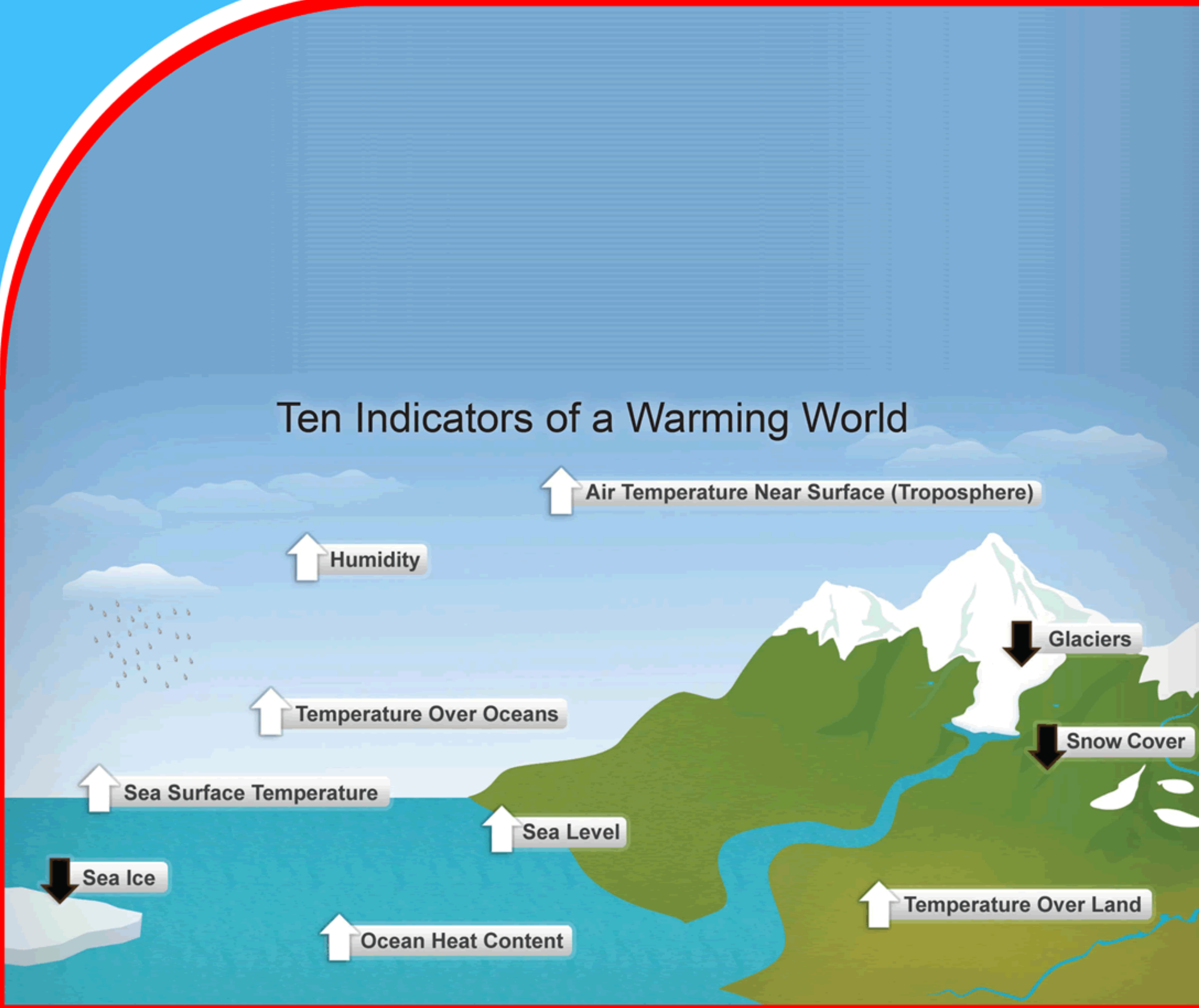
American Journal of
Climatic Studies
(AJCS)



An assessment of implications of seasonal variations of moisture and heat budget components on livestock production and farmer's adaptive capacities in Ndu Subdivision, Northwest Region, Cameroon.

Dr. Nkemasong Nicasius Anumveh and Yinkfu Randy

AJP

American Journal of Climatic Studies
ISSN 2520-0471 (Online)
Vol.3, Issue 1, pp 15 - 36, 2022
www.ajpojournals.org

An assessment of implications of seasonal variations of moisture and heat budget components on livestock production and farmer's adaptive capacities in Ndu Subdivision, Northwest Region, Cameroon.

[1*]Dr. Nkemasong Nicasius Anumveh and [2]Yinkfu Randy

[1]Lecturer of Geography, Geography Department, Faculty of Social and Management Sciences, Buea University.

[2]Postgraduate student, Geography Department, Faculty of Social and Management Sciences, Buea University.

*Corresponding Author's E-mail: nkemasong 2012@gmail.com

ABSTRACT

Purpose: The study sought to analyse and establish the pattern and magnitude of the inter-annual seasonal variations of key climatic elements (relative humidity rainfall totals and temperature) in Ndu Sub-Division, how the trends are affecting livestock production and the coping strategies adopted by the local livestock farmers.

Methodology: Direct filed observation, farmer's perception survey and statistical analyses were used to generate both primary and secondary data for processing. Climatic data were analysed through the empirical absolute seasonality index to establish seasonality, the regression line analysis used to establish inter-annual fluctuation and trends in climatic elements and key livestock numbers (cattle, goats and sheep), the coefficient of variations (CV%) to establish the degree of inter-annual fluctuation of study variables, the spearman rank correlation coefficient (rs) and coefficient of determination (r^2) to establish the degree of association between climate and livestock production. A percentile analysis of responses from 200 questionnaires, complemented by interviews and focus group discussions was used to assess the adaptation responses of the farmers.

Findings: Key results are that there is a higher degree of seasonality of the climatic elements (intra-annual variations). CV% values indicate more variation for the RH and rainfall totals than the elements of temperature. The seasonality of climate has been intensifying over the years with the dry seasons becoming hotter and drier, while the rainy season more humid and hotter. A total of 99.2% of the respondents indicated awareness of the intensifying seasonality of climate and its negative effects on livestock production and livestock farmers as degraded pastures and water sources, reducing livestock numbers and the appearance of new livestock diseases, drops in livestock prices and farmers' incomes, loss of organic manure, rise in farmers-grazers conflicts. The livestock farmers have adopted indigenous coping strategies to the intensifying seasonality, as transhumance, animal vaccination, the alliance farming system and paddocking. Rapid population growth, uncontrolled arable farming, ferocious farmer-grazier conflicts, limited rangelands, limited knowledge and government negligence stood are key hindrances to these indigenous adaptation measures.

Recommendation: The government livestock department (MINEPIA) should reinforce these indigenous coping strategies with conventional production techniques and facilities and organise regular training workshops for livestock farmers.

Keywords: *Seasonality, implications, Livestock production, farmer's adaptation strategies*.

1. INTRODUCTION

Climate on earth has always been varying in response to changes in the cryosphere, hydrosphere, biosphere and many other atmospheric and other factors that interact to formulate global climate. The level of Greenhouse Gases has surpassed the highest levels of concentrations on earth over the last 800,000 years (World Meteorology Organization, 2013). It is widely accepted that human activities are now increasingly influencing global climate (Pachauri & Reisinger, 2007). The changes occur mainly because of increasing concentration of greenhouse gases emitted from various economic activities of humans such as rapid deforestation and poor farming methods. Such changes have already had some impacts on the natural equilibrium and this has made risky the survival of human beings. Climate variability influences the duration of seasons which usually results into unexpected fluctuations that affects livestock activities.

Seasonality is defined as the intra- and inter-year variations in seasons. Seasonal changes remain a pervasive dimension of the lives of rural people, particularly those in tropical areas where the alternation of wet and dry seasons is well marked (Chambers *et al*., 1981). In Sub-Sahara Africa, rainfall pattern is mainly influenced by El-Niño Southern Oscillation (ENSO) events. These often result in frequent extreme weather events such as droughts and floods which lead to reduced food production causing severe food shortages (Dore, 2005; Haile, 2005). In many parts of Africa, natural disasters revolve around either too much rain (flooding) or too little rain (drought). Unpredictable rainfall and increased temperatures are projected to increase frequency and intensity of the extreme weather events. Droughts and floods have been commonly experienced in many parts of Africa and the Sahel (Kotir, 2010). According to UNDP (2008), a third of population in Africa resides in drought prone areas and therefore is vulnerable to the impact of droughts. In the 1990s and early 2000s, the East African countries of Ethiopia, Kenya and Somaliland suffered severe droughts. Food was scarce and rendered many people food insecure. Seasonal changes may greatly influence the priority given to animals in terms of health care, time and the availability of cash to spend on livestock inputs. Farmers' expenditure on animal health services is dependent on a range of factors, and particularly significant amongst these factors are other household needs at the time that animals require treatment. Seasonality as evidenced in many parts of the world is also a topical and a challenging phenomenon in the Ndu Sub-Division. Despite the potentials of the livestock activity in the area, much attention has not been paid towards it sustainability. It is in the light of this that the researcher seeks to do a comprehensive study on how the challenges of livestock production can be reverse.

2. STATEMENT OF THE PROBLEM

The North West Region of Cameroon ranks third in livestock production in the country, with Ndu, one of its subdivisions harbouring a significant proportion of the country's cattle. The livestock sector is a very important farming activity in Ndu subdivision as it is the major livelihood activity of the people in terms of the employment, income and the sustenance it offers. The visible frustration expressed and the raising of eye-brows by most villagers when livestock activity is negatively affected, gives a clear evidence that their livelihood highly depends on the activity. Variations in temperature, rainfall and relative humidity on a seasonal and annual basis across the subdivision have affected livestock production (sheep, goat and cattle). Seasonality brings about drought conditions and heat stress which affect the availability of pasture, water and the animal reproduction. Rainfall variability has implications on milk production as well as the pattern of diseases that affect livestock. The changing weather pattern tends to confused livestock farmers as they find it difficult to exactly time the onset of transhumance, as well as the period to vaccinate their animals against diseases. All these have implications on livestock production as well as on the livelihood of the livestock farmers in the Ndu Sub-Division. The research seeks to establish the magnitude of implications of seasonal variations on livestock production, analyse the extent of success of indigenous adaptation strategies and suggest sustainable management strategies.

3. LITERATURE REVIEW

Africa is generally noted to be hot and dry with current trends showing that it is warming faster than the global average (The World Meteorological Organisation, 2020). The occurrence and prevalence of infectious diseases is sensitive to relative humidity because the abnormal levels of humidity increase the infectivity of pathogens, so risks to animal health due to relative humidity have been found in livestock and poultry (Xiong *et al.*, 2017). Generally, shortage of feed and water contribute to reduced productivity and reproductive performance of livestock. This includes slow growth rate of animals, loss of body condition, reduced milk production and poor reproductive performance in mature animals. Draught oxen that are emaciated and in poor body condition cannot provide adequate draught power for ploughing, and thus affects crop cultivation. Increased incidence of diseases during the long dry season, when animals are in poor condition due to inadequate feed supply and increased heat stress is as a result of the increased temperature. Similar study reported that foot and mouth disease, black leg and CBPP were identified as the major three diseases in cattle, whereas, CCPP, *coenurus cerebralis* and general septicemia cause a serious damage to the sheep and goat population in Borane area (Amawa, 2007). In the horn of Africa millions of the livestock farmers currently live a lifestyle that is centred on the search for the increasingly scarce pasture and water. Floods have devastating effects on livelihoods and other human activities. They destroy pastures, cause animal diseases, affect production in animals, disrupt electricity supplies and demolish basic infrastructure such as roads, homes and bridges which are basic facilities for animal rearing (Ehrhart, 2009). This greenhouse effect, in turn, is causing increased rainfall, frequent hot extremes, floods, droughts, cyclones and gradual recession of glaciers (WMO, 2013).

4. STUDY AREA

This area lies between Latitude 6°20′ and 6°40′ north of the equator and Longitude 6°25′ and 11°20′ east of the Greenwich Meridian. It covers a total surface area of 1,350 km^2. This area corresponds to Ndu Subdivision Ndu Sub-Division, created by Presidential Decree *No. 93/322 of 25/11/1993*. The Map of the location and layout of the study area is shown on figure 1.

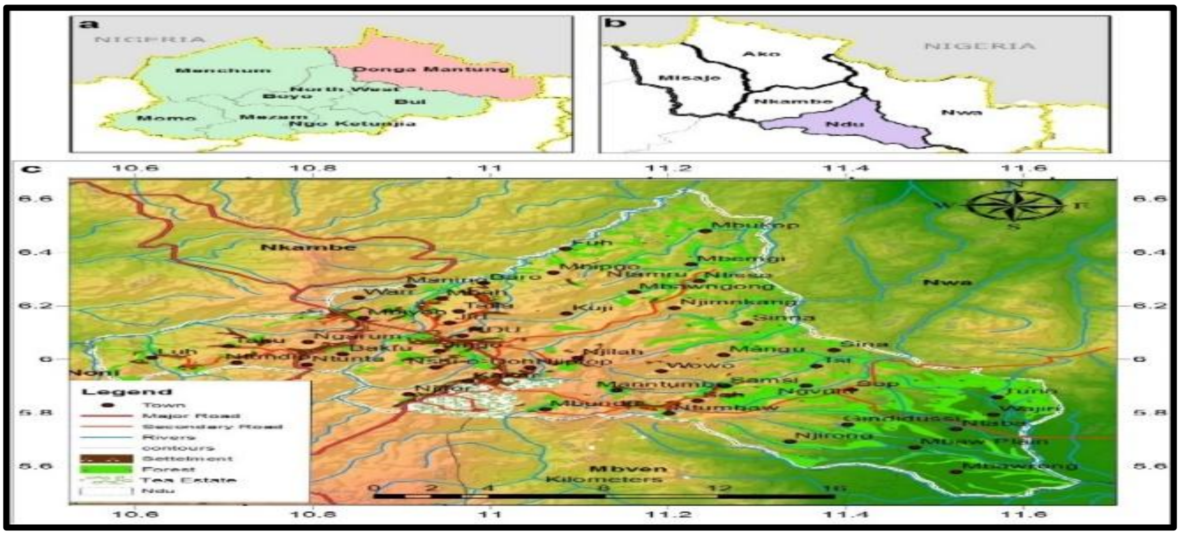


Figure 1: Map showing Location of Ndu Sub-Division

a=Donga-Mantung Division in the North West Region

b=Ndu Sub-division in Donga Mantung Division

c=Layout Map of Ndu Sub-Division

Source: Adapted from the Topographic Map Sheet of Nkambe

It is bounded to the North by Nkambe Central, to the west by Nwa Sub-Division, to the East by Nkum Sub-Division, to the South with Mbiame (Bui Division), to the South-West with Nkum Sub-Division (Bui division). It is the headquarters of Ndu Sub-Division (Ndu Council, 2010). It is therefore one of the five Sub-Divisions of Donga-Mantung Division, North West Region of Cameroon (Ndu Council, 2010).

5. RESEARCH METHODS

The study adopted a descriptive and an exploratory study design since it was out to investigate the implications of seasonality on livestock production, the adaptation methods and the challenges of adapting to seasonality in the study area. The mixed approach relying on both qualitative and quantitative methods was used so as to address the qualitative and the quantitative questions of the study, and also to overcome the weaknesses which could have arisen in case of using only one. Primary data were obtained through empirical analysis and survey procedures. To determine the degree of seasonality in the study area, climatic data collected from the Ndu Tea Meteorological Station were analysed on their monthly, seasonal and annual bases through trend line analysis. The coefficient of variation $(\frac{S}{\bar{x}} x\ 100)$ was used to establish the degree of variability in the climatic elements so as to give information on the degree of fluctuation of the relative humidity, rainfall totals and temperature of the study area.

The assessment of rainfall seasonality in this study considers only the absolute seasonality measure advanced by Walsh and Lawler, 1981, (Hayward *et al.,* 1987). Even though relative seasonality is a quantitative measure it is not used in the study because the calculations are very complex. Furthermore, the absolute seasonality has been applied to many similar studies in areas within the same latitudinal belt with reliable results. Absolute seasonality considers a given rainfall value as the threshold rainfall to describe a month as wet when (equal to or greater than it) or dry (when less than it). The definition of season however is quite challenging since several criteria exist for dividing the year into rainy and dry season. It is imperative therefore to streamline the concept of season before going into a deeper analysis of seasonality. Defining precisely the commencement and end (length) of the rainy season is therefore important since it will eliminate the high subjectivity associated with the terms "wet season" and "dry season". Many measures exist but Hayward *et al.*, (1987) highlight that the best used are pentads (accumulate rainfall for 5 consecutive days). Since daily rainfall records are largely absent, the study uses monthly rainfall totals as advanced Acheampong,1987, and Gregory, 1964 (Hayward *et al.*, 1987). They define the wet season as that sequence of months in which the mean rainfall is at least 4inches (102mm) since they considered that the amount of rainfall is adequate to offset loss of water by transpiration. This rainfall threshold (102mm) is therefore used for analysis involving dividing the year into the wet season and dry season.

The livestock considered in the study were ruminants (cattle, goats and sheep) because, since in Ndu they are largely reared free range, consequently they are highly climate dependent. To establish the degree to which seasonal variations affect livestock production, a measure of association was used. Since the climatic and livestock data used in this study were tested for normality using kurtosis and were established to be non-normally distributed the Spearman's rank correlation coefficient (r_s) was used. The Coefficient of Determination (r^2) was then used to establish the degree of explanation of the correlation. To gather information on the perception of livestock farmers on the effects of seasonal changes on their activities, a sample of 200 livestock breeders was selected for analysis. Information was sought from them through the use of interview guides, discussions with some focused groups, complemented by questionnaires administered through simple random sampling procedures. The perception analysis was statistically using the chi square (X^2) test. Secondary data were gotten from published and unpublished works lodged in sources such as university libraries, magazines, databases, council records, and livestock institutions. This information constituted the basis of discussions of findings. The statistics obtained from the data analysed are presented on tables, line graphs, figures and bar charts.

6. RESULTS/FINDINGS

6.1 Seasonality of climate

The seasonal distribution of precipitation is as important as the total amounts in the tropics. The times of the start, duration and end of the rainy season control all agricultural activities (crop and animal production) in the tropics. Furthermore, since temperature and other climatic elements are much more uniform, the seasonal rainfall distribution forms the basis of most classifications or subdivisions of tropical climates (Hayward *et al.*, 1987; Ayoade, 1988). This was established by analysing the moisture budget components of rainfall and relative humidity and the heat budget component of air temperatures. Emphasis was placed on the moisture budget components since in the tropical environment atmospheric moisture shows much seasonal variation while temperatures are less variable since there is the atmospheric characteristic of thermal monotony across the year. Thus, this analyses the intra-annual (monthly) variations of some climatic elements such as rainfall and humidity that greatly define seasonality and significantly affect livestock activities. The fluctuations are shown on figures 2a, 2b and 2c.

American Journal of Climatic Studies
ISSN 2520-0471 (Online)
Vol.3, Issue 1, pp 15 - 36, 2022

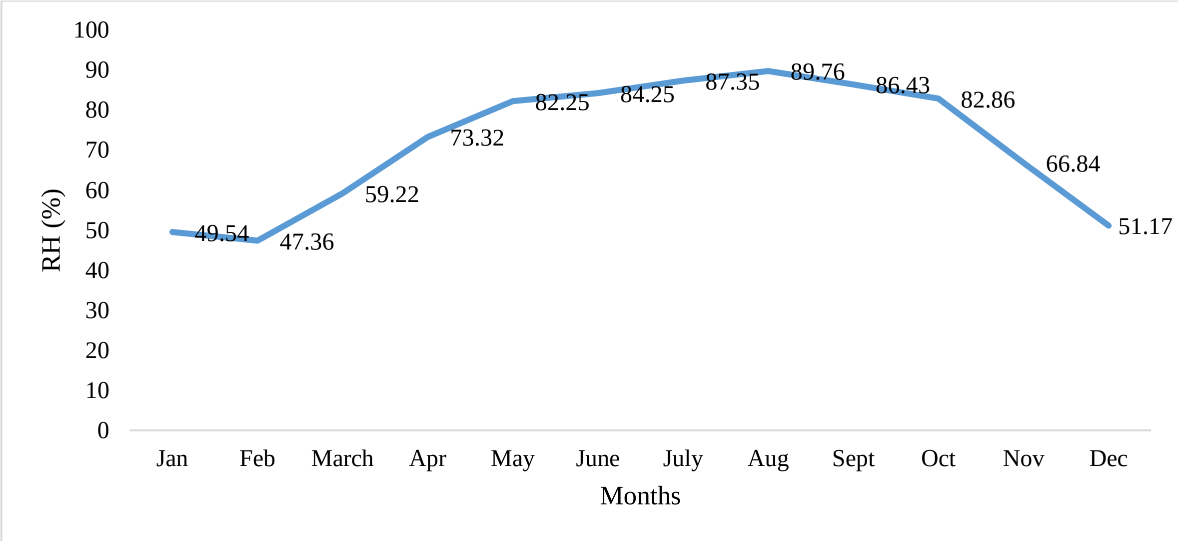


Figure 2 (a): Mean monthly relative humidity

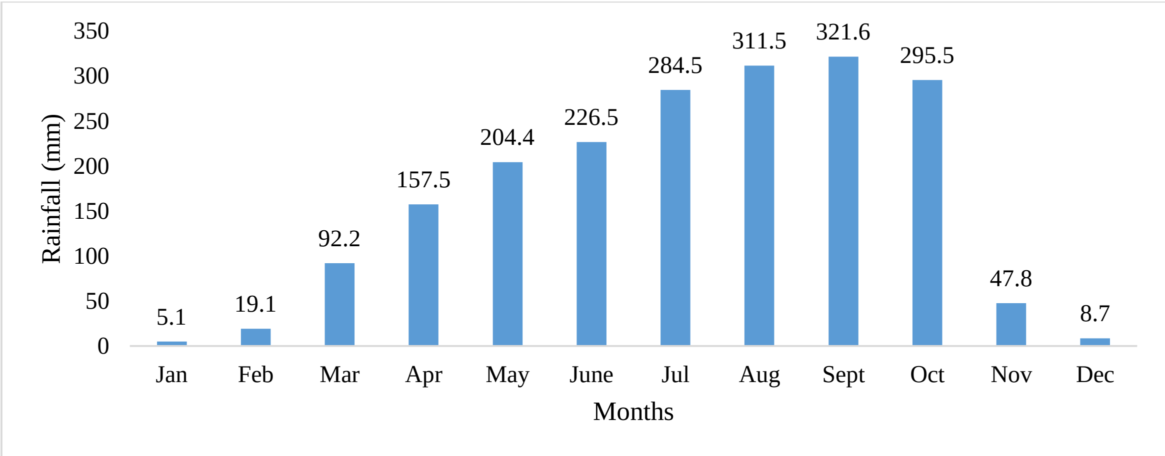


Figure 2 (b): Mean monthly rainfall

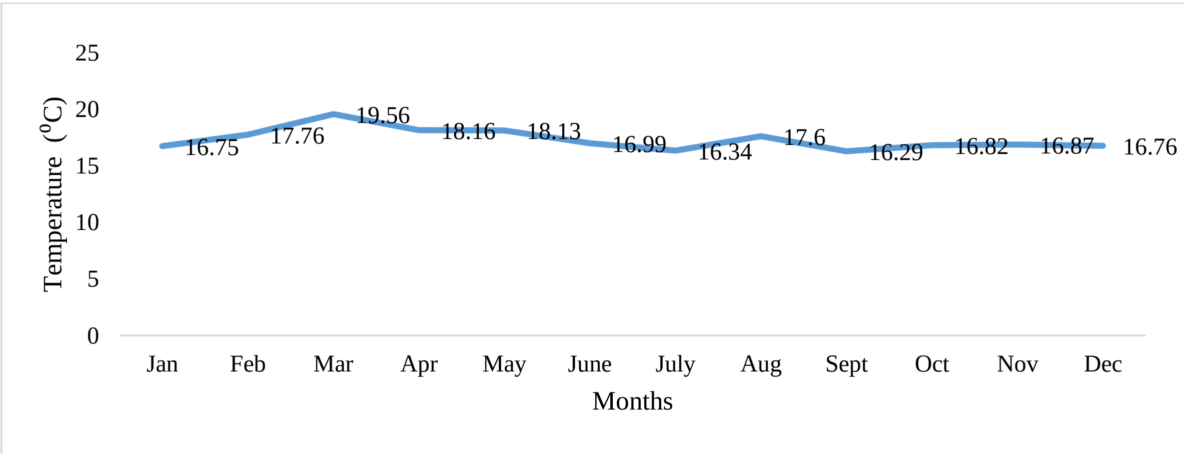


Figure 2 (c): Mean monthly temperatures

Source: Analysis of climatic data

The mean monthly relative humidity of the area is 69.9% but Figure 2a reveals that it greatly fluctuates throughout the year. A CV of 25.7% indicates a high rate of variation in humidity. Its drops to as low as 45%, 47.6%, 52.7% and 53.6% in the months of February, January, December and March respectively, and rises to values similar to those in the tropical rainforest area in the months of August (89.1%), July (87.9%), September (85.6%), June (83.3%), October (81.5%), and May (80.5%). Transition months between low and high humidity periods of the year are April (72.5%) and November (66.3%). This pattern of intra-annual variability closely follows that of rainfall. The highest relative humidity is experienced in the months of September and October is linked to the moist tropical maritime air mass (south west monsoon winds) blowing in from the southern part that dominates the area within this period. Conversely, the least relative humidity is recorded in the months of January and February is associated with the prevailing intense dry tropical continental air mass (harmattan winds) blowing from the Sahara desert in the north that prevails over the area at this period.

The mean monthly rainfall of Ndu Subdivision is 161.2 mm. Figure 2b however reveals wide fluctuation in the monthly mean rainfall across the year in Ndu and confirmed by the high Coefficient of Variation (CV) of 76%. Using the 102mm rainfall threshold, the duration of the rainy season over Ndu is seven months (from April to October) and the dry season five months (November to March). The seven months of September (321.6 mm), August (311.5 mm), October (295.5 mm), July (284.5 mm), June (226.5 mm), May (204.4 mm) and April (157.5 mm) have very high rainfall values while five months of January (5.1 mm), December (8.7 mm) February (19.1 mm), November (47.8 mm) and March (92.2 mm) have extremely low. The highest amounts are recorded in September and August while the lowest amounts in December and January. Rainfall amounts increase gradually from March to September and start dropping in the month of October but fall drastically from the month of November to that of March, marking the five dry season months in the area with elevated temperatures, sunshine intensity and lower relative humidity. This seasonal disparity of rainfall received is made clearer by the fact that the average rainfall amount received in the five dry season months is 35 mm while that of the seven rainy season months is 251.4 mm. thus rainy season receives slightly more than seven times (7.2) more rainfall than the dry season months. The rainy season period receives 91% (1759.9 mm) of the accumulated annual rainfall totals of 1934.8 mm giving the dry season period merely 9% (175 mm).

The energy budget component is assessed using the air temperatures. The mean monthly temperature for Ndu is 17.3 °C. The CV% of 5.5% for mean monthly temperatures across the year reveals that there is very low seasonality in mean air temperatures. Despite this near seasonal thermal homogeneity, there are some visible disparities. The temperatures are highest in the month of March, followed by the months of April, May, February and August. The coolest months are September and July. This pattern of temperature is explained by the annual apparent movement of the sun over the area. The high values of the CV% of these moisture budget components but low values for the energy budget component reveals that Ndu just as the rest of the tropical lands has marked seasonality of moisture than heat. The seasonality of the climate of Ndu has been variable at the secular scale. The inter-annual seasonal variations and trends of the climatic elements of Ndu are done for the moisture budget and energy budget components. Figures 3 shows the situation of relative humidity (figure 3a) and rainfall totals (figure 3b).

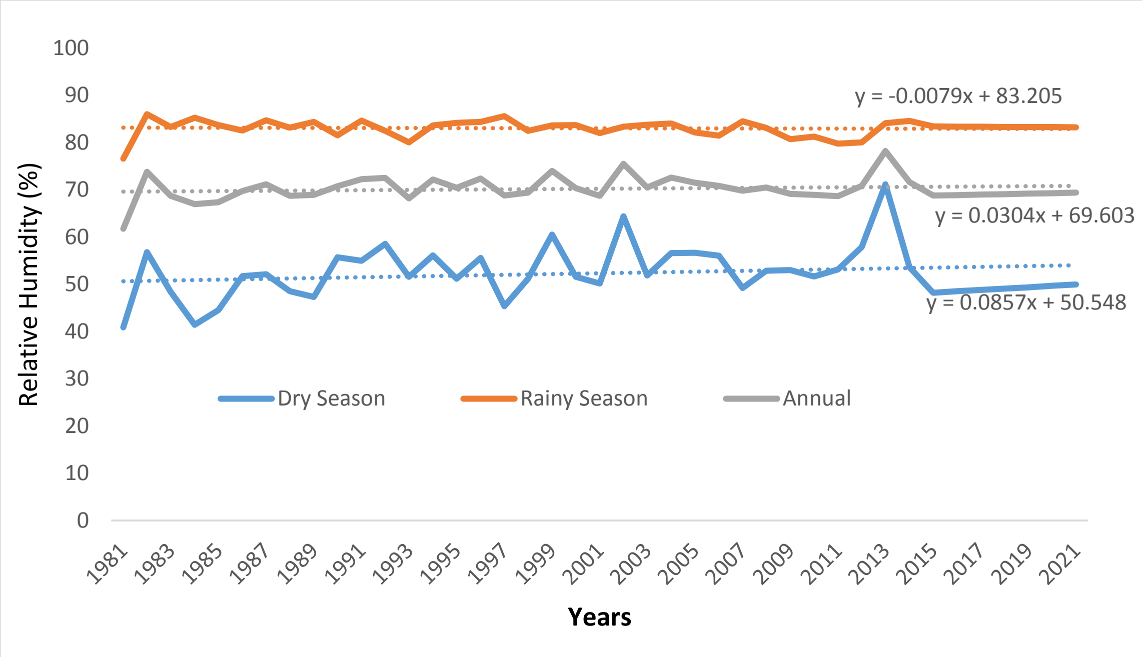


Figure 3 (a): Secular variations and trends of Relative Humidity for the seasons

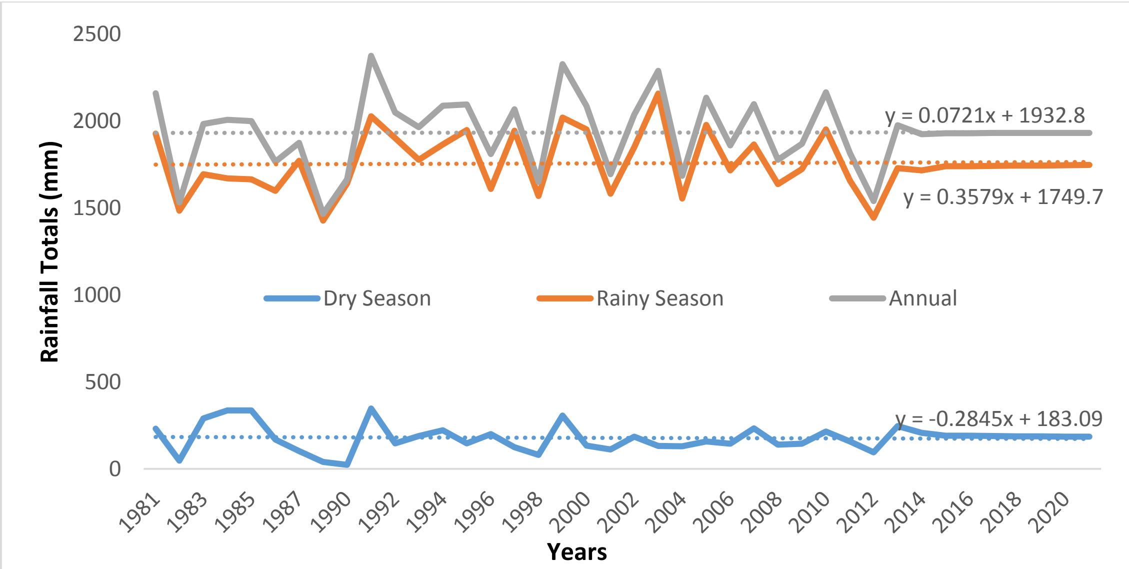


Figure 3 (b): Secular variations and trends of rainfall total for the seasons

CV% of secular variations of RH gives 3.7% indicates that relative humidity has remained significantly stable over the years. Despite this, there is marked seasonal disparity, as it is very stable (2.1%) for the rainy season months, but very variable (10.7%) for the dry season months. Trend line analysis reveals further that generally relative humidity has been on the rise over the years at a general rate of 0.03% a year. The seasonal disparity still imposes as the rainy season months have recorded a reducing trend at a slight rate of 0.01% drop a year, whereas for the dry season months there is an increasing trend at a rate of 0.4% per annum.

The secular pattern for rainfall totals reveals seasonal disparity just as RH. Although the overall rainfall totals have shown low variability (10.7%), there has been very high variability (42.9%) in the dry season months and very low (9.5%) for the rainy season months. The trend line

American Journal of Climatic Studies
ISSN 2520-0471 (Online)
Vol.3, Issue 1, pp 15 - 36, 2022

analysis exposes that the area is slightly becoming wetter over the years at a rate of 0.07mm rainfall increase a year. However, the dry seasons are becoming drier at a rate of 0.3 mm of rainfall drop each year, while the rainy season is increasingly wetter with 0.4 mm more rain each year. This changing pattern of RH and rainfall totals reveals that the seasonal contrast in moisture budget over Ndu is intensifying over the years and certainly with consequent impacts on livestock production.

The inter-annual analysis of the energy budget component of temperature (figures 4) is examined using the average (figure 4a), minimum (figure 4b) and maximum (figure 4c) temperatures.

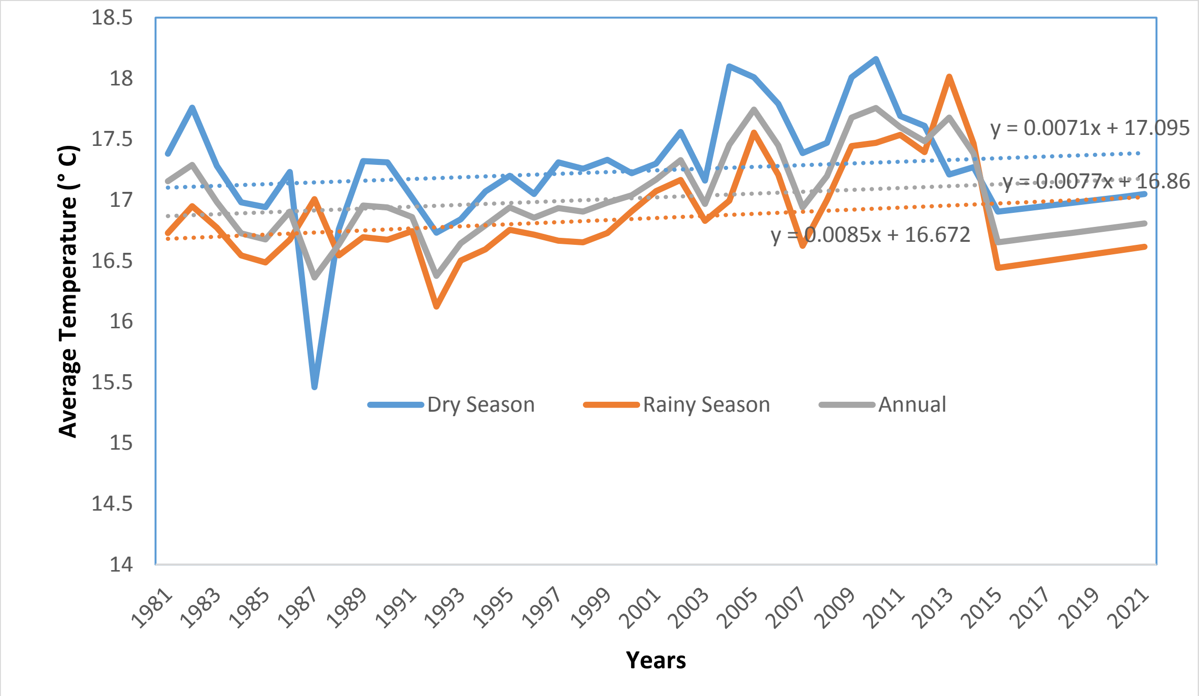


Figure 4 (a): Secular variations and trends for average temperature for the seasons

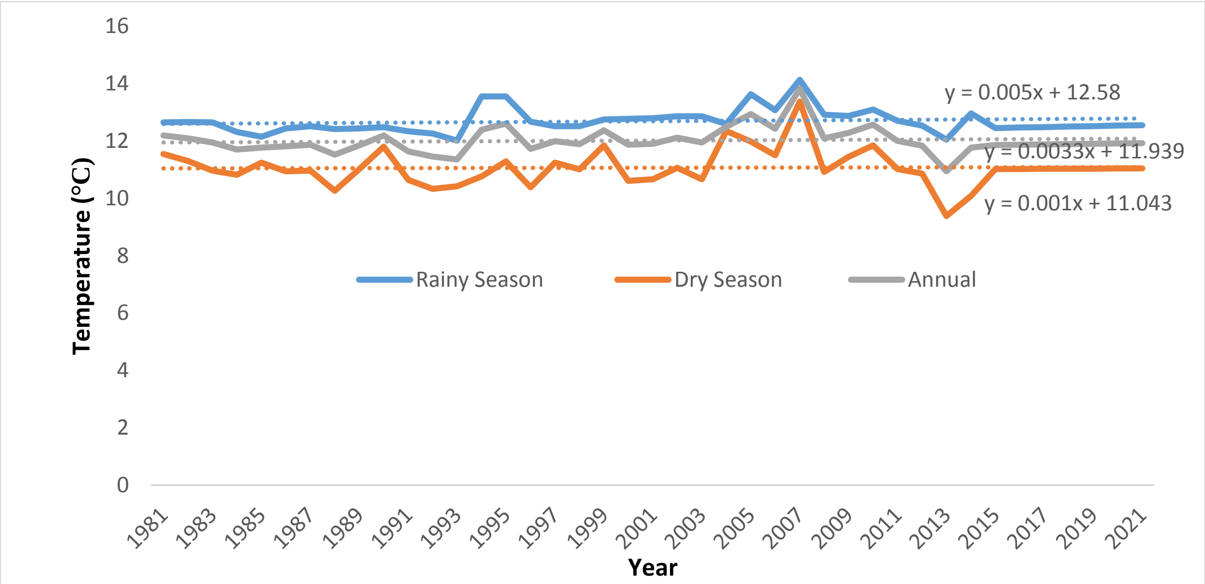
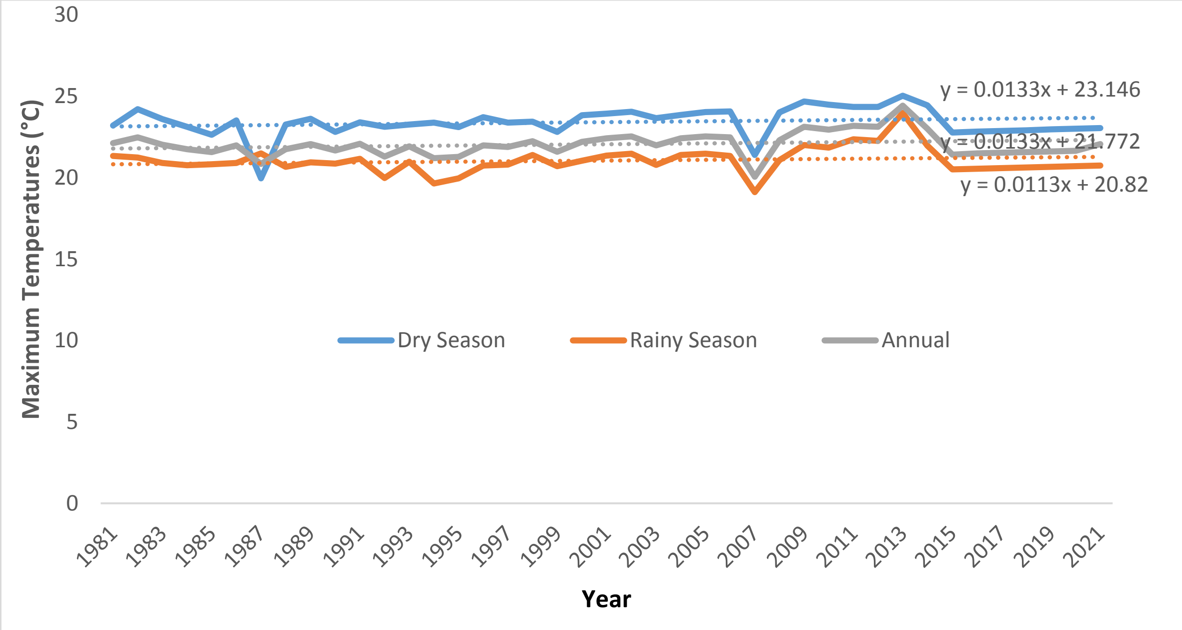


Figure 4 (b): Secular variations and trends of minimum temperatures for the seasons



4 c) Secular varaiations and trends of maximum temperatures for the seasons

CV% of 2.2%, 2.7% and 2.3% for the annual, dry season and rainy season variations of mean temperatures reveal that the inter-annual variability of temperature is low even across the seasons. However, mean temperatures of the dry season months have been varying more than those of the rainy season months. Also, CV% have been higher for minimum (3.4% for rainy season and 5.9% for dry season) and maximum (3.8% for rainy season and 3.7% for dry season) temperatures, indicating that the minimum and maximum temperatures have been more variable. It is deciphered from the trend lines that there has been a generalised but slight increase over the years of mean (0.007 °C/ year), minimum (0.003 °C/ year) and maximum (0.013 °C/ year) temperatures in Ndu be it in the dry season or rainy season, months. This warming trend indicates that the area of Ndu is becoming hotter as the years go by.

It is concluded from the above analysis that the climate of Ndu is marked by great seasonal contrasts especially in the moisture budget components of RH and rainfall. Furthermore, the degree of seasonality is intensifying over the years. A perception analysis of respondents in Ndu revealed that approximately, 98.3% of the farmers announced their awareness of an intense seasonal fluctuations**.** They confirmed the secular variations and trend towards drier and hotter dry seasons when their views converged on the point that ***"****the dry season is usually getting longer while the duration of the raining season is always shorter*". Since livestock farming activities in terms of production and ancillary activities are greatly sensitive to climate, it is therefore expected that the high and intensifying seasonality will have consequences on the activity.

6.2 The implications of seasonality on livestock production in Ndu

Data on livestock numbers for a 38 year period (1918 to 2019) obtained from the Livestock Services in Ndu, reveals that the average total livestock production (numbers) is about 104,256 heads with small ruminants goats (43,465) and sheep (37,598) being dominant over cattle (23,193). Going by these figures, Ndu is an important livestock breeding zone. The evolution of livestock production (numbers) over the years is shown on Figure 5.

American Journal of Climatic Studies
ISSN 2520-0471 (Online)
Vol.3, Issue 1, pp 15 - 36, 2022

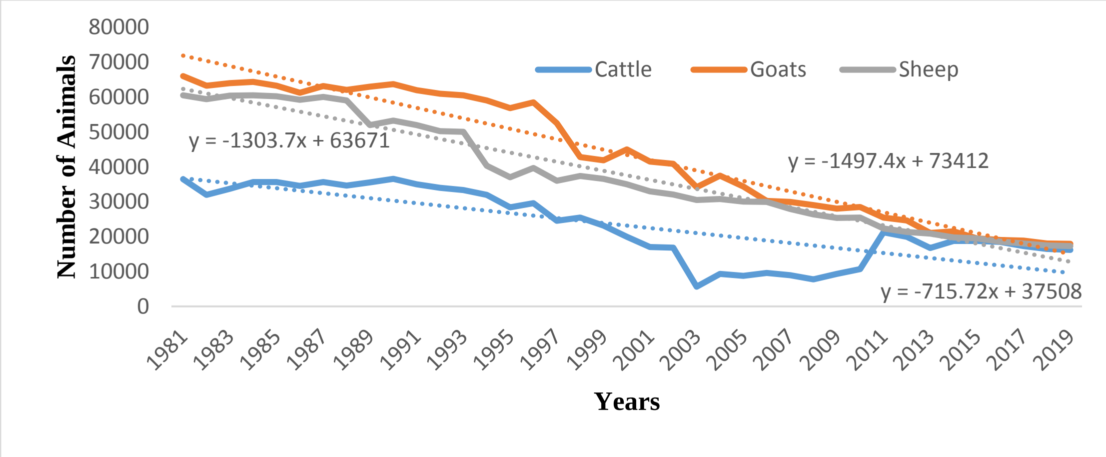


Figure 5: Interannual variations in livestock numbers

Figure 5 reveals that the numbers for all the ruminants has been fluctuating over the years. The very high CV values above 40% reveals a very significant inter-annual variations in livestock production. The variation is highest for cattle (44%), followed by sheep (40.3%) and goats (40.3%). Trend line analysis reveals that all the ruminants have recorded declining numbers over the years. The decline rate per year has been fastest for numbers of small ruminants- goats (1,498), sheep (1,304) than the large as cattle (716). The explanation of these trends in livestock production is complex, since many factors both human and physical interplay. However, since livestock production systems in terms of fodder (pastures and water) and animal diseases are highly dependent on baseline climatic conditions, the association of climatic trends with livestock trends shall be made. The spearman's rank correlation coefficients (r_s) for the association of inter-annual values of major climatic elements and livestock production are shown on Table 1.

Table 1: Correlation between annual climatic elements and livestock numbers

Climatic Element	Livestock					
	Cattle		Goats		Sheep	
	r	**r^2**	**r**	**r^2**	**r**	**r^2**
Relative Humidity	-0.2	**0.04**	-0.2	**0.04**	-0.2	**0.04**
Rainfall	0.03	**0.009**	0.02	**0.009**	-0.01	**0.001**
Average Temperatures	-0.6	**0.36**	-0.4	**0.16**	-0.4	**0.16**
Maximum Temperatures	-0.3	**0.09**	-0.3	**0.09**	-0.3	**0.09**
Minimum Temperatures	-0.4	**0.16**	-0.1	**0.01**	-0.2	**0.04**

The direction of the association reveals that there is an inverse relationship between variations in relative humidity and temperature (average, maximum and minimum) elements with the variation of all ruminants. Conversely, rainfall totals have a direct relationship with cattle and goats but inverse with sheep. These conclusions imply that the increasing trends observed in the RH as well as the warming trends in Ndu are negatively impacting on livestock production. It is also observed that the increasing annual rainfall total trends are positively impacting on the production of cattle and goats but negatively on sheep.

It is deciphered generally from the table that the strength of association (r) between inter-annual climate variability and variations in livestock production numbers is very weak for the moisture budget components of relative humidity and rainfall (weakest). For the energy component of average temperatures it is a tendency towards above average for cattle and near average for goats and sheep. Maximum temperatures have weak associations with the production of all the ruminants while minimum temperatures have very weak association with sheep and goats but near average with cattle. Looking at the coefficients of determination (r^2) average temperatures explain about 36% of the variation in cattle production and 16% of that for goats and sheep. Minimum temperatures explain about 16% of variations of cattle production. Maximum temperatures explain at 9% of the variation in the numbers of all the ruminants. The moisture budget components (RH and rainfall) explain below 5% of these variations. Implicitly, except for average temperatures, inter-annual variability of climate in general does not significantly affect the production of livestock in terms of evolution of numbers of animals. Air temperatures therefore stand out as a more important influence on livestock production especially cattle in the Ndu area.

The very weak association of annual climatic trends and livestock production trends induces a deeper analysis of the climatic pattern on and the likely implications of climate on livestock production in Ndu. The implications of the inter-annual seasonal patterns of the climate are correlated with livestock production for effects. This analysis of impacts of seasonality is important because about 99.2% of the respondents held that seasonal oscillations have implications on both the animals and the livestock farmers. The Spearman's rank correlation coefficients (r_s) values are shown on Table 2.

Table 2: Correlation between seasonal climatic elements and livestock numbers

Climatic Element	Seasonal Situation	Livestock					
		Cattle		Goats		Sheep	
		r	r^2	r	r^2	r	r^2
Relative Humidity	Rainy Season	0.05	**0.003**	0.1	**0.01**	0.1	**0.01**
	Dry Season	-0.3	**0.09**	-0.2	**0.04**	-0.3	**0.09**
Rainfall Totals	Rainy Season	-0.02	**0.0004**	0.02	**0.0004**	0.05	**0.003**
	Dry Season	0.1	**0.01**	0.01	**0.0001**	0.1	**0.01**
Average Temperatures	Rainy Season	-0.5	**0.25**	-0.4	**0.16**	-0.4	**0.16**
	Dry Season	-0.5	**0.25**	-0.3	**0.09**	-0.3	**0.09**
Maximum temperatures	Rainy Season	-0.2	**0.04**	-0.3	**0.09**	-0.2	**0.04**
	Dry Season	-0.3	**0.09**	-0.3	**0.09**	-0.3	**0.09**
Minimum temperatures	Rainy Season	-0.5	**0.25**	-0.2	**0.04**	-0.3	**0.09**
	Dry Season	-0.3	**0.09**	-0.1	**0.01**	-0.1	**0.01**

From table 2 the directions and strengths (r) for the association of seasonality of climatic parameters with variations in livestock production shows similar patterns as for annual values. The seasonal variations of temperatures still stand out as the most important influence on livestock numbers. This explains 25% of cattle production variations for the rainy and dry seasons, 16% for goats and sheep each in the rainy season and 9% each in the dry season. Maximum temperatures explain 9% of the variation in the production of all ruminants in the dry season and goats in the rainy season. The minimum temperature also explain 25% of the variation of cattle production in the rainy season and 9% in the dry season as well as 9% of variation of sheep production in the rainy season. Though the impact of variation in moisture is low it is observe that there is RH is more influential in the dry season as explains about 9% of the variation of the production of cattle and sheep. The least influential is the variation in rainfall totals, though it is observed that rainfall variations in the dry season affects livestock production more than in the rainy season except for goats. It is observed also that the large ruminant (cattle) is affected more by the seasonal variations in the climatic elements than the small ruminants (goats and sheep).

The perception analysis of 200 livestock farmers reveals that the livestock breeders highlight that the intensifying seasonal contrasts have great effects on their activities. 26.7% of the raised limited pastures in quality and quantity to feed the animals, 23.5% emphasised the problem of growing water scarcity for the animals, 20% talked of the rise of new animal diseases and pests, 16.7 % pointed to declining animal reproduction while 13% underscored the changing feeding habits of the animals. These problems are linked to the intensification of drying conditions that hinder pastures regeneration and fosters drying up of few water sources. All these are due to the fact that the dry season is becoming longer and drier and hotter.

The various animals suffer from different diseases. The diseases identified for goats and sheep were pneumonia, pneumoenteritis, mastitis and helminthosis. For cattle, the major diseases existing in the study area were blue tongue, rinder pest, trypanosomiasis, tuberculosis, foot and mouth disease, mastitis, babesiasis, black quarter and the lumpy skin diseases. The following picture (Plate 1) shows a cow suffering from skin disease.

Plate 1. A cow suffering from tick infection in the Mbawngong Village in the Ndu Sub-Division

These diseases on the ruminants reveal a seasonal pattern. For cattle, in the lowland, common dry season diseases are rinder pest, tripanosomiasis, tuberculosis, chronic respiratory diseases, contagious bovin-plearoprenonia and hemorrhagic septicaemia. This is prevalent in transhumance areas like the Mbaw plain. They develop due to elevated temperature conditions experienced during this season. Since the tempertaures are rising, it means the incidence of these heat-induced diseases is intensifying. During the rainy season, diseases are foot and mouth disease, mastitis and babesiasis, black quarter, lumpy skin disease, endo-parasite cause by round worm and tape worm and ecto-parasite caused by heavy ticks' infestation and ring worm. Most of the diseases develops due to extreme rainfall and humidity conditions experienced in some months. As the area is becoming more humid and wetter in the rainy season, it explains why these diseases are becoming more widespread.

The seasonal occurrence of diseases on small ruminants (goats and sheep) as shown on figure 6a and 6b.

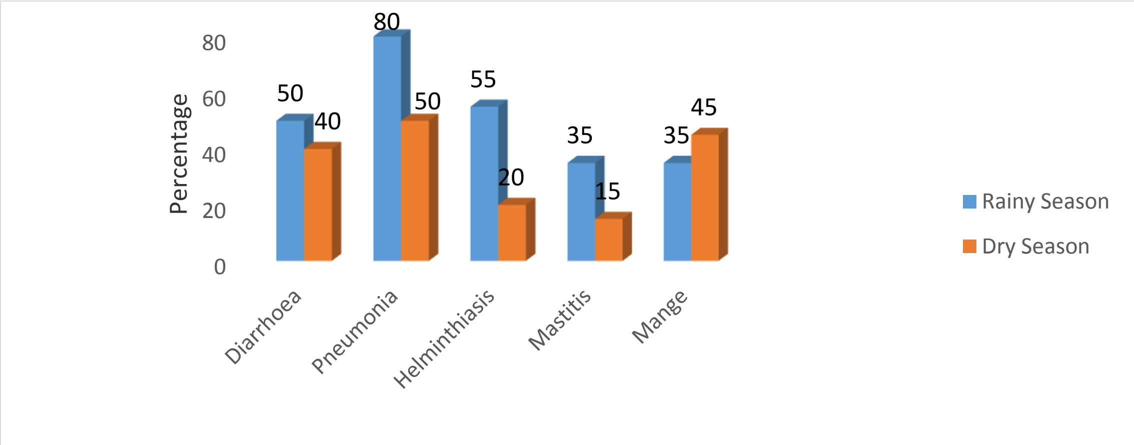


Figure 6(a): Seasonal occurrences of the major goat's diseases

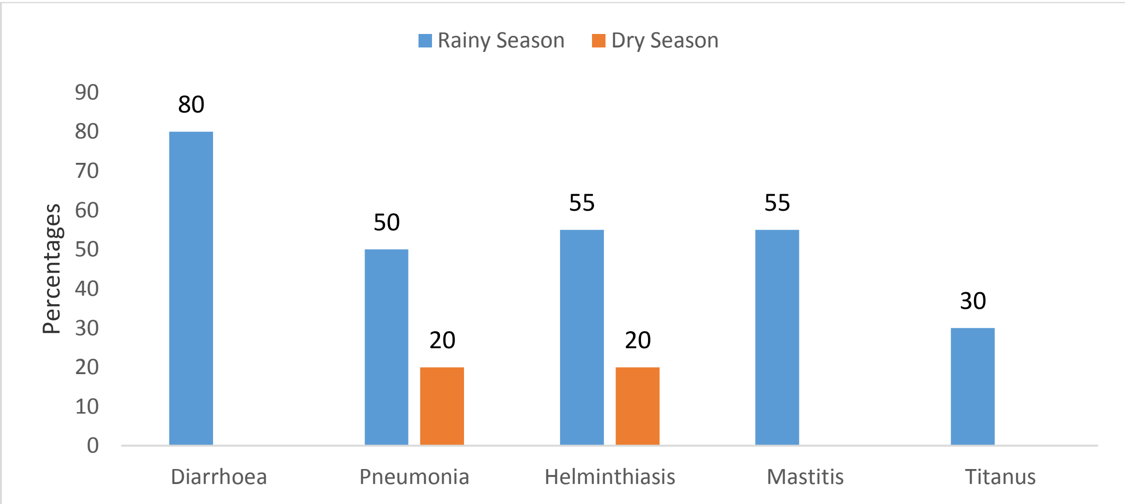


Figure 6(b): Seasonal occurrences of the major sheep diseases

The figure exposes that the major goat diseases occurring in the rainy season are pneumonia, helminthiasis and diarrhoea in this order while those dominant in the dry season were pneumonia and sarcoptic mange in that order. Field investigations revealed that in addition to the diseases on the figure, goats in this area also commonly suffer from sore foot, conjunctivitis, and anorexia in the rainy season due to low temperatures. For sheep the most of the diseases are rainy season based with dominant ones diarrhoea, helminthiasis, mastitis and pneumonia. Tetanus is least common. The dry season is more disease free as sheep are affected very limitedly by only two diseases- pneumonia and helminthiasis.

Seasonal fluctuations in Ndu Sub-Division such as the extended dry season with elevated temperatures and drought affects livestock activities and reproduction through heat stress. Periods with elevated temperatures are unfavourable to livestock because each animal has its idle temperature at which it flourishes. When the rectal temperature goes up to extremes, it actually affect the animal. The elevated dry season temperature of most areas in Ndu sub-Division affect livestock fertility. The abnormal dry seasons today in Ndu are leading to dust storm which are raising respiratory problems in animals and also diseases and pest which are harmful to animals.

Seasonal fluctuation has implications on the availability of pastures. During seasonal fluctuations like the periods of long dry season, pastures dry up and there is insufficient feeds for the animals. As the dry season is intensifying (drier and longer), drying off of pastures during these periods has become a major concern to be overcome by the livestock breeders. During the dry season in Ndu Sub-Division, some rangelands get completely parched with no green pastures visible. Evidence of drought affected pastures in the area is shown on Plate 2.

Plate 2: Dry season pastures in Ntumbaw village in Ndu

This picture shows animals grazing on an area bare of pasture due to the extended dry season in Ntumbaw village. There are visible signs of overgrazing in the picture and many more were spotted in Mbawngong, Mbaw and Ntamruh villages of Ndu Sub-Division. The number of animals in these areas now exceed the carrying capacity of the land especially during the dry season. These adverse situations are increasingly leading to malnutrition of animals and loss some of the animals. Furthermore, seasonality has brought about more transhumance challenges as the estimated time in the process has to be extended. This was confirmed by 26.7% of the respondents. They held that due to limited pastures in some exposed places like in Luh, Kakar, Njimkang and Mbah villages where most of the hillsides and wetlands have been exploited for farming activities, transhumance tracks have become long and are getting longer by the years. Long distances are covered by the animals to areas as Noni, Nkor and Mbaw plain. The result is much stress by the animals and some contact diseases in the process and after returning into confinement, they spread it to other animals.

At these times of limited pastures in Ndu-Sub Division, goats and sheep are left to free range and search for fodder and water into all direction. The consequence is that they often stray into arable farms since general soil infertility in farming areas has coerced food crop farmers to encroach grazing zones. This has provoked ugly consequences as poisoning of animals and the growing frequent by the farmer-graziers conflicts as underscored by 23.3% of the respondents. This picture (Plate 3) shows an inspection team at a farmland destroyed by strayed animals.

Plate 3: The MBOSCUDA examining potatoes farmland destroyed by Cattle in Ndu village

It was also established that seasonal variability also affected the feeding habits of most animals. As weather conditions are becoming hotter especially during extreme drought periods in the dry season, most animals do not feed well. They struggle to find shades to regulate their body temperature rather than feeding on the available pastures under extreme heat conditions. When this happens to lactating animals like cattle, the calf might not breastfeed well and might not survive the period. In the field, it was discovered that in the early morning periods, the movement of animals are less rampant as the conducive environmental conditions favour them to take their time and feed on the available pastures unlike the afternoon hours when they move about freely in order to regulate body temperatures and avoid heat stress . Due to this, they feed less and there is the reduction in the quantity and quality of milk, fat content, lower-chain fatty acids and solid-non-fat while increased palmitic and stearic acid content are observed. This is a normal phenomenon in Ndu Sub-Division because of the long dry season experienced in most villages today.

All these negative consequences have led to significant dropped in the income of livestock farmers as attested by 33.3% of the respondents and also fast reducing secondary benefits from pastoral farming such as organic manure production which 16.7% of the respondents held that it dropped. Since it was established that livestock farming and related activities constitute the backbone of Ndu, the farmers have developed indigenous and modern coping strategies.

6.3 Adaptation measures to seasonality and constraints in the Ndu Sub-Division

Though seasonality is so intense in Ndu interviews and focus group discussions revealed several coping measures that have been put in place by the livestock farmers for each season, as shown on figure 7.

American Journal of Climatic Studies
ISSN 2520-0471 (Online)
Vol.3, Issue 1, pp 15 - 36, 2022

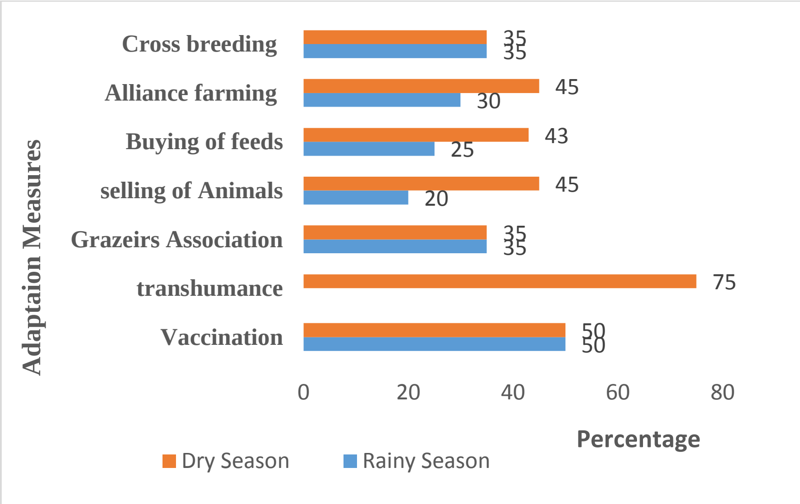


Figure 7: Indigenous adaptation measures to seasonality in the Ndu Sub-Division

Respondent views on Figure 7 reveal that vaccination of animals, creation of grazier's associations and the cross breeding of animals were the most widely used adaptation strategies implemented with equal proportion for the dry and the rainy seasons. Transhumance, selling of animals and buying of feeds and the alliance farming system were the frequent methods used during the extended dry season months. Vaccination for animal treatment and disease prevention is a very common strategy. The case of a livestock farmer treating a cow suffering from the mastitis disease that affects the breast of feeding animal and causes a lot of pains when the calf is sucking is shown on Plate 4.

Plate 4: Treatment of a cow with the mastitis infection in the Ndu Sub-Division

Animals are inoculated twice a year to fight the rinder pest disease. Also, sick animals are isolated and treatment against dehydration by intravenous injection. The alliance farming system has been used to reduce the frequency of farmers-graziers conflicts. In this kind of farming system, farmers allows animals to feed on their farms after the harvesting periods and in doing so, animals excretes and fertilizes their farms and this results into mutual benefits and prevent conflicts. Dry crop residue have been confirmed by most livestock keepers to have high nutritive values for the animals unlike the greenish stems of the rainy season.

The livestock farmers in Ndu and Ntumbaw villages, the core livestock producing areas, have pulled their effort to irk a living within the worsening climatic conditions by creating many Livestock Farmers Common Initiative Groups. From 2007 to 2018, LIPIDEP (Livestock and

Fisheries Development Program) has provided livestock farmers with improved pastures. There is also the MBOSCUDA and RDP that are working tirelessly to improve livestock reproduction and productivity in the area. The RDP also distributes equipment to livestock owners like barbed wires, sprayers, hand gloves, hand chart, wheel barrows and inputs like insecticides and pesticides. Drought resistance pastures like the bracheria and the gwatamalar seeds are being distributed to livestock keepers to cultivate them so as to reduce the pressure on available pasture during the dry season.

Furthermore, many livestock keepers buy improved hybrids. These improved hybrids are resistance to droughts and diseases. During high precipitation and flood events, there is always an increased risk of outbreaks of diseases transmitted by arthropod and water borne victors, such improved hybrids are capable of resisting them and they also produces a lot of milk. Other have resorted to stall feeding the animals during great periods of drought in the dry season, as shown on Plate 5.

Plate 5: Indigenous feeding strategies during Drought in Mbawngong Village in Ndu Sub-Division

During the season of pasture scarcity, the scarce fodder is harvested from far off wetlands in wheelbarrows and brought into the animals bedding to feed them. Some farmers buy the fodder to cope with the scarcity. In addition there is improved management of existing breeding fields. During periods of extended dry season most of the livestock keepers maintain the same rearing fields since there is no other way which the animals can be fed. Most livestock breeders have introduced paddocking into their animal rearing plan. In doing so they have avoided overgrazing by reducing the feeding frequencies of the livestock. At times the livestock remain in paddock while the herders go out and cut feeds and bring right to the beddings to feed them as shown on Plate 5.

Crossbreeding is increasingly being used as a coping strategy. In Ndu some livestock keepers import male Simmental species from other areas to cross breed the Gudali. The resultant calves which survive with little or no additional input, gain weight within a few month after birth more than any other species, resist more the environmental stresses induced by intensifying seasonality, and produce more beef and milk. In Ndu Sub-Division, some breeders have reduced the feeding frequencies of their animals, precipitated the sale of some of their animals as well as completely moving out of livestock activities so as to cope with the seasonal fluctuation challenges.

Despite these efforts at adaptation, the efficacy of these indigenous coping strategies in Ndu subdivision have been constrained by challenges. Investigations and confirmed by the most of the livestock actors revealed seven barriers to indigenous adaptation measures in Ndu subdivision. These were limited grazing (76%), inadequate finances (70%), population growth (65%), limited water resources (63%), inadequate veterinary services (62%), limited knowledge of coping strategies (58%), and farmers-grazers conflicts (55%), in this order of importance.

7. DISCUSSIONS

Livestock activities require specific rainfall, relative humidity and temperature in order to do well in terms of reproduction, milk production and the provision of high quality meats. The results of the study revealed that there was intense seasonality in the study area and that the dry season months were extending longer than the rainy season months. This was in line with the findings of Xue *et al.*, (2013) climate change has altered not only the overall magnitude of rainfall but also its seasonal distribution and inter-annual variability worldwide. Such changes in the rainfall regimes will be most keenly felt in arid and semiarid regions, where water availability and timing are key factors controlling biogeochemical cycles, primary productivity and the phenology of growth and reproduction, while also regulating agricultural production. The study also unveiled information that seasonal fluctuation which was manifesting itself through the fluctuation in the amount and the frequency of rainfall, temperature and relative humidity has implications on livestock production. As confirmed by the livestock farmers, elevated temperatures affect animals' reproduction and bring about the inversion of livestock diseases and pest. This result confirmed the findings of Tata *et al*. (2012) who in assessing the effects of climatic variability on cattle and milk production in Jakiri noted that the seasonal climatic variability in the rangelands influence the pattern of diseases that affect cattle and Chiambah, (2015) on vulnerability of agriculture to climate variability in Ndu subdivision.

Results from the study as accounted for by approximate 75% of the respondents revealed that there were also abnormal situations in the occurrences of the relative humidity in the study area which affects livestock activities through temperature elevations and diseases inversion. This finding had connections with that of Sherwood and Fu (2014) who noted in their study that relative humidity as a key environmental factor plays an important role in air quality and climate control. Previous investigation by Xiong *et al*. (2017) confirmed that abnormal levels of relative humidity increases the infectivity of pathogens which result to the prevalence of the infectious disease; abnormal relative humidity levels is also responsible for respiratory damages in calves.

Results from the study also confirmed that the frequency, duration and the patterns of rainfall have reduced though there are situations with heavy downpour during which rangelands are flooded. About 60% of the respondents claimed that in such areas there exist some specific diseases and animals find it difficult to graze over the area. These results were in line with that of Ehrhart (2009) who noted that erratic rainfall and floods are increasing the pastoralists' inability to feed their animals leading to loss of source of livelihood and thus food insecurity in many African Sub-Region. In the field, most livestock keepers said that due to seasonality, they have adopted several coping strategies as transhumance during the dry season, vaccinations of animals, managements of breeding fields, and the formation of graziers associations. These were in line with the findings of AGNES (2020) that desertification as land degradation in arid, semi-arid, and dry sub-humid areas result from many factors, including climatic variations and human activities. It leads to reduction in crop yields and weakens the resilience of agricultural and pastoral systems - key livelihood pillars in Africa. Also, the findings conform to the conclusions of Van de Steeg *et al.*, and Rojas *et al.*, (2017) that climate change will affect livestock production through competition for natural resources, quantity and quality of feeds, livestock diseases, heat stress and biodiversity loss. Livestock keepers revealed that the unreliability of the coping measures were because of the following: A greater proportion of the sampled breeders attributed that poverty and inadequate capital were some of the hindrance to those measures, about 60% of the respondents advanced the limited knowledge on how to deal with seasonal fluctuation challenges. This conforms to the conclusions of UNEP (2009) that the weak capacity of pastoralist institutions and pastoralist civil society organisations to organise themselves around the sustained collective action required to utilize political leverage in policy circles to look into the challenges of the sector.

Findings also revealed that in trying to implement some of the adaptation measures, there are always insufficient supports from the government and NGOs as 50% of the respondents supported this while 16% were against. This finding had a link with the ideas of the UNEP (2009) who made mentioned that failure of the international and national organization in addressing seasonality stress is due to the marginalization of the pastoral sectors. GECHs (2008) and also outline that in addressing this issues, it is good to build the capacity of key governance institutions addressing pastoralism through improving accountability, transparency and responsiveness.

The findings also revealed that population growth and limited grazing land were other barriers as most grazing areas are today occupied by human settlements. This is in consonance with the UNDP (2008) finding that also mentioned that the coping strategies that have served drought affected communities well may become inadequate in light of the frequent and rapid socio-economic growth. Other vital measures implemented in the study area as revealed by the findings were: highly poverty situation, inadequate veterinaries, mal-nutrition, low living standard and grazier-grazier conflicts.

8. CONCLUSIONS AND RECOMMENDATIONS

Livestock production remains the most reliable livelihood source to the population in the Ndu Sub-Division as it provides employment opportunities, source of revenue to the state, source of food to the population both at the national and international levels, income generation to local farmers and a growth pole for development in the study area. It is also one of the activities that attracts the government’s attention to the rural sector and also provides manure for the farmers thereby enhancing the change from shifting fields to permanent fields of cultivation. The activity is compromised by seasonality and obviously animals require good welfare as it gives them the benefit of good health and high productivity. Seasonality is gradually limiting the socio-economic and political benefits derived from this activity. Policies must therefore be implemented against some harmful anthropogenic activities such as deforestation, over grazing, poor farming methods, pollution and urban sprawl. If these are controlled, most of the rangelands shall be restored and the restoration of degraded rangelands does not only entails the increase in the scale of grazing units but it shall goes a long way to increase the quality of breathing air, increase in food production, clean water, booming economic activities and the reduction in the rate of rural to urban migration. Government departments like MINEPIA (Ministry of Livestock, Fisheries and Animal Industries), should therefore make provisions for livestock facilities like animal dips, veterinaries, animal drugs, organise regular pastoral shows and workshops geared at encouraging and training livestock farmers. With these, livestock activities shall provide perennial benefits to the livelihoods of the population in the Ndu Sub-Division.

REFERENCES

Acheapong, P.K. (1987). “ Rainfall characteristics over the west-african Sahel: the Nigerian Example. In: Singapore Journal of Tropical Agriculture.

AGNES (2020). Desertification and Climate Change in Africa1. Policy Brief No. 1 March, 2020. African Group of negotiators experts Supports.

Amawa, S., Bate, G. B., Jude, N. K. (2007). Determinants and policy Implications of farmers' climate adaptation choices in Rural Cameroon

Ayoade, J.O. (1988). Introduction to Climatology for the Tropics. Ibadan, Nigeria, Spectrum Books Limited.

Chambers, L. E. & Richard, H. L. (1981). The influence of climate variability on animal species in Western Port, Victoria.

Cheng, Y., He, K. B., Du, Z. Y., Zheng, M., Duan, F. K. & Ma, Y. L. (2015). Humidity plays an important role in the PM2.5 pollution in Beijing. Environmental Pollution, 197C, 68-75. Retrieved October 11, 2020, from https://www.researchgate.net.

Chiambah, C. Z. (2015). An Assessment of the Impacts of climate Variability on Agricultural vulnerability in Ndu Sub-Division, North West Region of Cameroon, *Unpublished M.Sc. Thesis in Geography*, University of Buea.

Ehrhart, C. & Twena, M. (2009). Climate Change and Poverty in Tanzania. Realities and response options for CARE. Background Report. CARE International Poverty-Climate Change Initiative.

Hayward, D. and Oguntonyinbo, J. (1987). The Climatology of West Africa. Barnes and Noble Books.

Kotir, J. H. (2010). Climate change and variability in sub-Saharan Africa: A review of current and future trends and impacts on agriculture and food security. Environment Development and Sustainability, 13, 587-605

Rojas-Downing M., Nejadhashemi. A. P., Harrigan T., and Woznicki S. A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. Elsevier. Climate Risk Management. Volume 16, 2017, Pages 145-163

Sherwood, S. & Fu, Q. (2014). Climate change. A drier future? Science, 343, 737-739. Retrieved September 2nd 2020 from, https://www.atmos.washington.edu

Tata, E. S., Sunder S.K., and Amawa, S. G. (2012). The implications of rainfall variability on cattle and milk production in Jakiri sub division, North West Region; Cameroon. URL:http://dx.doi,org/10.5539/jas.v4n 10p 237 extreme events

UNEP (2009). Climate Change in the African Dry lands: Options and Opportunities for Adaptation and Mitigation. Accessed on the 17th of June 2019from, http://www.unccd.int/Lists/Site DocumentLibrary/Publications

UNDP. (2008). Assessing the evidence of climate variability on livestock production in the northern part of Ethiopia.

Van de Steeg J., and Tibbo M. (2012). Livestock and climate change in the Near East Region: Measures to adapt to and mitigate Climate Change. Food and Agricultural Organisation of the United Nations

WMO. (2013). The State of Greenhouse Gases in the Atmosphere Based on Global Observations; 2013. Bulletin No. 9. Accessed on the 14th of June 2019 from, http://www.wmo.int/pages/prog/arep/gaw/ghg.

WMO (2021). State of the Climate in Africa 2020 report. AU, WMO, 19 October, 2021. World Meteorological Organization (WMO)

Xiong Y., Meng Q.S., Gao J., Tang X.., Zhang H. (2017). Effects of relative humidity on animal health and welfare. Journal of Integrative Agriculture 2017, 16(8): 1653–1658 REVIEW

Xue F., Amilcare P. & Ignacio R-I. (2013). Changes in rainfall seasonality in the Tropics. Nature Climate Change volume 3, pages811–815