

Comparative Analysis of the Experiences, Impacts and Adaptation Strategies to Climate Change Among Sahel Zone's Agro-pastoralists of Northeast, Nigeria.

¹Johnson Egbemudia Dudu PhD & ²Job Imharobere Eronmhonele

¹Department of Geography, Faculty of Social Sciences, Federal University of Kashere, Gombe State, Nigeria.

²Centre for Population and Environmental Development (CPED), Benin City, Edo State, Nigeria.
Email: jedudu@yahoo.co.uk & loyaltyisgood@yahoo.co.uk

Abstract

The study is a cross-sectional comparative study of the experiences, impacts and adaption strategies to climate change in Sahel Zone's agro-pastoralists in Northeast, Nigeria. Quantitative research approach was used to collect data. The study was conducted in 6 Local Government Areas (LGAs), with three LGAs each purposively selected in Bauchi and Gombe States where 3,041 copies of questionnaire were administered after the stratification of the LGAs. The data were analyzed using descriptive and Chi Square statistics in SPSS version 25.0. Results as well as conclusion from the study indicate that agro-pastoralists in Bauchi and Gombe have heard about climate change (89.1%), have various experiences and were aware of different impacts of climate change. The data also revealed that agro-pastoralists have used numerous adaptation strategies to combat impact of climate change. A Pearson Chi-square test of significant relationship between some socio-demographic factors such as location, age, sex including, education and experiences, impacts and adaptation strategies produced mixed associations as the factors were not consistently related. Based on the findings, the study recommends that Governments develop climate change institutions where extension agents would highlight known impacts and available adaption strategies of climate change, in order for agro-pastoralists to know the steps to take in dealing with climate change challenges. The proposed institutions should assist in better management of the environment, develop more climate friendly crops and livestock varieties that can withstand diseases/drier conditions and investment in irrigation for the betterment of agro-pastoralists activities and communities.

Keywords: Adaptation strategies, climate change, experiences, impact, northeast & Sahel zone

Introduction

Africa already has a population of 1,462,000,000 people in 2023 (UNFPA, 2023). This is faster than expected against the projection of over one billion people by Thornton et al (2009) by 2050. This increased population depends on climate sensitive livelihoods with people with very poor adaptive competencies, therefore making most African rural population to be vulnerable to the vagaries of climatic conditions or climatic variability (Belay *et al*, 2022; Gebeyehu *et al*, 2021; Kgosikoma *et al*, 2018). Unfortunately, the majorities of African nations, including Nigeria have weak adaptive abilities, and it has been predicted that they will be more susceptible to the devastating effects of climate change and variability, including agro-pastoralists whose survival depends on their environment, hence climate change has become a global concern, especially in food security which agro-pastoralists are major contributors (Asante *et al.*, 2021; Jellason *et al*, 2022; Nyang'au *et al.*, 2021; Pedersen *et al.*, 2021; Xie *et al.*, 2022).

Agro-pastoral agriculture system plays a crucial role in the food security system in Africa including Nigeria (Ibe *et al*, 2022; Menghistu *et al.*, 2020; Mwakaje, 2013). Agro-pastoral

communities in Sub-Saharan Africa (SSA) mostly rely on livestock and mixed crop–livestock production systems for their livelihoods. The primary characteristics of these production systems are low and irregular rainfall coupled with arid and semi-arid climatic condition. There is uncontrolled movement as a result of this enormous production system, which is dependent on the seasonal availability of water and fodder. (Menghistu *et al.*, 2020; Mwakaje, 2013). Just like in other farming endeavours, climate change elements like rainfall and level of temperature determine the seasonal availability of water and folder for agro-pastoralists, hence productive in agro-pastoralists businesses are determined by climatic factors (Xie *et al.*, 2022). Therefore, it is critical for agro-pastoralists to be aware of these environmental conditions, as poorly understood climate change factors will have a detrimental effect on agro-pastoralists yields and efforts (Alex, 2018; Belay *et al.*, 2022; Xie *et al.*, 2022). In order to understand agro-pastoralists' perceptions, the nature of their impacts and adaptation strategies over time, and the relationship between the variables of experience, impact, and adaptation strategies in the North East Nigeria, a comparative analysis of the experience, impact, and mitigation strategies to climate change among agro-pastoralists in Northeast, Nigeria, is therefore essential. The objectives of the study are to:

- i. evaluate how agro-pastoralists in the study area experience climate change
- ii. determine whether the demographic characteristics of agro-pastoralists and their experiences with climate change are related
- iii. examine what agro-pastoralists perceived as the impacts of climate change in their locations and
- iv. assess ways in which agro-pastoralists are adapting to the local climate in the study area.

Literature Review

According to the Intergovernmental Panel on Climate Change of the United Nations (IPCC) (2018), "climate change" is defined as alterations in the properties of the climate that last for a considerable amount of time, usually decades or more, and can be detected (for example, through statistical tests) by variations in the mean and/or variability of those properties. It describes any long-term change in climate, whether brought on by human activity or natural variability (IPCC, 2007). Evidence of extreme climate change experiences which are now detrimental to human survival, affecting agro-pastoralists endeavours have been documented. These include: general awareness of climate change (Belay *et al.*, 2022; Ibe *et al.*, 2022; Xie *et al.*, 2022), reduction in rainfall amount (Belay *et al.*, 2022; Gebeyehu *et al.*, 2021; Kgosikoma *et al.*, 2018; Snaibi *et al.*, 2021, Tofu *et al.*, 2023), global warming/temperature increase (Sewando *et al.*, 2016; Tofu *et al.*, 2023), heat stress/extreme hotness (Adger *et al.*, 2007; Godson-Ibeji *et al.*, 2022), increased evaporations (Belay *et al.*, 2022); increase frequency of drought (Ibe *et al.*, 2022; Jones & Thornton, 2003; Mwakaje, 2013; Tofu *et al.*, 2023), delay in the onset of rains (Belay *et al.*, 2022), unexplainable and drastic change of climatic element (Bobadoye *et al.*, 2016), unpredictability of rainfall (Godson-Ibeji *et al.*, 2022), increased frequencies of flooding (Belay *et al.*, 2022) and extreme volume of annual rainfall (Godson-Ibeji *et al.*, 2022).

These climatic experiences have had various impacts on agro-pastoral livelihood activities. These effects of extreme climatic condition manifest in the form of increase of crop evapotranspiration, reduced water availability, quality and dryness of water ponds (Kongnso *et al.*, 2021; Snaibi *et al.*, 2021), reduction in pasture quality (Feng *et al.*, 2021; Rojas-Downing *et al.*, 2017; Tofu *et al.*, 2023), increased livestock diseases (Kongnso *et al.*, 2021, Xie *et al.*, 2022), land degradation and

abandonment (Snaibi et al., 2021; Tofu et al., 2023) long migration (Belay et al., 2022; Godson-Ibeji et al., 2022; Tofu et al., 2023; Xie et al., 2022) and changing planting dates of crops (IPCC, 2014; Xie et al., 2022). Other impacts of climate change in the literature are: displacements of people from their locations of farming and livestock activities (Solomon et al., 2018); increased conflicts and disruptions of families (Mwakaje, 2013; van Weezel, 2019). All these reduces agro-pastoral productivity to a certain extent (Hilemeleket et al., 2021; IPCC, 2014; IPCC, 2018), leading to failing prices of livestock/crops and in turn lower agro-pastoralists income (Belay et al., 2022; Xie et al., 2022); with the ultimate consequence of food insecurity and poverty (Guodaar & Appiah, 2022; Hayhoe et al., 2018; Kgosikoma et al., 2018; Kimaro et al., 2018; Seife, 2021), to which the agro-pastoralists have used different adaptation strategies to manage.

Agro-pastoralists use variety of strategies to adapt to climate change. These include training/capacity-building initiatives to empower agro-pastoralists (Xie *et al.*, 2022), supplementing livestock feed (Gebeyehu *et al.*, 2021; Ng'ang'a *et al.*, 2020), increased water supply to animals (Godson-Ibeji *et al.*, 2022; Ibe *et al.*, 2022), use of local species of animals/crops that withstand weather situation (Godson-Ibeji et al., 2022), vaccinating animals (Ibe *et al.*, 2022), livestock migration (Godson-Ibeji *et al.*, 2022; Ibe *et al.*, 2022), migration to urban area (Mwakaje, 2013), sales of livestock before bad times (Godson-Ibeji *et al.*, 2022), cultivation of drought-tolerant crop varieties (Akinagbe & Irohibe, 2014; Xie *et al.*, 2022), planting and the distribution of improve crop varieties (Xie *et al.*, 2022), use of fertilizer (Kgosikoma *et al.*, 2018), use of irrigation (Ng'ang'a et al., 2020) and the use of soil conservation techniques (Xie et al., 2022). Other adaptive techniques adopted by agro-pastoralists are crop and animal diversification (Ng'ang'a et al., 2020; Xie *et al.*, 2022), rest grazing/rotational grazing models (Xie et al., 2022), strengthening the construction of forage storage warehouses (Xie et al., 2022) and change in planting date for crops to suit rainfall patterns (Kgosikoma et al., 2018).

Climate change experiences, impact and adaptation strategies by agro-pastoral though have been subject of recent studies in different parts of the world including researches in parts of Africa. Studies in Nigeria deal essentially on general impact on smaller farmers or outside Sahel region of the northeast (Bose et al., 2014; Farauta et al., 2012; Godson-Ibeji et al., 2022; Ibe et al., 2022; Madaki et al., 2023).

Description of the Study Area

Nigeria's northeast is made up of six states of Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe with their state capitals in Yola, Bauchi, Maiduguri, Gombe, Jalingo, and Damaturu respectively. According to the National Population Commission (2010), the area has a population of 18,984, 299. The population resides on about 277,174 km³. The study was conducted in Bauchi and Gombe States that are part of the Sahel stretch of the Northeast region. Bauchi State geographically lies between latitudes 9° 3' and 12° 3' North and longitudes 8° 50' and 11° 00'E East (Abubakar, 2022) while Gombe State on the other hand is located between latitude 9°30' and 12° 00' N and Longitude 8°45' and 11°45'E. The two states fall within the Sahel region of Nigeria (Bello *et al.*, 2020).

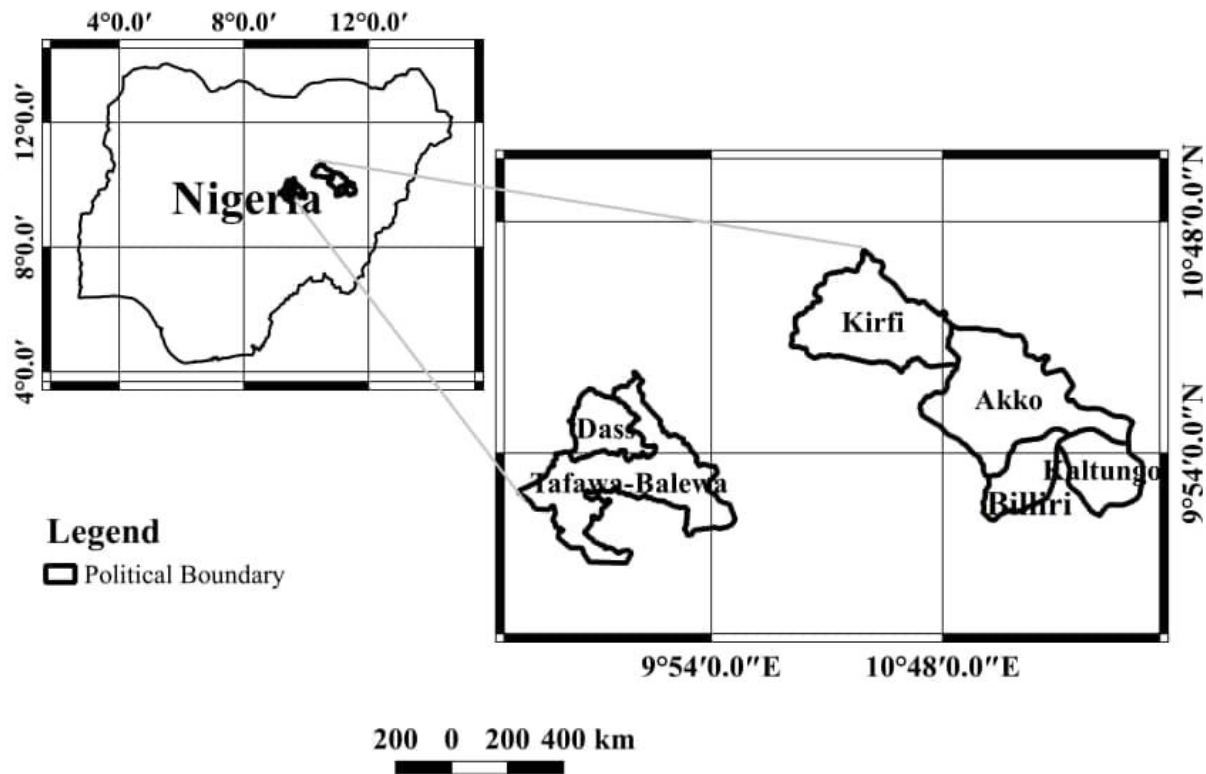


Fig. 1: Locations of the study area in Bauchi and Gombe States.

Materials and Methods

A cross-sectional household survey was carried out using multistage random sampling techniques. Bauchi and Gombe were chosen for this study because they are located in the Sahel region, where agro-pastoral activities are common in northeastern Nigeria. Furthermore, three local government areas (LGAs) were selected to conduct the study in each of the selected state. Each of the three designated LGAs was divided into wards, which are smaller administrative areas, using a stratified sampling technique. When choosing the homes for interviews, the disproportionate sampling principle was applied. The following assumptions were made when selecting a sample size of 510 households per Local Government Area (LGA):

- a. that at least 70% of households were engaged in agriculture and pastoralism
- b. 5% confidence limits
- c. 95% confidence level and
- d. that data analysis would take place at the LGA level.

A total of 3,000 households were included in the sample size for analysis in the two target states, with an additional 60 households (510 per LGA x 6 LGAs) to account for errors. Nonetheless, 3041 surveys were received back and analyzed. Based on the size of each ward, which was further divided into blocks, the sample size for each category of survey participants was proportionately distributed across all the socio-economic and political wards that were demarcated in a target LGAs. The data were analyzed using SPSS Version 25 which includes descriptive statistics such as frequency tables and percentages. To determine the association between the demographic

characteristics of agro-pastoralists and their experiences with climate change, Chi-Square and cross-tabulation were employed. Some ethical guidelines were followed by the study. Verbal consent was obtained from participants at all levels prior to the administration of the questionnaire. Furthermore, every participant was made to be aware of their entitlement to withdraw from the study at any point during the process. The participant in the study were assured of their privacy both before and after the study.

Result of the Findings

Demographic and Socio-economic Characteristic

Table 1 shows the demographic and socio-economic characteristics of the sampled respondents in Bauchi and Gombe State. Table 1 indicates that the respondents were 49.9% sampled from Bauchi State as well as 50.1% from Gombe State. They were mostly within the age range of 20 -39 years and 40 – 59 years with 50.3% and 38.5% respectively, out of which 75.3% were females compared to the 24.7% that were males. A preponderant (86.1%) were married with a relatively almost the same proportion of them having secondary (29%) and primary (26.9%) education. However, despite 10.2% having one form of tertiary education or the other, a comparatively high proportion (33.8%) has no formal education. Occupationally, 45.7% of the sampled populations were into farming while 42.2% were into livestock production. However, these groups combined both farming and livestock production as the qualitative discussion with the participants revealed. The respondents are into their occupation full-time (82.5%) and have been in these occupations for less than 10 years (43.7%), 10 -20 years (36.7%) and above 20 years (19.6%). The family sizes of the respondents are relatively large as they range from 6-8 persons (34.3%), 9 persons and above (30.4%) and 3-5 person (27.6%) with more than half of them (51.3%) having income that are less than ₦10,000 monthly. The other income groups are ₦10,000 – ₦20,000 and above ₦20,000 monthly income with a proportion of 36.8% and 11.9% indicating low income of the respondents.

Demographic and Socio-economic Characteristic of Respondents.

Table 1. Demographic and Socio-economic Characteristic

Variable	(3041)	%
States		
Bauchi State	1516	49.9
Gombe State	1525	50.1
Age (Year)		
Less than 20 years	94	3.1
20-39 years	1530	50.3
40 -59 years	1172	38.5
60 years and above	245	8.1
Sex		
Male	751	24.7
Female	2290	75.3
Marital Status		
Single	147	4.8
Married	2618	86.1
Widowed	230	7.6
Separated/Divorced	46	1.5
Highest Education Level		
No formal education	1029	33.8
Primary education	819	26.9
Secondary education	882	29.0
Tertiary Education	311	10.2
Occupation		
Farming	1391	45.7
Livestock Production	1291	42.5
Trading	297	9.8
Public Sector	34	1.1
Private Sector	28	.9
Length of time in Occupation		
Less than 10 Years	1328	43.7
10-20 Years	1117	36.7
Above 20 Years	596	19.6
Whether Occupation is full or Parttime		
Full-Time	2509	82.5
Part -Time	532	17.5
Family Size		
Less than 3 persons	236	7.8
3 – 5 persons = 2	838	27.6
6 – 8 persons	1044	34.3
9 persons and above	923	30.4
Income Size		
Less than N10,000	1559	51.3
N10,000 - N20,000	1120	36.8
Above N20,000	362	11.9

Source: CPED's field survey, 2022.

Agro-pastoralists Awareness and Sources of Climate Change Information in Bauchi and Gombe States

Findings of the study in Table 2 reveals that 89.1% responded in affirmative that they have heard about climate change in the study area. However, there was no marked difference in the two states since the proportions of persons that have heard about climate change in Bauchi were 89.5%

compared to 88.7% in Gombe State. The test of relationship using Pearson Chi-Square between the two states (locations), did not show any significant relationship. This reveals that irrespective of the states, awareness is the same. Nevertheless, sex, age and education, where significant factors in having heard of climate change as Table 2 indicates from the result of the Chi-Square test of .000, 000 and 001 respectively for sex, age and education. The findings in this study are in line with the findings of studies by Belay et al (2022), Ibe et al (2022), Kgosikoma et al (2018), Xie et al (2022) where sampled population were found to be generally aware of climate change.

Table 2: Agro-pastoralists awareness of Climate Change in Bauchi and Gombe States

States	Male				Female				Average for sex in States (Yes Average)	X ²	p-value
	Yes		No		Yes		No				
	No	%	No	%	No	%	No	%			
Heard about Climate Change											
Bauchi State	347	92.0	30	8.0	991	87.0	148	13.0	89.5	.974	.324*
Gombe State	343	91.7	31	8.3	985	85.6	166	14.4	88.7	16.337 16.386	.000^ .001**
Study Area	690	91.9	61	8.1	1976	86.3	314	13.7	89.1	38.107	.000+

Note: Association for States (), Age (+), Sex (^) and Education (**)* with indicated variables (a and b)

Source: CPED’s field survey, 2022.

Table 3 reveals that agro-pastoralists in Bauchi and Gombe States source their climate change information mainly from radio (88.7%), with a negligible proportion of 9.6% and 0.8% getting information from family/friends and extension agents respectively. Radio and family/friend have always been major media through which local population source information (Olaley et al., 2009). However, the minimum role being played today by extension agents calls for a concern as climate change is becoming everyday realities in our communities.

Table 3. Agro-pastoralists Sources of Climatic Information in Bauchi and Gombe States

States	Weather Station		Extension Agent		Radio		Television		Peer Group		Family/Friends		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Bauchi State	0	0.0	16	1.2	1159	86.9	2	0.1	8	0.6	153	11.4	1338	100
Gombe State	2	0.2	6	0.5	1205	90.7	8	0.6	5	0.4	102	7.7	1328	100
Study Area	2	0.1	22	0.8	2364	88.7	10	0.4	13	0.5	255	9.6	2666	100

Source: CPED’s field survey, 2022.

Length of Time Climate Change has been Experienced by Agro-pastoralists in Bauchi and Gombe States

Table 4 shows that a predominant proportion of the respondents (84.3%) in the study area agreed they noticed climate change in less than 10 years ago compared to 14.9% and 0.8% who have had the awareness for 10-30 years and for more than 30 years ago. Some differences could be noticed between Bauchi and Gombe States. While the category of persons that noticed for less than 10

years in Bauchi State is 91.7%, it was 76.8% in Gombe State. Thus, it is safe to say that more persons (23.2%) noticed climate change for a longer time in Gombe State compared to 8.3% in Bauchi State as Table 4 depicts which agreed with Guodaar and Appiah (2022) that agro-pastoralists have been experiencing climate change for a long time.

Table 4. Length of time Climate Change has been experienced by Agro-pastoralists in Bauchi and Gombe States

States	Less than 10 years		10-30 years		More than 30 years ago		Total	
	No	%	No	%	No	%	No	%
Bauchi State	1226	91.7	104	7.8	7	0.5	1338	100
Gombe State	1020	76.8	293	22.1	15	1.1	1328	100
Study Area	2246	84.3	397	14.9	22	0.8	2666	100

Source: CPED's field survey, 2022.

Experience/Perception of Climate Change Among Agro-pastoralists in Bauchi and Gombe State

Table 5 indicates that 97.3% of the respondents believed that there has been increase in temperature. The proportion was almost the same for Bauchi and Gombe States with 98% and 96.6% respectively. Similarly, respondents attested to experiencing heat/extreme hotness in the study area as claimed by 93.3% of the respondents. No noticeable difference was noticed in the opinion of those in Bauchi compared to Gombe as the proportion in Gombe is 93.6% and that of Bauchi State is 92.9%. This may be related to the facts that both states are found in the same climatic zone of the Sahel Savannah. The respondents in the study area (86.1%) also believed that there has been increase in the rate of evapotranspiration of plants. The same also hold true for Bauchi (86.9%) and Gombe (85.3%) States. This is not surprising considering the facts that there have been increase temperature and extreme hotness as the responded in the study reported. Expectedly, in the study area, 96.6% of the respondents are of the opinion that rainfalls have reduced over time. This was also the case in Bauchi and Gombe States where 97% and 96.1% of the respondents respectively held the same views. On the issue of unpredictability of rainfall, 81.3% of the respondents in the study area held that rains have become unpredictable while the proportions stood at 83.3% and 79.3% respectively in Gombe and Bauchi States. The Pearson Chi-Square tests of association between the states (locations), age, sex and education did not indicate association of any type in these experiences or perceptions except for location (States) and increase in temperature (P-value of .052) and education and heat/extreme hotness experiences with P-value of .001. Thus, demographic and socio-economic variables have very little influence on the way agro-pastoralists in Bauchi and Gombe State perceived climate change. Several studies have revealed similar experiences/perceptions of climate change such as: reduction in rainfall amount (Tofu *et al*, 2023), increased temperature (Snaibi *et al.*, 2021), heat stress/extreme hotness (Godson-Ibeji *et al.*, 2022), increased evaporations (Belay *et al.*, 2022) and unpredictability of rainfall (Ibe *et al.*, 2022).

Table 5: Evidence of Climate Change Experiences Among Agro-pastoralists in Bauchi and Gombe State

States	Male				Female				Average for sex in States (Yes Average)	X2	P-value
	Yes		No		Yes		No				
	No	%	No	%	No	%	No	%			
Increased temperature											
Bauchi State	338	97.4	9	2.6	976	98.5	15	1.5	98.0	3.774	.052*
Gombe State	328	95.6	15	4.4	961	97.6	24	2.4	96.6	2.133	.545+
Study Area	666	96.5	24	3.5	1937	98.0	39	2.0	97.3	5.018	.025^
										1.330	.722**
Heat/Extreme hotness											
Bauchi State	325	93.7	22	6.3	913	92.1	78	7.9	92.9	1.189	.276*
Gombe State	321	93.6	22	6.4	922	93.6	63	6.4	93.6	1.541	.673+
Study Area	646	93.7	44	6.4	1835	92.9	141	7.2	93.3	1.456	.499^
										16.590	.001*
Increased evapotranspiration											
Bauchi State	304	87.6	43	12.4	853	86.1	138	13.9	86.9	.221	.638*
Gombe State	288	84.0	55	16.0	852	86.5	133	13.5	85.3	4.018	.260+
Study Area	592	85.8	98	14.2	1705	86.3	271	13.7	86.1	.102	.749^
										5.153	.161*
Reduction in rainfall											
Bauchi State	342	98.6	5	1.4	945	95.4	46	4.6	97.0	.027	.868*
Gombe State	328	95.6	15	4.4	951	96.5	34	3.5	96.1	3.306	.347+
Study Area	670	97.1	20	2.9	1896	96.0	80	4.1	96.6	1.874	.171^
										5.943	.114*
Unpredictability of rainfall											
Bauchi State	269	77.5	78	22.5	803	81.0	188	19.0	79.3	.790	.374*
Gombe State	298	86.9	45	13.1	784	79.6	201	20.4	83.3	1.422	.700+
Study Area	567	82.2	123	17.8	1587	80.3	389	19.7	81.3	1.140	.286^
										3.959	.266*

Note: Association for States (*), Age (+), Sex (^) and Education (***) with indicated variables. Source: CPED's field survey, 2022.

Impacts of Climate Change on Agro-Pastoralists in Bauchi and Gombe

Table 6 reveals that climate change brought about dryness and reduction of water quality in ponds and streams in the study area (96%). It was 96.9% and 95.1% respectively in Bauchi and Gombe State, indicating dryness and reduction of water quality across the two states. Table 6 also shows that 92.1% of respondents in the study area believe climate change brought about scarcity, dryness and reduction in quality of pasture for livestock. It was 93.7% and 90.3% respectively for Bauchi and Gombe State revealing that the situation is the same for both states. This may not be unconnected to the little amount of water found with the zone due to high temperature and transpirations. Other impacts of climate change in the study area include: land degradation and abandonment (92.1%), crops/livestock losses (89.7%) and long migration with animals (72.2%). However, slight differences were noticed between the two states in each variable of climatic impacts mentioned above. For example, the proportion of respondents that have experienced land degradation and abandonment as impacts of climate change was 94.8% in Gombe, lower in Bauchi State with 89.4%. While long migration with animals in Bauchi State is 75.5%, it is 70% in Gombe State.

In this study, the respondents were of the opinion that climate change made them to change their planting dates and plant their crops untimely in the study area as claimed by 80.3% of the respondents, including 82.4% of them who held this view in Bauchi State compared to 78.3% in Gombe State. Additionally, 89.8% of the respondents were of the view that climate change led to the displacement of people from their homes in search of better locations with 92.6% and 86.9% of the respondents holding this view in Bauchi and Gombe States respectively. On how climate change has led to increase in conflicts between herders and farmers in the study area, 77% of the respondents in the study area believed that climate change has increased conflict between herders and farmers. However, this response was 78.2% in Gombe State compared 75.8% in Bauchi State. The impacts of climate change on agro-pastoralists lives were also seen from the fact that yields from their productivities declined (93.7%), they had lower prices and income from agro-pastoral activities (88%) and were faced with food insecurity and poverty (94%). In all the three variables of limited agro-pastoral yields and productivities, lower prices and income from agro-pastoral activities and food insecurity and poverty there was no striking difference between the two states of Bauchi and Gombe. The test of association between the two location and limited agro-pastoral yields and productivities show that there is a relationship at P-value of .035, thus showing some level of association.

A test of Chi-square for association between locations (states), age, sex and education and impact of climate change shows mixed association, as there was lacked of outright consistencies. For example when there was a significant relationship between location and some variables of impacts such as: increase in livestock diseases (P.value =.000), land degradation and abandonment (P.value =.000), displacement of people from their home in search of better locations (P.value =.000), it was not so for crop/livestock loss (P.value =.433), lower prices and income from agro-pastoral activities (P.value =.624) and food insecurity and poverty (P.value =.710). The chi-square test of age, sex and education followed the same pattern, thus indicating that these factors are not consistent in the respondents view of climate change impact, even though there seems to be a minimum level of consistency recorded between location and impact variables. The impacts of climate change on agro-pastoral activities have been reported by other studies. For example, Tofu et al (2023) reported the scarcity/reduction in pasture quality in their studies. Kongnso et al (2021) talked of the outcome of their study on increased livestock diseases. Xie et al (2022) presented

long migration of agro-pastoralists in search of green pasture as one of the impacts of climate change.

Table 6. Impact of Climate Change on Agro-pastoralists in Bauchi and Gombe States

States	Male				Female				Average for sex in States (Yes Average)	X ²	p-value
	Yes	No	Yes	No	Yes	No	Yes	No			
	No	%	No	%	No	%	No	%			
Dryness and reduction of water quality in pounds and stream.											
Bauchi State	340	98.0	7	2.0	949	95.8	42	4.2	96.9	4.762	.029*
Gombe State	330	96.2	13	3.8	926	94.0	59	6.0	95.1	3.914	.271 ⁺
			20	2.9			101	5.1		5.780	.016 [^]
Study Area	670	97.1			1875	94.9				12.51	.006*
									96.0	8	*
Scarcity, dryness and reduction of quality of pasture for livestock											
Bauchi State	329	94.8	18	5.2	918	92.6	73	7.4	93.7	3.480	.062*
Gombe State	303	88.3	40	11.7	909	92.3	76	7.7	90.3	5.837	.120 ⁺
			58	8.4			149	7.5		.535	.465 [^]
Study Area	632	91.6			1827	92.5				10.83	.013*
									92.1	8	*
Increased in livestock diseases											
Bauchi State	282	81.3	65	18.7	739	74.6	252	25.4	78.0	15.96	.000*
Gombe State	230	67.1	113	32.9	692	70.3	293	29.7	68.7	1.208	.751 ⁺
			178	25.8			545	27.6		.823	.364 [^]
Study Area	512	74.2			1431	72.4				7.194	.066*
									73.3		*
Land degradation and abandonment											
Bauchi State	301	86.7	46	13.3	912	92.0	79	8.0	89.4	22.32	.000*
Gombe State	321	93.6	22	6.4	945	95.9	40	4.1	94.8	1.526	.676 ⁺
			68	9.9			119	6.0		11.51	.001 [^]
Study Area	622	90.1			1857	94.0				9	.930*
									92.1	.450	*
Crop/livestock loss											
Bauchi State	300	86.5	47	13.5	901	90.9	90	9.1	88.7	.614	.433*
Gombe State	312	91.0	31	9.0	892	90.6	93	9.4	90.8	1.489	.685 ⁺
			78	11.3			183	9.3		2.418	.120 [^]
Study Area	612	88.7			1793	90.7				15.06	.002*
									89.7	5	*
Long migration with animals											
Bauchi State	269	77.5	78	22.5	728	73.5	263	26.5	75.5	3.465	.063*
Gombe State	230	67.1	113	32.9	717	72.8	268	27.2	70.0	.673	.879 ⁺
			191	27.7			531	26.9		.169	.681 [^]
Study Area	499	72.3			1445	73.1				1.851	.604*
									72.7		*
Change in planting dates and untimely planting											
Bauchi State	296	85.3	51	14.7	787	79.4	204	20.6	82.4	2.530	.112*
Gombe State	267	77.8	76	22.2	775	78.7	210	21.3	78.3	3.202	.361 ⁺
			127	18.4			414	21.0		2.049	.152 [^]
Study Area	563	81.6			1562	79.0				1.070	.784*
									80.3		*

Displacement of people from their home in search of better locations											
Bauchi State	327	94.2	20	5.8	902	91.0	89	9.0	92.6	10.79	.001*
Gombe State	290	84.5	53	15.5	879	89.2	106	10.8	86.9	8.484	.037+
			73	10.6			195	9.9		.286	.593^
Study Area	617	89.4			1781	90.1				12.61	.006*
									89.8	1	*
increased conflicts of herder and farmers											
Bauchi State	117	33.7	230	66.3	240	24.2	751	75.8	29.0	8.239	.004*
Gombe State	76	22.2	267	77.8	215	21.8	770	78.2	22.0	3.210	.360+
			497	72.0			1521	77.0		6.796	.009^
Study Area	193	28.0			455	23.0				15.46	.001*
									25.5	7	*
Limited agro-pastoral yields and productivities											
Bauchi State	322	92.8	25	7.2	950	95.9	41	4.1	94.4	3.432	.035*
Gombe State	318	92.7	25	7.3	919	93.3	66	6.7		15.70	.001+
									93.0	3	
Study Area	640	92.8	50	7.2	1869	94.6	107	5.4		3.095	.079^
									93.7	2.027	.567*
Lower prices and income from agro-pastoral activities											
Bauchi State	301	86.7	46	13.3	882	89.0	109	11.0	87.9	.240	.624*
Gombe State	304	88.6	39	11.4	862	87.5	123	12.5		10.15	.017+
									88.1	0	
Study Area	605	87.7	85	12.3	1744	88.3	232	11.7		.163	.686^
									88.0	19.68	.000*
										5	*
Food insecurity and poverty											
Bauchi State	331	95.4	16	4.6	927	93.5	64	6.5	94.5	.138	.710*
Gombe State	320	93.3	23	6.7	924	93.8	61	6.2	93.5	2.918	.404+
			39	5.7			125	6.3		.402	.526^
Study Area	651	94.3			1851	93.7				1.381	.710*
									94.0		*

Note: Association for States (), Age (+), Sex (^) and Education (**)* with indicated variables.
 Source: CPED's field survey, 2022.

Adaptation Strategies in Agro-pastoralists Systems in Bauchi and Gombe State

The findings of the study in Table 7 reveals that adaptation strategies adopted by agro-pastoralists in the study area include the use of fertilizer and irrigation for crops as indicated by 95.8% of the respondents. There was basically no appreciable difference between Bauchi State (96.6%) and Gombe State (94.9%). Another strategy of climate change mitigation by agro-pastoralists is the increase of water supply as indicated by 86.7% of the respondents. This response was 86.8% and 86.6% in Bauchi and Gombe States respectively, showing an almost the same proportion, without a visible difference between the states. To remedy shortage of fodder in the dry environment, agro-pastoralists supplement livestock through purchased or harvested fodders as indicated by 81.1% of the respondents in the study area compared to 81.3% in Gombe State and 80.8% in Bauchi State. The findings of the study in Table 7 reveal that 72.2% of the respondents practice migration of their livestock in search of greener pasture in the study area compared to 75.5% and 70% in Bauchi and Gombe States. The study findings reveal that 59% claimed that use of multiple cropping, mixed cropping and share cropping were adaptive strategies used by agro-pastoralists in the study

area. The proportion was almost the same for Gombe State (60.2%) and 57.7% for Bauchi State with no noticeable variations. Additionally, agro-pastoralists equally plant and distribute improved crop varieties, as this accounted for 57.1% in the study area with 58.9% of persons in Bauchi State using this method compared to 55.2% in Gombe State. Also, agro-pastoralists in the study area diversify their crops and livestock. Table 7 reveals that 56.1% of the agro-pastoralists adopted this method, with Gombe and Bauchi States accounting for 57.1% and 55.1.3% of respondents who use this system as an adaptive mechanism without any significant differences in the two concerned states. Some agro-pastoralists sell their livestock before the situation get out of hand. In this way, they are able to sell at good prices. In Table 7, 13.2% of respondents believed this is the situation in the study area compared to 15.1% in Gombe State and 11.4% in Bauchi State.

Other adaptation strategies adopted by agro-pastoralists in the study as shown in Table 7 area include: use of local species of animal that withstand weather situation (49%), rest grazing/rotational grazing models (45.2%), cultivation of drought-tolerant crop varieties (29.5%), vaccination of animals (20.4%), obtaining loans (18.9%), sales of livestock before bad times (13.2%), early harvest of crops (7.8%), migration to urban areas for alternative livelihood (2.9%) and construction of forage storage warehouses to store fodder (2%). The test of association using Chi-Square did not show significant relationship between locations (States), age, sex and education since there were mixed associations except in few instances of sex and education being associated with adaptation. The findings of adaptive strategies to climate change in this study have been mentioned in other studies. Among other things, Ng'ang'a *et al* (2020) mentioned supplementing livestock feed as agro-pastoralists climate change mitigation strategy. Ibe *et al* (2022) listed increased water supply to livestock as climate change adaption strategy and Kgosikoma *et al* (2018) had as their findings in their study the use of irrigation as a climate change mitigation strategy by agro-pastoralists.

Table 7. Adaptation Strategies to Climate Change in Bauchi and Gombe States

States	Male		Female		Average for sex in States (Yes Average)	X ²	P-value				
	Yes	No	Yes	No							
Use of fertilizer and irrigation for crops											
Bauchi State	333	96.0	14	4.0	963	97.2	28	2.8	96.6	.220	.639*
Gombe State	314	91.5	29	8.5	968	98.3	17	1.7	94.9	.419	.936 ⁺
			43	6.2	1931		45	2.3		25.05	.000 [^]
Study Area	647	93.8				97.7				7	.014*
										10.63	*
									95.8	7	
Increased water supply to animals by moving animal close to water sources or digging water holes for them											
Bauchi State	313	90.2	34	9.8	826	83.4	165	16.6	86.8	.480	.488*
Gombe State	300	87.5	43	12.5	843	85.6	142	14.4	86.6	5.334	.149 ⁺
			77	11.2	1669		307	15.5		7.947	.005 [^]
Study Area	613	88.8				84.5				4.373	.224*
									86.7		*
Supplementing livestock through purchased or harvested fodder											
Bauchi State	285	82.1	62	17.9	787	79.4	204	20.6	80.8	.704	.402*
Gombe State	278	81.0	65	19.0	803	81.5	182	18.5	81.3	7.435	.059 ⁺
Study Area	563	81.6	127	18.4	1590	80.5	386	19.5	81.1	.419	.515 [^]

									5.419	.144*	
										*	
Migrate with livestock to areas with greener pasture											
Bauchi State	269	77.5	78	22.5	728	73.5	263	26.5	75.5	3.465	.063*
Gombe State	230	67.1	113	32.9	717	72.8	268	27.2	70.0	.673	.879 ⁺
		72.3	191	27.7			531	26.9		.169	.681 [^]
Study Area	499				1445	73.1				1.851	.604*
									72.7		*
Multiple cropping, mixed cropping and share cropping											
Bauchi State	192	55.3	155	44.7	595	60.0	396	40.0	57.7	.185	.667*
Gombe State	210	61.2	133	38.8	582	59.1	403	40.9	60.2	.940	.816 ⁺
		58.3	288	41.7			799	40.4		.360	.548 [^]
Study Area	402				1177	59.6				10.90	.012*
									59.0	6	*
Planting and the distribution of improve crop varieties											
Bauchi State	216	62.2	131	37.8	550	55.5	441	44.5	58.9	1.802	.180*
Gombe State	193	56.3	150	43.7	533	54.1	452	45.9	55.2	4.883	.181 ⁺
			281	40.7			893	45.2		4.142	.042 [^]
Study Area	409	59.3			1083	54.8				1.415	.702*
									57.1		*
Crops and livestock diversification											
Bauchi State	179	51.6	168	48.4	580	58.5	411	41.5	55.1	.223	.629*
Gombe State	205	59.8	138	40.2	536	54.4	449	45.6	57.1	.796	.851 ⁺
			306	44.3			860	43.5		.142	.707 [^]
Study Area	384	55.7			1116	56.5				7.998	.046*
									56.1		*
Use of local species of animal that withstand weather situation											
Bauchi State	175	50.4	172	49.6	504	50.9	487	49.1	50.7	4.902	.027*
Gombe State	168	49.0	175	51.0	449	45.6	536	54.4	47.3	6.932	.074 ⁺
			347	50.3	953		1023	51.8		.449	.503 [^]
Study Area	343	49.7				48.2				3.996	.262*
									49.0		*
Rest grazing/rotational grazing models											
Bauchi State	165	47.6	182	52.4	427	43.1	564	56.9	45.4	.030	.863*
Gombe State	158	46.1	185	53.9	434	44.1	551	55.9	45.1	3.385	.336 ⁺
			367	53.2			1115	56.4		2.173	.140 [^]
Study Area	323	46.8			861	43.6				1.731	.630*
									45.2		*
Cultivation of drought-tolerant crop varieties											
Bauchi State	89	25.6	258	74.4	323	32.6	668	67.4		.179	.0672*
									29.1		*
Gombe State	91	26.5	252	73.5	328	33.3	657	66.7	29.9	2.735	.434 ⁺
			510	73.9			1325	67.1			.001 [^]
Study Area	180	26.1			651	32.9				Bauch i State	.001*
									29.5		*
Vaccinating animals											
Bauchi State	84	24.2	263	75.8	185	18.7	806	81.3	21.5	.193	.661*
Gombe State	65	19.0	278	81.0	193	19.6	792	80.4	19.3	5.823	.121 ⁺
			541	78.4			1598	80.9		1.959	.162 [^]
Study Area	149	21.6			378	19.1				.854	.837*
									20.4		*
Obtained loans											
Bauchi State	58	16.7	289	83.3	206	20.8	785	79.2	18.8	2.250	.134*

Gombe State	75	21.9	268	78.1	157	15.9	828	84.1	18.9	2.229	.526 ⁺
		19.3	557	80.7			1613	81.6		.227	.599 [^]
Study Area	133				363	18.4				15.07	.002 [*]
									18.9	7	*
Sales of livestock before bad times											
Bauchi State	37	10.7	310	89.3	120	12.1	871	87.9	11.4	2.163	.141 [*]
Gombe State	62	18.1	281	81.9	119	12.1	866	87.9	15.1	6.540	.088 ⁺
			591	85.7			1737	87.9		2.344	.126 [^]
Study Area	99	14.3			239	12.1				2.859	.414 [*]
									13.2		*
Early harvest of crops											
Bauchi State	30	8.6	317	91.4	102	10.3	889	89.7		24.06	.000 [*]
									9.5	6	
Gombe State	29	8.5	314	91.5	36	3.7	949	96.3	6.1	4.408	.221 ⁺
		8.6	631	91.4			1838	93.0		1.835	.176 [^]
Study Area	59				138	7.0				28.27	.000 [*]
									7.8	0	*
Migration to urban area for alternative livelihood											
Bauchi State	4	1.2	343	98.8	27	2.7	964	97.3	2.0	4.316	.038 [*]
Gombe State	13	3.8	330	96.2	36	3.7	949	96.3	3.8	4.035	.258 ⁺
		2.5	673	97.5	63		1913	96.8		.922	.337 [^]
Study Area	17					3.2				13.41	.004 [*]
									2.9	7	*
Construction of forage storage warehouses to store fodder											
Bauchi State	7	2.0	340	98.0	22	2.2	969	97.8	2.1	.001	.977 [*]
Gombe State	4	1.2	339	98.8	25	2.5	960	97.5	1.9	4.184	.242 ⁺
		1.6	679	98.4			1929	97.6		1.478	.224 [^]
Study Area	11				47	2.4				13.37	.004 [*]
									2.0	0	*

Note: Association for States (*), Age (+), Sex (^) and Education (***) with indicated variables.

Source: CPED's field survey, 2022.

Conclusion

This study is a comparative analysis of the experiences, impacts and adaptation strategies to climate change among Sahel zone's agro-pastoralists of Northeast, Nigeria. Climate change is a reality that most sectors of the world contend with today, including those in agro-pastoral pursuits. It is imperative to know the experiences/perceptions, knowledge of the people's impact and adaptation mechanism over time. These were the tasks that this study took up. Results show that agro-pastoralists in the Northeast part of Nigeria, specifically, those in Bauchi and Gombe States, have had varying, experiences/perceptions, impacts and used different adaptive solutions to combat the menace stemming from the impacts of climate change and variability. The reality of climate change has become more obvious today in the world, especially in developing countries such as Nigeria. We must all strive to achieve sustainable development goal 13 – taking actions to combat climate change and local. Indeed, no time is better for such actions, but now.

Recommendations

Based on the findings of the study, the following recommendations are made;

- i. Government extension agents should highlight know impacts and available adaption strategies so that the agro-pastoralists and indeed other stakeholders will know the right steps to take at all times in dealing with climate change.

- ii. Replacement of local short-term strategies by more advanced solution for a better resilience by agro-pastoralists in the region in order to guarantee gradual transformation of known impacts over time.
- iii. Government should develop a Climate Change Institution where policy to encourage better management of the environment, development of more climate friendly crops and livestock varieties that can withstand diseases/drier condition and investment in irrigation should be promoted for the betterment of agro-pastoralists activities

Acknowledgement

This article is a product of a large action research project title: "Empowerment of Women in Pastoralism and Agriculture in Nigeria's Sahel Region" The authors are grateful to the Centre of Population and Environmental Development, Benin City, Edo State, Nigeria and the Supporting Pastoralism and Agriculture in Recurrent and Protracted Crises (SPARC) - funded by International Development Research Centre (IDRC), Canada for the use of the data from the study and the financial support for some the publication.

References

- Abubakar, A. (2022). Geospatial-based approach to siting suitable cattle ranch in Bauchi state, Nigeria. *International Journal of Science and Research Archive*, 7(1), 098-114.
- Adger, N., Aggarwal, P., Agrawala, S., Alcamo, J., Allali, A., Anisimov, O., & Yohe, G. (2007). Climate change 2007: impacts, adaptation and vulnerability: working group II contribution to the Intergovernmental Panel on Climate Change: summary for policymakers. *IPCC Secretariat: Geneva, Switzerland*.
- Akinnagbe, O.M., & Irohibe, I.J. (2014). Agricultural adaptation strategies to climate change impacts in Africa: A review. *Bangladesh Journal of Agricultural Research*, 39(3), 407-418.
- Alex, S. (2018). *The impact of climate change on rural agro-pastoralist communities in Aweil East County, South Sudan* (Doctoral dissertation, Nkumba University).
- Asante, F., Guodaar, L., & Arimiyaw, S. (2021). Climate change and variability awareness and livelihood adaptive strategies among smallholder farmers in semi-arid northern Ghana. *Environmental Development*, 39, 100629..
- Belay, A., Oludhe, C., Mirzabaev, A., Recha, J. W., Berhane, Z., Osano, P. M. & Solomon, D. (2022). Knowledge of climate change and adaptation by smallholder farmers: evidence from southern Ethiopia. *Heliyon*, 8(12), 1-16.
- Bello, Y., Adebayo, A.A., & Abubakar, B. (2020). Analysis of rainfall and temperature changes in Gombe State, Nigeria. *FUDMA Journal of Sciences*, 4(1), 632-646.
- Bobadoye, A. O., Ogara, W. O., Ouma, G. O., & Onono, J. O. (2016). Assessing climate change adaptation strategies among rural Maasai pastoralist in Kenya.
- Bose, M. M., Abdullah, A. M., Harun, R., Jamalani, M. A., Elawad, R. E., & Fallah, M. (2014). Perception of and adaptation to climate change by farmers in the semi-arid zone of North-eastern Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 8(11), 52-57.
- Edenhofer, O. (Ed.). (2015). *Climate change 2014: mitigation of climate change* (Vol. 3). Cambridge University Press.
- Farauta, B. K., Egbule, C. L., Agwu, A. E., Idrisa, Y. L., & Onyekuru, N. A. (2012). Farmers'

- adaptation initiatives to the impact of climate change on agriculture in northern Nigeria. *Journal of Agricultural Extension*, 16(1), 132-144.
- Feng, X., Qiu, H., Pan, J., & Tang, J. (2021). The impact of climate change on livestock production in pastoral areas of China. *Science of the Total Environment*, 770, 144838.
- Gebeyehu, A. K., Snelder, D., Sonneveld, B., & Abbink, J. (2021). How do agro-pastoralists cope with climate change? The case of the Nyangatom in the Lower Omo Valley of Ethiopia. *Journal of Arid Environments*, 189, 104485.
- Godson-Ibeji, C. C., Ibe, M. N., & Chikaire, J. U. (2022). Effects of climate change on agro-pastoralists' economy and adaptation strategies used in Southeast, Nigeria. *MOJ Eco Environ Sci*, 7(1), 18-22.
- Guodaar, L., & Appiah, D.O. (2022). Evolving farm-level adaptation to climate variability and change risks in the forest-savanna transitional zone of Ghana. *Environmental Challenges*, 9, 1-11.
- Hayhoe, K., Wuebbles, D. J., Easterling, D. R., Fahey, D. W., Doherty, S., Kossin, J.P. & Wehner, M. F. (2018). Our changing climate. impacts, risks, and adaptation in the united states: The fourth national climate assessment, volume II.
- Hilemelekot, F., Ayal, D.Y., Ture, K., & Zeleke, T.T. (2021). Climate change and variability adaptation strategies and their implications for household food Security: the case of Basona Worena District, North Shewa zone, Ethiopia. *Climate Services*, 24, 100269.
- Ibe, M.N., Chikaire, J.U., Ajaero, J.O., & Aminu, G.O., (2022). Climate change information needs of agro-pastoralists in Southeast Nigeria” *MOJ Eco Environ Sci*, 7(2), 48-51.
- IPCC (2007). IPCC fourth assessment report. Geneva, Switzerland: IPCC.
- IPCC (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
- IPCC (2018). An IPCC Special Report on the Impacts of Global Warming of 1.5_C. Intergovernmental Panel on Climate Change.
- Jellason, N.P., Salite, D., Conway, J. S., & Ogbaga, C. C. (2022). A systematic review of smallholder farmers' climate change adaptation and enabling conditions for knowledge integration in Sub-Saharan African (SSA) drylands. *Environmental Development*, 100733.
- Jones, P.G., & Thornton, P. K. (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. *Global environmental change*, 13(1), 51-59.
- Kgosikoma, K.R., Lekota, P.C., & Kgosikoma, O.E. (2018). Agro-pastoralists' determinants of adaptation to climate change. *International Journal of Climate Change Strategies and Management*, 10(3), 488-500.
- Kimaro, E.G., Mor, S.M., & Toribio, J. A. L. (2018). Climate change perception and impacts on cattle production in pastoral communities of northern Tanzania. *Pastoralism*, 8, 1-16.
- Kongnso, M. E., Buba, U. H., & Nfor, J. T. (2021). Implications of Climatic Stressors on Agro-Pastoral Resources Among Mbororo Communities Along the Slopes of Kilum-Ijim Mountain, North West Region, Cameroon. *Frontiers in Sustainable Food Systems*, 5, 685071.
- Madaki, M. Y., Muench, S., Kaechele, H., & Bavorova, M. (2023). Climate Change Knowledge and Perception among Farming Households in Nigeria. *Climate*, 11(6), 115.
- Menghistu, H. T., Abraha, A. Z., Tesfay, G., & Mawcha, G. T. (2020). Determinant factors of

- climate change adaptation by pastoral/agro-pastoral communities and smallholder farmers in sub-Saharan Africa: A systematic review. *International Journal of Climate Change Strategies and Management*, 12(3), 305-321.
- Mwakaje, A. G. (2013). The impact of climate change and variability on agro-pastoralists' economy in Tanzania. *Environmental Economics*, (4, Iss. 1), 30-38.
- Ng'ang'a, T. W., Coulibaly, J. Y., Crane, T. A., Gachene, C. K., & Kironchi, G. (2020). Propensity to adapt to climate change: Insights from pastoralist and agro-pastoralist households of Laikipia County, Kenya. *Climatic Change*, 161, 393-413.
- Nyang'au, J. O., Mohamed, J. H., Mango, N., Makate, C., & Wangeci, A. N. (2021). Smallholder farmers' perception of climate change and adoption of climate smart agriculture practices in Masaba South Sub-county, Kisii, Kenya. *Heliyon*, 7(4).
- Pedersen, J. S. T., Santos, F. D., van Vuuren, D., Gupta, J., Coelho, R. E., Aparício, B. A., & Swart, R. (2021). An assessment of the performance of scenarios against historical global emissions for IPCC reports. *Global Environmental Change*, 66, 102199.
- Olaleye, R. S., Gana, F. S., Umar, I. S., Ndanitsa, M. A., & Peter, E. W. (2009). Effectiveness of radio in the dissemination of agricultural information among farmers in Edu Local Government Area of Kwara State, Nigeria.
- Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., & Woznicki, S. A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. *Climate risk management*, 16, 145-163.
- Seife, T. K. (2021). The impact of climate change on agriculture and food security in the greater horn of Africa. *Politikon*, 48(1), 98-114.
- Sewando, P. T., Mutabazi, K. D., & Mdoe, N. Y. (2016). Vulnerability of agro-pastoral farmers to climate risks in northern and central Tanzania. *Development Studies Research*, 3(1), 11-24.
- Snaibi, W., Mezrhab, A., Sy, O., & Morton, J. F. (2021). Perception and adaptation of pastoralists to climate variability and change in Morocco's arid rangelands. *Heliyon*, 7(11).
- Solomon, N., Birhane, E., Gordon, C., Haile, M., Taheri, F., Azadi, H., & Scheffran, J. (2018). Environmental impacts and causes of conflict in the Horn of Africa: A review. *Earth-science reviews*, 177, 284-290.
- Thornton, P. K., van de Steeg, J., Notenbaert, A., & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. *Agricultural systems*, 101(3), 113-127.
- Tofu, D. A., Fana, C., Dilbato, T., Dirbaba, N. B., & Tesso, G. (2023). Pastoralists' and agro-pastoralists' livelihood resilience to climate change-induced risks in the Borana zone, south Ethiopia: Using resilience index measurement approach. *Pastoralism*, 13(1), 1- 14.
- UNFPA (2023): *The State of World Population* is UNFPA's annual flagship report.
- van Weezel, S. (2019). On climate and conflict: Precipitation decline and communal conflict in Ethiopia and Kenya. *Journal of Peace Research*, 56(4), 514-528.
- Xie, S., Ding, W., Ye, W., & Deng, Z. (2022). Agro-pastoralists' perception of climate change and adaptation in the Qilian Mountains of northwest China. *Scientific Reports*, 12(1), 12689.