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Effect of Climate Variability on Livestock Population in the Sokoto Rima River Basin, Nigeria

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ABSTRACT: The study examines the effect of climate variability on livestock population in the Sokoto Rima River Basin, Nigeria. The cluster sampling technique was used to administer the questionnaire to 450 farmers who were sampled from 15 agricultural settlements in fifteen local governments in the basin. Data were analysed using frequency, percentages, and multiple regression. The population of cattle and sheep decreased while that of goats increased during the period of study. However, the slaughtered cattle, sheep, and goats increased tremendously. The annual rainfall and temperature had no significant influence on cattle, sheep, and goat population in Sokoto-Rima River Basin, except at Sokoto where temperature significantly influenced goats positively at $p<0.05$. The coefficient of determination revealed that annual temperature explained 72% of the variation in the goats' population at Sokoto while 28 % of goats' population variation was explained by non-climatic elements including forage quality, management practices, ill-health, epidemic disease, and so on.

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Several studies have shown that climatic variability affects livestock production (Oba, 2001; Australian Bureau of Statistic, 2004; Güney *et al*., 2009; Oladele and Moilwa, 2010). Studies have also shown that relationships exist between rainfall variability and livestock population dynamics (Desta and Coppock, 2002; Begzsuren *et al.*, 2004; Kgosikoma, 2006). Most of these studies suggest that the seasonal cycle of reproductive activity in both males and females is driven by an endogenous annual rhythm being synchronized by photoperiod which is directly affected by climate changes (Güney *et al.*, 2009). Sweet (1998) observed that drought is an aspect of climate variability that directly reduced livestock holdings through mortalities and indirectly through distress sales. Globally, climatic change has several effects on animal production (Guney *et al*., 2009). In drylands, livestock populations are characterized by fluctuations in response to rainfall variability (Desta and Coppock, 2002). Ellis and Galvin (1994) observed that if rainfall variability is high, the livestock populations are modulated by frequent droughts and subsequently never reaching equilibrium. In arid and semi-arid zones, seasonal and annual drought has a serious effect on rangelands and consequently on livestock (Coppock and Reed, 1992; Oba, 2001). Rainfall fluctuation affects the quantity and quality of herbage available to animals. Regeneration of vegetation becomes difficult during drought extensions. The vulnerability of livestock to drought comes about because of a decrease in range resources. In such situations, the available livestock population will be difficult to maintain on natural rangelands throughout the year. This leads to chronic inadequate feed supply for livestock, with dramatic consequences in dry years. Hence, drought directly reduced livestock holdings through increase mortality and reduced birth rates (Ellis and Swift, 1988; Sweet, 1998; Kgosikoma, 2006). This present study has incorporated several issues which had hitherto been neglected or

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deliberately avoided even though studies existed on livestock production (Ndamukong *et al.*, 1989; Adejuwon *et al*., 2019). The effect of climate variability on the livestock population and its statistical analysis in the study area has not been documented. The existing study on the livestock population in Nigeria was based on projected figures with a growth rate of 0.129 percent (RIM, 1992). Projected figures do not take factors including drought, ill-health, epidemic disease, and death that might cause variation in livestock population figures into consideration. Therefore, this study addressed gaps identified in previous works towards establishing effective climate change response on livestock population and help in the strategic planning of the response to food security challenges.

MATERIALS AND METHODS

Study Area: Sokoto Rima River Basin is situated in the northwestern part of the country. The study area lies between latitude 10.8o N and 13.58o N and longitude 3.30o E and 7.13o E (Figure 1), covering an estimated land area of 106, 547 square kilometers (Iliya and Kwabe, 2000; Mamman, 2000). It is bounded by the Niger Republic to the north, Niger and Kaduna States to the south and southeast, the Benin Republic to the west, and Katsina State to the east. Sokoto-Rima Basin experiences a tropical climate, governed by the Inter-tropical Discontinuity (ITD; Obasi, 1965). The ITD marks the boundary line between two air masses - the tropical maritime (mT) air mass from the Atlantic Ocean and the dry tropical continental (cT) air mass from the Sahara Desert (Adejuwon, 2016). The prevailing air mass at a particular period has a strong influence on the climate. The climate exhibits a definite and marked wet and dry season. The mT dominates during the wet season while the cT air mass predominates during the dry season

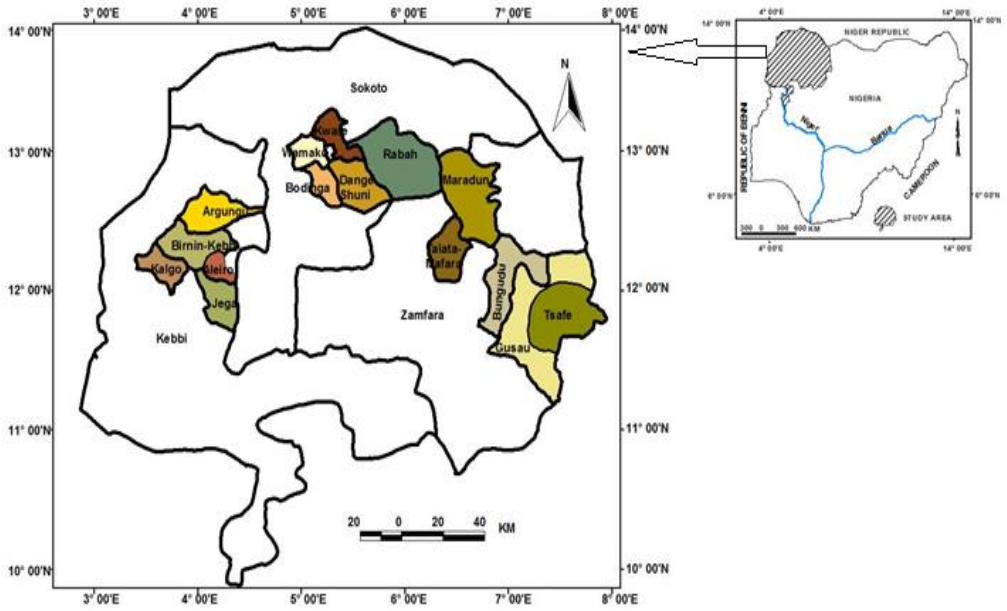

Fig 1: Selected local governments where questionnaires were administered

The wet season is between May and September in the southern part and June to September in the north (Adejuwon, 2012). Annual rainfall amount varied from about 1013 mm in the southern part to about 650 mm in the northern part and is single maxima in character (Emielu, 2000; Mistry, 2000; Adejuwon, 2018). The rainfall decreases in both duration and amount from the south northward. High humidity is experienced in the wet season while low humidity of less than 30% is often experienced in the dry season (Oboli, 1967; Emielu, 2000). The area is characterized by the dry and dust-laden northeast trade winds called 'Harmattan' that blows from the Sahara under cloudless but dusty conditions from January to February. This period is marked by very low temperatures and thick fog at this time. The mean annual temperature range is between 5ºC and 10ºC while the mean annual temperature is 34.5ºC (Adejuwon, 2019). The extremes diurnal and seasonal range is affected by seasonal and latitudinal variations. The highest temperatures are normally in the dry season, March to April while the minimum temperatures are usually recorded in January to February.

Data Collection and Analysis: Data for this study were obtained from field investigations, involving direct interaction with the respondents. A total number of

four hundred and fifty copies of the structured questionnaire were administered to farmers in fifteen agricultural settlements in fifteen Local Governments (Table 1).

A cluster sampling technique was used for the study. Agricultural settlements and the local governments were selected by purposive sampling technique. Thirty copies of questionnaires were administered in each of the settlements. This was because the settlements were small, hence the number of farmers. Data were analyzed using frequency, percentages, and multiple regression.

Table 1: Locations of data collection in Sokoto-Rima River Basin

State	Local Government	Communities
Sokoto	Wamakko	Gumbi
	Bodinga	Mil Goma
	Kware	Durbawa
	Dange Shuni	Dange
	Rabah	Maikujera
Kebbi	Kalgo	Kalgo
	Birni-Kebbi	Gulumbe
	Aliero	Dakala
	Jega	Basaura
	Argungu	Alwasa
Zamfara	Talata Mafara	Tunfafiya
	Gusau	Madidi
	Maradun	Dosara
	Bungudu	Tazame
	Tsafe	Tsafe

RESULT AND DISCUSSION

The fluctuation in cattle population in Sokoto-Rima River Basin is shown in Figure 2. The cattle population increase of 2,754,627 in 2002 crashed to 1,505,427 in 2003 and started to recover and steadily increased till 2006 when a population of 2,662,330 was recorded. Since 2003, the population loss has not been regained. The cattle slaughtered increased from 98,406 in 2000 to 163,504 in 2001, decline to 160,879 in 2002, and then increased progressively till it reached 258,856 in 2006 (Figure 3). Sheep population had double decrease from 2,516,959 in 2002 to 2,417,496 in 2003 and from 2,527,767 to 2,382,870 in 2006 while the sheep slaughtered declined from 400,771 in 2002 to 321,796 but since then increased till 2006 when 411,592 sheep were slaughtered. In 2001, the goat number crashed from its initial population of 2,015,725 in 2000 to 1,235573 in 2001 and later followed by population growth until 2006 when 3,990,626 were recorded. However, goat slaughtered consistently increased from 297,012 in 2000 to 442,520 in 2006. The decrease in the population and increase in slaughtered cattle and sheep in 2003 is a result of drought in most stations especially Gusau and Yelwa (Adejuwon, 2012). Adefolalu (2007) reported that increasing drought occurrences in the semi-arid region of northern Nigeria were majorly caused by the increase in temperature and declined rainfall. However, the goat population increased while slaughtered goats decreased at the same period. The thriving of goats at this period could have resulted from their ability to survive and reproduce in harsh environments because of their low metabolic requirements and body mass (Silanikove, 2000: Chukwuka *et al*., 2010). Goats with thermal comfort zone ranges from 0-30^{o}C, can withstand heat stress and endure protracted water deprivation, making them more adaptable to adverse climatic and geographical conditions, where cattle and sheep cannot survive (Assan, 2013; Adejuwon, 2019). Cain *et al.* (2005) reported that goats can store urine in their kidney, therefore can avoid drinking water during water scarcity, and can thrive in extreme temperatures and limited water. The cattle slaughtered to cattle population in Sokoto-Rima River Basin as shown in table 2 revealed that 7.5%, 12.3%, 5.8% of cattle population was slaughtered in 2000, 2001, and 2002 respectively. Since 2002, there was an increase in the number of cattle slaughtered till 2005. However, there was a serious reduction in this number in 2006 when 9.7% was recorded. The sheep population was slaughtered in 2000 was 21.6% which increased to 29.4% in 2001 and later declined to 12.8% in 2002. After this, there was a yearly increase till 2006 when it reached 17.3% (Table 3). The percentage of goats' population slaughtered increased from 14.7% in 2000 to 26.5% in 2001 but later reduced to 15.2% in 2002 and 10.4% in 2003. This was followed by a consistent slight increase until 2006 when 11.1% of the population was slaughtered (Table 4).

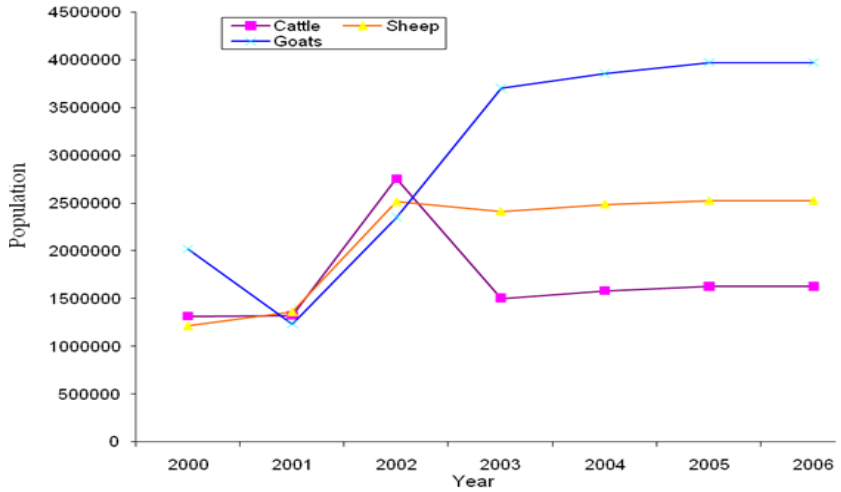

Fig 2: Livestock population in Sokoto-Rima River Basin

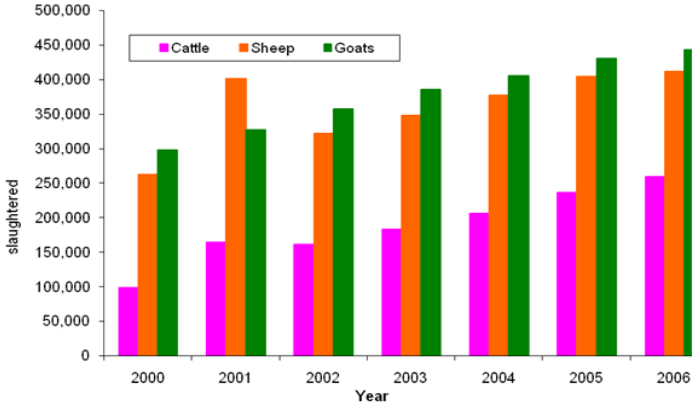

Fig 3: Livestock slaughtered in Sokoto-Rima River Basin

Table 2: The number of slaughtered cattle to cattle population

Year	Cattle Population	Slaughtered	%
2000	1,317,402	98,406	7.5
2001	1,325,385	163,504	12.3
2002	2,754,627	160,879	5.8
2003	1,505,427	182,454	12.1
2004	1,580,849	205,550	13.0
2005	1,626,051	236,185	14.5
2006	2,662,330	258,856	9.7

Table 3: The number of slaughtered sheep to sheep population

Year	Sheep Population	Slaughtered	%
2000	1,213,616	262,233	21.6
2001	1,362,324	400,771	29.4
2002	2,516,959	321,796	12.8
2003	2,417,496	347,992	14.4
2004	2,490,821	377,108	15.1
2005	2,527,767	404,480	16.0
2006	2,382,870	411,592	17.3

Table 4: The number of slaughtered goats to goat population

Year	Goat Population	Slaughtered	%
2000	2,015,725	297,012	14.7
2001	1,235,573	327,186	26.5
2002	2,352,621	356,502	15.2
2003	3,701,374	385,542	10.4
2004	3,855,198	405,455	10.5
2005	3,970,581	429,814	11.1
2006	3,990,626	442,520	11.1

The livestock population of cattle, sheep, and goats in the River Basin followed upward and downward fluctuation, which Kgosikoma (2006) referred to as a "boom and bust" pattern. Such results have been reported in the literature (Perkins, 1991; Desta and Coppock, 2002; Kgosikoma, 2006). Sokoto-Rima River Basin is one of the areas controlling the bulk of livestock production in Nigeria. The major species of domesticated animals are mostly cattle, sheep, and goats. With a total estimated population of 10.9 million ruminants in 1986, Sokoto State (now Sokoto, Kebbi, and the Zamfara States) contributed about a quarter of the national populations of the three species (UDUCONSULT, 1990). According to Yakubu and Yakubu (2008), the effect of harsh weather and climate results in low productivity and brings about low livestock production. Table 5 shows the multiple regression analysis between climate variables of temperature and rainfall and livestock population of cattle, sheep, and goats in the Sokoto-Rima River Basin. The annual rainfall does not have a significant

influence on cattle, sheep, and goats at Sokoto, Gusau, and Yelwa. Temperature significantly influenced the goat population positively ($p \leq 0.05$) at Sokoto but does not have a significant influence on goats at Gusau and Yelwa. The coefficient of determination (R2) for goats at Sokoto was 0.042. Also, the temperature does not have a significant influence on cattle and sheep at Sokoto, Gusau, and Yelwa. The annual rainfall and temperature had no significant influence on cattle, sheep, and goat population in Sokoto-Rima River Basin, except at Sokoto where temperature significantly influenced goats positively. This study revealed that cattle, sheep, and goats were not affected by rainfall and temperature variability in Sokoto Rima River Basin except Sokoto where an increase in the annual temperature for consideration increased goats' population. The coefficient of determination revealed that annual temperature explained 72% of the variation in the goats' population at Sokoto. This means that 28 % of goats' population variation was unexplained by temperature. They were explained by other factors than climatic elements considered. These include forage quality, management practices, ill-health, epidemic disease, and so on (Seleka, 2001; Kgosikoma, 2006). The results of the present study support findings in the literature that goat populations were more resilient to harsh conditions than sheep and cattle (RIM, 1992; Toulmin, 1996). Toulmin (1996) observed that small stocks especially goats are more resilient under adverse conditions. This was corroborated by Wilson (1987) who noted that environmental factors have little influence on goats.

Table 5: Regression analysis for the relationship between Climate and livestock population

Station	Livestock	Regression Model	R^2	Significance (α)	
				Rf	Tp
Sokoto	Cattle	3849424.365 + 100.344RF +110736.012TP (-1.727) (0.250) (1.928)	0.54	0.815	0.126
	Sheep	-2952098.599 + 32.708RF + 91848.52TP (-1.030) (0.063) (1.244)	0.35	0.953	0.282
	Goats	-6138610.030 + 270.856RF + 76380.716TP (-2.639) (0.646) (2.942)	0.72	0.553	0.042
Gusau	Cattle	-2759309.837 -4.920RF + 87042.612TP (-2.046) (-0.060) (2.148)	0.56	0.955	0.098
	Sheep	-2415540.004 -52.908RF + 83407.499TP (-1.424) (-0.510) (1.637)	0.40	0.637	0.177
	Goats	-2938455.471 + 54.117RF + 95983.881TP (-1.531) (0.461) (1.665)	0.49	0.669	0.171
Yelwa	Cattle	1277827.173 -65.450RF -29623.217TP (0.416) (-0.260) (-0.354)	0.03	0.808	0.741
	Sheep	-904187.660 + 202.295RF+ 30772.230TP (-0.291) (0.792) (0.363)	0.144	0.473	0.735
	Goats	1128529.218 -123.501RF -18439.044TP (0.277) (-0.370) (-0.166)	0.04	0.730	0.876

RF – Rainfall TP – Temperature t value – Figures in bracket

Conclusion: The study has examined the effect of climate variability on livestock production in the Sokoto Rima River Basin, Nigeria. The goat's population and the slaughtered cattle, sheep, and goats increased while cattle and sheep population decreased. Only annual temperature significantly influenced goats positively at Sokoto and explained 72% of the variation in the goats' population. This means that 28 % of goats' population variation, the slaughtered cattle, sheep, and goats increase was unexplained by temperature.

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