearing leading to low milk production in dairy cows (Key *et al.,* 2014).

Climate change already is impacting negatively in the Sub-Saharan Africa on livestock systems and crop farming. Many hazards emanating from climate change are being experienced in Kenya as climate variability is causing heat stress and disease outbreaks, change of rainfall patterns and prolonged dry spells, flash floods and intense rainfall (IPCC, 2007). Dairy farming in Kenya majorly is dominated by Bos-Taurus dairy genotype (DBG) that comprises the Jersey, Guernsey, Ayrshire, Friesian and they cross breed among themselves. DBG are kept in different ecological zones with diverse production environments with different climatic characteristics (Ngeno and Bebe, 2013). This makes the dairy breeds to be vulnerable to disease incidences, heat load, poor feeding and increased magnitude intensity due to climate variability.
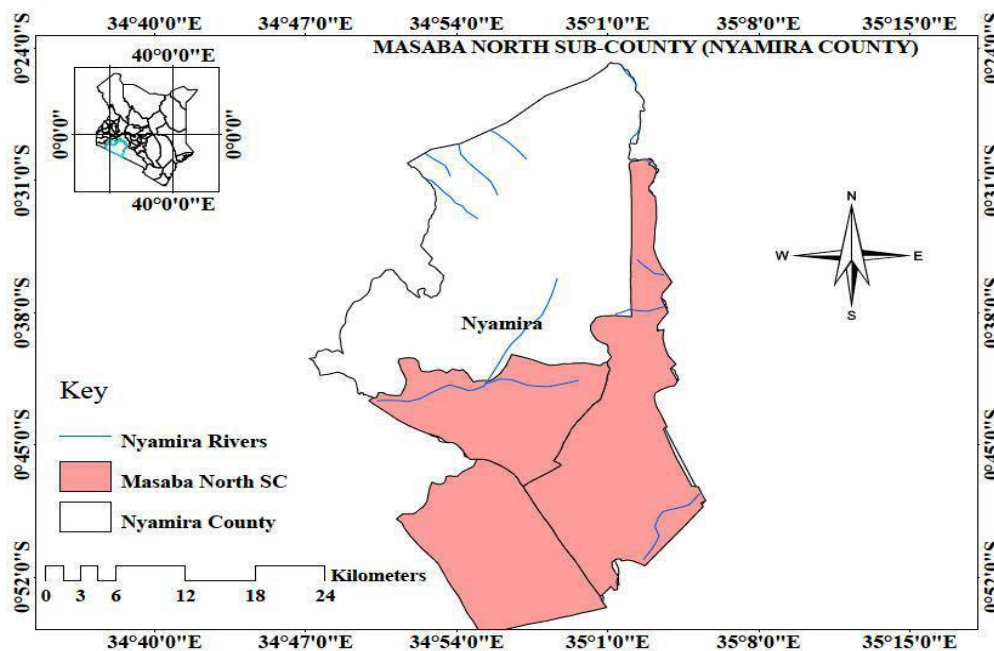
Climate variability affects dairy cattle in the following ways: low quality animal forage, milk

production level, spread of diseases, heat stress, animal breeding patterns and animal growth (Valtorta, 2012). Climate change has both indirect and direct impacts to dairy farming resulting from variability. Indirect effects affect animal performance and majorly emerge from nutritional alterations and the environment driven by climatic change. Animal pastures and forage crops are hit causing shortage of food supply to dairy animals a parameter that hinders the dairy animal production.

Direct climate variability impacts cut across the animal morphology and the immediate climatic factors like temperature, precipitation, radiations, wind speed and humidity. The surrounding environment of an animal determines its performance. For instance, heat from the immediate surroundings where the animal habits, determines its milk productivity. Heat stress has a negative impact on animal productivity like dairy cows (Johnson, 2012). Kenya is among the countries in the African continent projected to be hit most by climate change impacts that will both affect its agricultural productivity positively and negatively (IPCC, 2007). Climate change has two phases, the negative and the positive. However, the negative phase has more impact globally, therefore demanding for adaptation and mitigation strategies linger in it heavily.

2. Study Area

The study was carried out at Nyamira County in Kenya. The sub-county had an estimated population of 120,000 people (IEBC, 2012). The main economic activity in the area was agricultural farming with crop production and livestock majorly dominating. Masaba North lies within the latitudes of $34^0 40^{'}0^{''}$ E,35^0 $15^{'}0^{''}$E and longitudes of $0^0 52^{'}0^{''}$S, 0^0 $31^{'}0^{''}$S. Demographically the area was characterized to be densely populated as the households were closely adjacent in the region. The climate in the past was described as cool and wet however with climate change, this varies across all season of the year.

Dairy production in Masaba North is vulnerable to climate variability effects, affecting both the farmers and cattle. Calil, 2012 adds that climate change is expected to hinder livestock production, hydrologic balances and other agricultural systems. An immediate research work was to be done in the area on climate variability effects in dairy milk production. The destroying effects of global climate variability are increasing and their effects are predicted to occur in developing countries such as Kenya because they purely depend on agricultural production that is livestock and crop growing (Musema *et al.,* 2012).

The objective of the study was to determine the trend of climate variability and its effect on dairy cattle in Masaba North.The study also involved hypothesis that was to test the validity and relevance of scientific study from the findings. The hypothesis for the study was; H_0 Increase in temperature decreases dairy cattle milk production.

3. Materials and Methods

In order to account for climate variability changes and establish its predisposing vulnerability factors to dairy farmers in Masaba North.The study used research survey design. Both qualitative and quantitative techniques of data were used to form the dairy farmers' baseline during the study. The households were randomly selected with purposive sampling being applied to key informants Primary sources involved application of questionnaires

and interviews. Secondary sources was mainly review of journals, books, reports, archived data and periodicals. A sample size of 100 respondents was used on dairy farmers (Naissuma, 2000).

Structured questionnaires with recalling questions were used during the survey. The questions were designed to capture the bio data, economic status and climate variability knowledge of dairy farmers. Different thematic techniques were used to differentiate data collected, for instance rainy seasons, dry spells and alternating season. To climate variability, respondents were asked to state if it was high, severe or alternating as per the changing season. They were to respond to this in the past 10 years.

Precipitation and temperature data was analyzed through application of descriptive statistics technique that involved the calculation of maximum and minimum of both sets, calculation of annual and monthly averages. In addition, the precipitation and temperature trends were analyzed too. Microsoft Excel was used to analyze precipitation and temperature. Pearson Chi-Square ((X^2)) was used to test the association between the farmers' perceived changes in temperature and precipitation patterns had led to decline of milk production. Selected dairy farming attributes were analyzed using Statistical Package for Social Scientists (SPSS). Descriptive statistics including percentages and frequencies were applied for summary and presenting the findings.

4. Results and Discussions

The study was conducted in Masaba North located in Nyamira County, Kenya. A total of 100 dairy cattle farmers were interviewed during the study. Of the total, 7% had no formal education, 52% had access to primary education and those with secondary were 30%. Those who had university education were 11%. From study, the findings indicated that over 90% of the respondents had access to primary education (93%), see Table 4.1.

4.1 Education Levels of Respondents
Table 4.1 Education level

Education level	Frequency (N)	Percentage (%)
No. Formal Education	7	7
Primary	52	52
Secondary	30	30
Tertiary/university	11	11
TOTAL	**100**	**100**

Respondents with only primary (52%) dominated in the study. It was observed that the level of education had a role in determining someone to be a dairy farmer from the study area. For instance, findings from Table 4.1, farmers with none education were recorded 7% as those with university or tertiary education recording 11%. However, Ondersteijin *et al.,* (2003) argue that, better educated farmers can cope with environmental pressures thus be able to increase the intensity of their farming systems and improving dairy production. This is evident from the study as over 93% (n=93) of respondents at least had access to primary education.

4.2 Maximum Averages of Temperature and Precipitation
Table 4.2 Average temperature and precipitation

Month	Year	Average temp(max)	Precipitation (max)
Jan	(1980 – 2015)	26.26	106.11
Feb	(1980 – 2015)	27.33	91.92
Mar	(1980 – 2015)	26.99	193.86
Apr	(1980 – 2015)	25.54	259.81
May	(1980 – 2015)	25.08	254.34
Jun	(1980 – 2015)	24.65	170.53
Jul	(1980 – 2015)	24.51	115.41
Aug	(1980 – 2015)	24.97	173.53
Sep	(1980 – 2015)	25.90	167.66
Oct	(1980 – 2015)	25.86	185.31
Nov	(1980 – 2015)	25.12	201.22
Dec	(1980 – 2015)	25.53	135.79

Average temperature & precipitation, Nyamira County. (KMD, 2015)

Climate variability continue to impact regional seasons as some areas are experiencing changes in temperature and rainfall tends (Wang *et al.,* 2016). Table 4.2 shows that in the past 30 years within Nyamira County, the months of February and March records the highest maximum temperature compared to other months. February had 27.33 (^{0}C) and March had 26.99 (^{0}C) respectively. From the table, the month of February is the hottest month and July the month with least average monthly temperature in the past 30 years.

The total precipitation of months of February is 91.92mm as that of months of July is 115mm. This therefore indicates that, from the totals the hottest and coldest month determine the amount of rainfall a month receives. The tabulated data indicates April as the wettest month with a total of precipitation of 259.81mm with an average temperature of 25.54 ^{0}C in the past 30 years. Figure 4.2 shows variability trend of average monthly rainfall and precipitation in the region in the past 30 years.
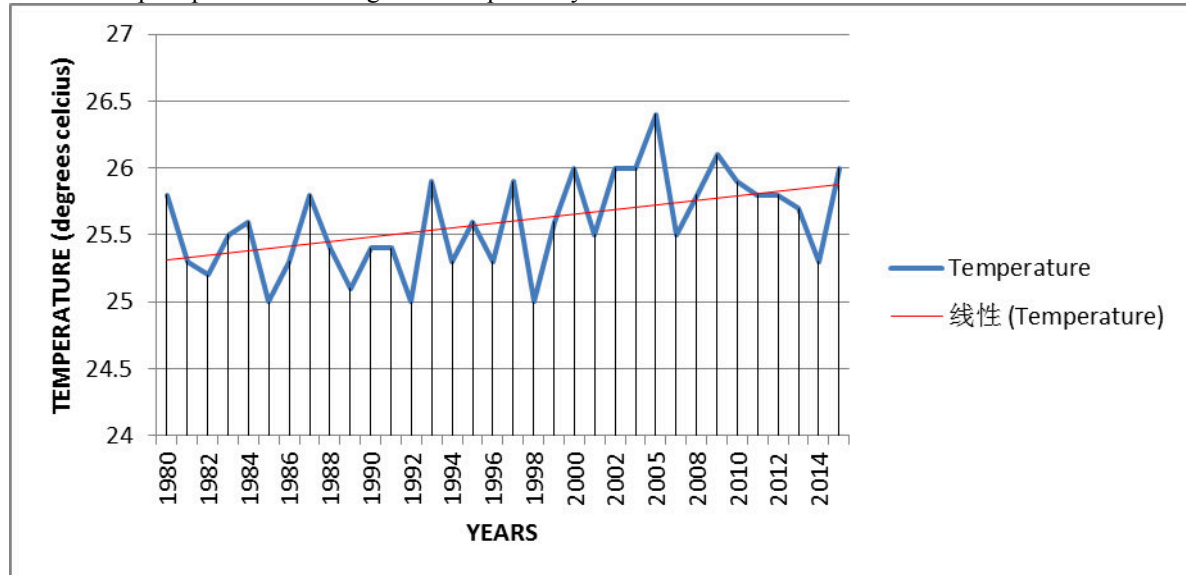

Figure 4.1: Maximum average temperature between (1980-2015)

Lowest maximum temperatures from the findings were observed in the year 1985, 1989 and 1998 between 1980 – 2015. It is observed too that the three years with lowest maximum temperature has identical same average temperature of 25°C. The year 2003 had the highest average maximum above all the years it recording 26.4ºC. This can be seen in figure 4.1 through the linear trend of temperature.

Different temperature ascending changes were observed in different years. For example, between the years 1985-1987, 1992-1993 and 2014-2015. However, there were other observed changes where the temperatures were descending. For instance, the years 1987-1989, 1997-1988 and 2005-2007. Therefore, this ascending and descending seen on the findings might have been due to climate variability.

Figure 4.1 as shown from the findings analysis, temperature has slightly increased with an average of around 0.8^{0}C as per the Kenya Meteorological Department, 2015. This study concurs with IPCC that of NOAA, 2012 that suggests global average temperature increase of +0.9°C through models. Wang *et al.,* (2016) study on temperature and precipitation indicate that climate variability continue to impact regional seasons as some areas are experiencing changes in temperature and rainfall tends. Therefore, this changes in temperature are expected to impact agricultural sector where crop production and livestock will be vulnerable to this changes.
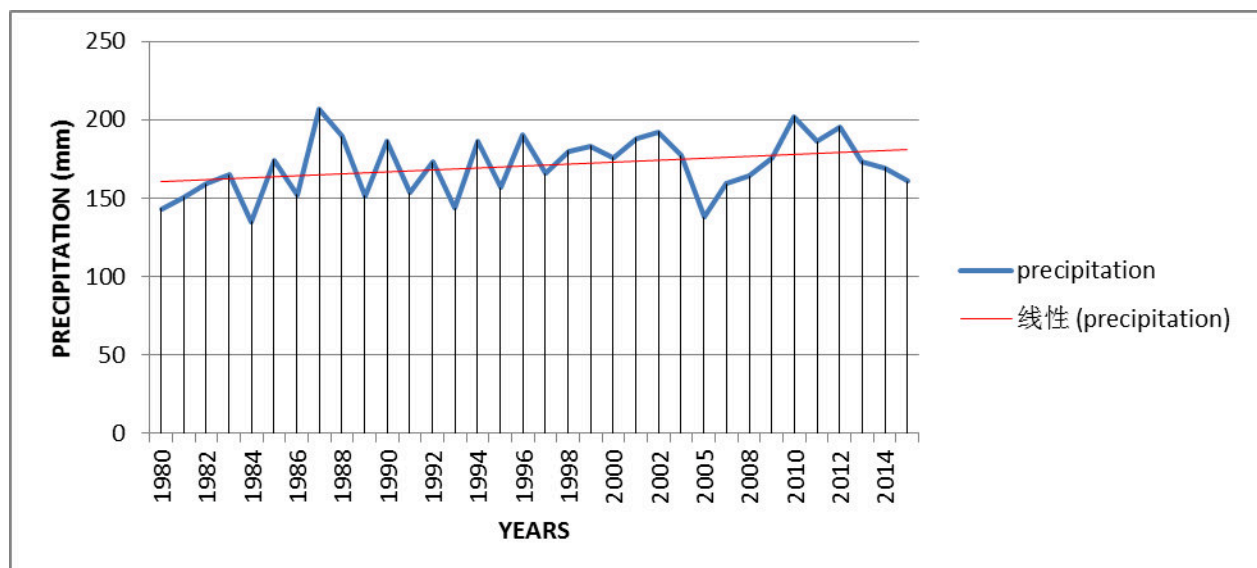

Figure 4.2: Precipitation trend in the past 30 years

Figure 4.2, shows the observed trend of precipitation per year between 1980 – 2015 in Nyamira County. From the liner observation, various assumption can be made on the variability effect in the past 30 years. Some changes in precipitation can be noted overtime. The trend series shows that 1988 recorded the highest amount of precipitation received in the region with an average of 2482.1 mm. However, there is a change as decades changed where the year 2011 had 1643.3mm. Thus there might be a conclusion that climate amplified effect affects the rainfall trend in the area.

There are changes in precipitation between (1980 -2015) from the findings. Precipitation keeps rising between the years 2004 – 2011 as observed on the trend line. This is the opposite from the previous year 2002-2004 where precipitation dropped and started increasing as from 2004. There reason might be the effect of climate variability in the area. It tends to affect consistency of precipitation trend in the area data was obtained. There is a sharp drop of precipitation between 2010 to 2011 across the series. The year 2010 (2345.6mm) to 2011 (1643.3mm) with a drop of 702.3mm within a year. In 1987 and 2008, are the years with high precipitation in the past 30 years marking highest points above the liner trend line.

4.3 Genders' Perceptions on Predisposing Climate Variability Factors
Table 4.3: Predisposing climate variability factors and genders understanding perception

Gender	Alternating dry and wet season		High temperatures and abundant rainfall		Severe dry spells		Delayed fodder growth as per alternating seasons	
	N	(%)	N	(%)	N	(%)	N	(%)
Female	42	47.19	27	44.26	7	58.33	13	50
Male	47	52.81	34	55.74	5	41.67	13	50
Total	**89**	**100**	**61**	**100**	**12**	**100**	**26**	**100**

Predisposing climate variability factors effect on dairy cattle production

The tabulated analysis of (Table 4.3) above shows gender as the independent variable and female and male used as dependent variables. The intervening variables like alternating, high, severe and delay have been used as degrees of determination. From the responses, the grand total was 100 Respondents = 100%. From the study, out of the total 100 respondents, 89 respondents responded that alternating dry and wet season affect cattle production. Where female recorded 47.19% certainty with their male counterparts recording 52.81% certainty. Therefore, male having higher % of 5.62% response to that of female.

To the changes in temperature and rainfall, 34 male of the total 100 male respondents responded recording 55.74%. From the grand total, out of 61 responses, 34 were male and 27 were female. This recorded 7 more male counterparts who responded than women. Hence from temperature and rainfall alteration, male are more conversant than female.

Delayed fodder growth due to alternating seasons resulting from climate change had an equal response from both male and female each having 13 respondents. This made the grand total 26 responses equating 100%, where 13 respondents = 50%. Alternating temperatures and rainfall response and alternating dry and wet season in relation to dairy production had the highest responses. Where, 61 respondents and 89 respondents responded respectively. This therefore was an indication that climate variability affects rainfall, temperature and season. After the study the following hypothesis was tested.

H₀ An increase in temperature results to a decrease in milk production

The alternative hypothesis H_a is that temperature increase does not result into a decrease in milk. The hypothesis under investigation is that the temperature increase has resulted in low milk production. After performing the test it was realized that the obtained chi-square (X^2) = 0.087) value is less that the critical chi-square value (X^2 =1.103 at 0.05 level of significance, P = 0.002). This values clearly shows that there is enough statistical evidence to accept the null hypothesis. In conclusion from the test, we can say with some level of confidence that the increase in temperature has resulted to a decrease in the production of milk in the region.

Conclusion

Climate variability factors were evident in the area, as per the data from the Kenya Meteorological Department, temperature has increased a view that has been championed globally. This was hypothetically accepted from the null H_0 projecting more climate variability will be ever severe by 2050. The variability changes were observed on precipitation and temperature. The respondents concurred from the study the season are changing thus impacting dairy farming in the area of study.

Focusing on the emerging negative effects of climate variability on dairy production, it is of benefit to sensitize communities in the study area about the emerging and predicted changes in climate. In addition, it is of benefit to identify and analyze the effects of those changes on dairy production in Masaba North and other

related areas to provide appropriate mitigation adaptation methods. Thus, there is agency for further studies in the climate variability vulnerability to dairy farmers. The Adaptation study might consider development of improved breeds and other alternative animal feed sources to match the effects of climate variability.

Acknowledgement

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