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ASSESSMENT OF FARMERS' PERCEIVED IMPACT OF CLIMATE CHANGE ON CROP PRODUCTION AND RESILIENCE TOWARD FOOD SECURITY IN BENUE STATE, NIGERIA

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Abstract

This study assessed farmers' perceived impact of climate change on crop production and resilience toward food security in Benue State, Nigeria. The study assessed the farmers' awareness and perception of climate change; evaluate the farmers' perceived impacts of climate change; and identify the farmers' resilience strategies toward food security. Rainfall and temperature data (1980 – 2020) were collected from the Nigerian Meteorological Agency (NiMet).The data were used to characterise the climate of the study area. A total of 382 farmers were purposively selected. Primary data were collected through structured questionnaire and Focused Group Discussion (FGD). The data were analysed using trendline equations, Likert-type rating scale and Relative Importance Index technique (RII). The results of the trendline equation showed increase in total annual rainfall and temperature. Further findings showed that 95% of the farmers are aware of climate change issues, 4% were not aware while 1% were undecided; 48% got information about climate change from personal observations, 27% by interacting with friends and 7% from the electronic media. The farmers' perceived effects of climate change on the yield of crops include shortage of food ($4.3\overline{\chi}$); increase in crop infestation by pests and diseases ($3.6\overline{\chi}$), and increase in poverty rate, migration of farmers and conflicts with cattle herdsmen ($3.9\overline{\chi}$). The result of the RII showed that mixed cropping, use of early maturing crop varieties and use of crop varieties that are well acclimatized are the most effective resilient strategies.The study concluded that climate change is evident in the study area as shown in the late onset, early cessation of rainfall, increasing trends

in rainfall and temperature. Climate change has negatively impacted on crop production. Findings showed that 95% of the farmers are aware of climate change issues; personal observation was the major source of information on climate change; mixed cropping and use of improved seed varieties were the main resilient strategies among others the farmers are using in the study area. Since improved seed varieties was a major resilience strategy, the Cereal Research Institutes should develop more drought resistant seeds and early maturing varieties in the study area.

Keywords: Adaptation; Climate; Crop Production; Farmers and Food security

INTRODUCTION

Agriculture remain one of the important human economic activities.[1] However, its sensitivities to change in climate has makes it more vulnerable to degradation. All stages of agricultural production from land clearing and preparation, through crop growth, management, harvesting, storage, transportation, and marketing of agricultural products are subjected to the influence of weather and climate[1]. No other sector contributes so directly to the provision of employment, food and livelihoods of people like agriculture. However, despite being the most important sector to Africans, production is primarily subsistence oriented and rain-fed. Any change in climatic pattern would affect the production of different crops in Africa, hence, the need to integrate agriculture within resilience efforts and financing[2]. Africa is the most vulnerable continent to climate change impacts under all climate scenarios above 1.5ºC. Despite having contributed the least to global warming and having the lowest emissions, Africa faces exponential collateral damage, posing systemic risks to its economies, water, food systems, agriculture, and livelihoods[3].

Food security exists when all people, always, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability. The nutritional dimension is integral to the concept of food security and to the work of Committee on World Food Security[4]. The sensitivity of the agricultural sector to the climate and the high reliance of this sector on rainfall and water resources have important implications for Benue's farmers and economy.

Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change[5]. It is the capacity for a socio-ecological system to absorb stresses, adapt and maintain function in the face of external stresses imposed upon it by climate change[6]. Climate change resilience focuses on improving the sustainability of the system, leaving it better prepared for future climate change impacts[7]. Nigerian communities are responding to climate risks in their own ways with the limited knowledge and resources available to them.

Previous studies[8, 9, 10]has considered Benue State vulnerable to climate change. Flooding is on the rise in terms of long-term changes in temperature or precipitation. In some places, floods and droughts could become more frequent and severe. These local changes in temperature, precipitation and soil moisture could severely influence many important human activities such as

agriculture, ecosystem and food supplies. The results of these effects have caused difficulties in the livelihoods of many local people[9].

Despite the effort made by numerous researchers on farmers' perception studies, less attention has been made in assessing the impact of climate change on crop production and resilience strategies in Benue State over the years. Therefore, this research is aimed at assessing farmers' perceived impact of climate change on crop production and resilience toward food security in Apa LocalGovernmentArea (LGA) of Benue State, Nigeria.

STUDY AREA AND METHODOLOGY

Study Area

Apa LGA islocated at the North-Western part of Benue State on Latitude 7º 20′ North to 7º 50′ North of the Equator and Longitude 7º 40′ East to 8º 10′of the Greenwich meridian. The study area is surrounded by Agatu LGA to the North,Otukpo LGA to the South, Gwer-West LGA to the East and Olamaboro LGA of Kogi State to the West[10]. The LGA has its headquarters at Ugbokpo and it consists of 11 council wards. The LGA has a population of about 96,780 people and a land area of about 995 Km^{2}[11].

Climatically, the State belongs to the Koppen's Aw climate group and experiences seasonal wet and dry seasons. The rain falls for seven months from April to October with total annual amount ranging between 12,000-20,000mm while dry season sets in November and ends in March[12]. Temperatures are constantly high averaging between 28-32ºC and sometimes rising to 37ºC. The vegetation still possesses relics of the guinea savanna with coarse grasses and numerous species of scattered trees. Dense forests are very few and far apart in the State and exist either as gallery forest, village forest or forest reserves[13]. Agriculture forms the backbone of the State economy, engaging more than 70% of the population. The State has an advantage of being located across both the forest zone where tree crops are grown and the savanna where mainly grains are cultivated.

Apa LGA is called "the green land" of Benue State because of its huge agricultural potential. The area is endowed with rich fertile lands, which encourage variety of arable crops such as yam, rice, cassava guinea corn, maize, groundnuts, beniseed, pepper, cowpea, e.t.c. Crops such as vegetables are produced on smaller scale during the dry season[10].

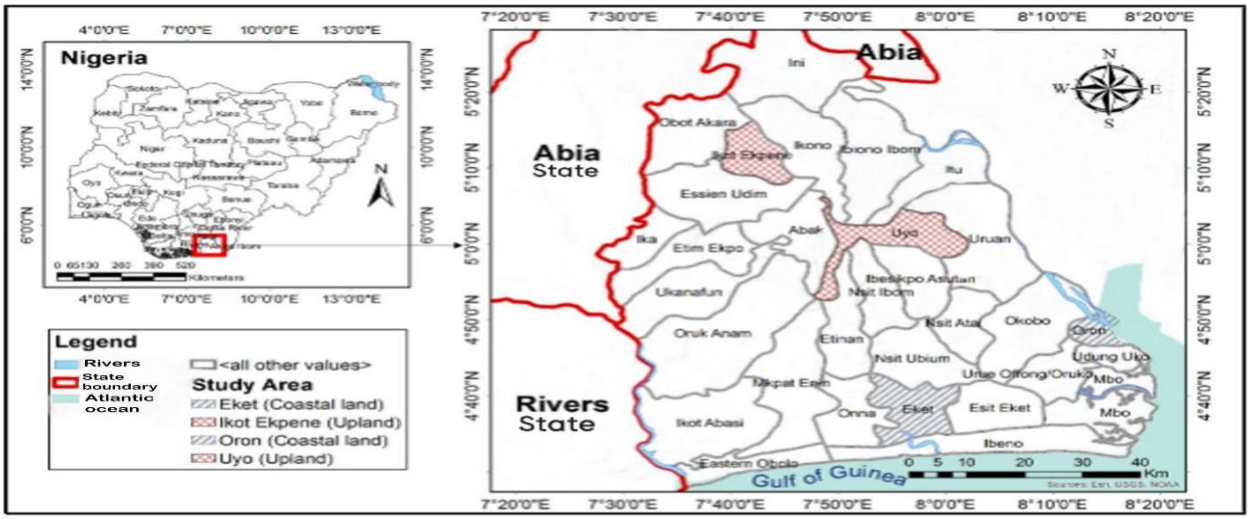

Fig. 1 Akwa Ibom State showing the study locations
Source: Nigeria shape file

Methods of Data Collection

Rainfall and temperature data (1980 – 2020) were collected from the Nigerian Meteorological Agency (NiMet).The data were used to characterise the climate of the study area.Krejcie and Morgan's[14] method of determining sample size was used to sample 385 farmers. Questionnaire survey and Focused Group Discussion (FGD) were used to elicit relevant information from the sampled farmers.

The 385 questionnaires were distributed equally among the 12 wards for wants of actual population figures for the localities for proportional distribution. Thirty-two (32) respondents were purposively sampled from each ward for data collection.

Purposeful sampling technique was used to select farmers who are above 30 years of age, who must have lived at least 20 years within the study area. The reason for this decision is that those within the age bracket may have the information needed about climate change in the study area. A total of 360 questionnaires were successfully returned and validated for the analysis and discussion.

Methods of Data Analysis

Trendlines were used to show the trends in rainfall and temperature (1980-2020). The data were used to characterize the climate of the study area. Frequencies and percentages were used to analyse the socio-demographic data. The questionnaire uses Likert Rating Scale (LRS). The five-point LRS was assigned numerical values thus: SA (Strongly Agree) =5; A (Agree) =4; D (Disagree) =3, and SD (Strongly Disagree) =2 and U (Undecided) =1.Thus, 3.0 was the decision mean, implying that any mean score above 3.0 will be accepted as being significant.Mean score ( ) and Standard Deviation (SD) was used to present the results.Importance Index Technique (RII) was used to determine the extent of adoption of the resilient strategies by farmers. The various strategies used were examined and ranked in terms of their frequency using the RII[15].

RESULTS

Climatic characteristics of the study area

Among the climatic elements, rainfall is the most variable. Rainfall determines the growing season in developing countries like Nigeria where agriculture is predominantly rain-fed[12]. Almost every farmer is interested in what the expected rainfall would be, more than any other climatic elements as it determines the success or failure of crops. Timely and accurate weather forecasting is crucial to improving farming activities. Trend in the Total Annual Rainfall (TAR) of the study area (1980-2020) is presented in Fig. 2.

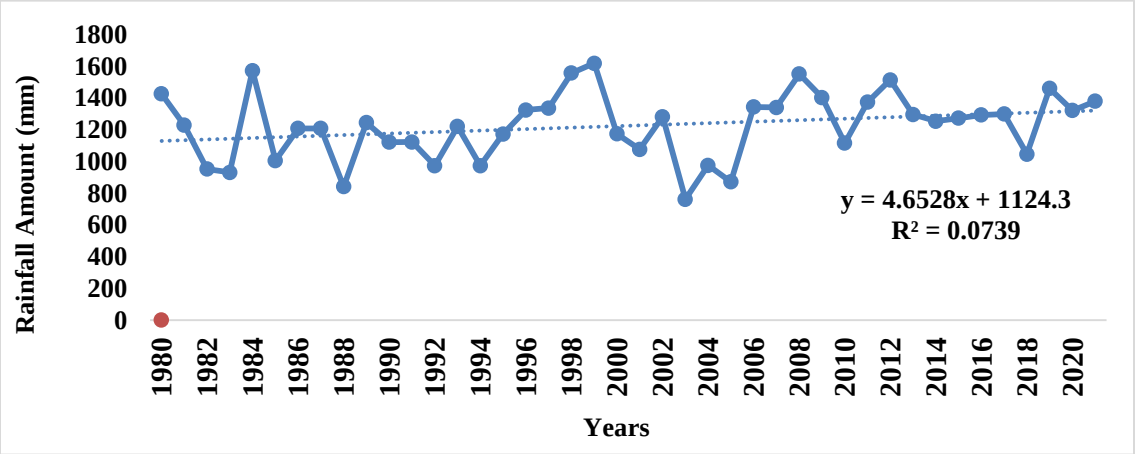

Figure 2: Total Annual Rainfall of Benue State (1980 – 2020)

The trend shows a fluctuating pattern in the TAR for the 40 years reviewed. The best fit trendline shows a positive equation (y = 4.6528x + 1124.3) which implies that TAR is on the increase. The trend line equation for the average annual maximum and annual minimum temperature (y = 0.0147x + 31.314) shows an increasing temperature (Fig. 3).

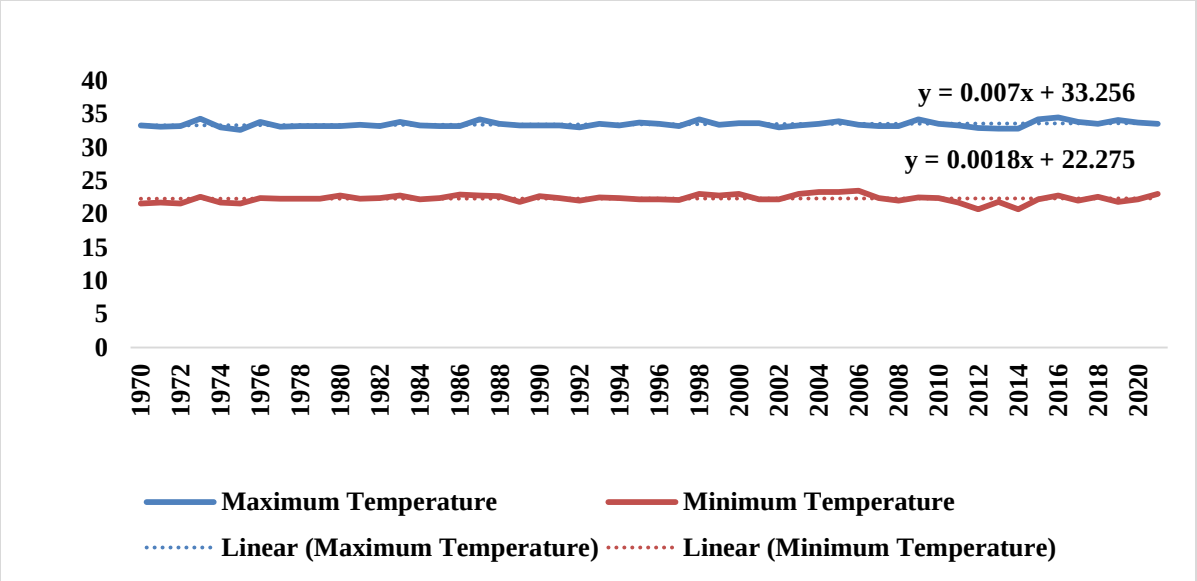

Figure 3: Maximum and minimum temperature of Benue State

The demographic characteristics of the farmers in the study area were analyzed and presented in Table 1 and 2.

Table 1: Demographic characteristics of the farmers

Variable	**Respondents**	**Percentage**
Male	330	92
Female	30	8
Total	**360**	**100**
Distribution of the Farmers by Age		
Age	**Respondents**	**Percentage**
30 – 40	23	6
41 – 50	103	28
51 –60	180	52
61 – 70	45	12
71 & above	9	2
Total	**360**	**100**
Religious Belief of the Farmers		
Religion	**Respondents**	**Percentage**
Christianity	327	91
Islam	21	6
Others	12	3
Total	**360**	**100**
Marital Status of the Farmers		
Marital Status	**Respondents**	**Percentage**
Married	312	87
Divorced	12	3
Single	23	6
Widowed	13	4
Total	**360**	**100**

Source: Fieldwork 2023

A majority (92%) of the sampled farmers were male, while 8% were female. The age distribution of the farmers (Table 1) showed that majority (94%) of the farmers fell within the age of 41 and above. Table 1 further indicates that 91% are Christians and 6% Muslims. The religious belief/faith of the respondents plays a major role on their perception of climate change and resilience measures, especially on what causes climate change. The marital status of the farmers (Table 1) shows that the majority (87%) were married, while only 6% were single. These indicated that majority of the farming household members were married, implying that married household members have more persons to feed, therefore, engage more in farming activities in order to provide food and income for the family.

Table 2 shows that 50% of the farmers attended primary school; 38% attended secondary school; 9% attended higher institution at various level. This showed that most of the respondents received various forms of education. This might have probably helped them in their farming activities. Family labour is recognized as a major source of labour supply in smallholder crop production in most parts of Africa, including Nigeria. This comprises the labour of all males and females including children in a household, who contribute their mental and physical efforts to the household holdings. Table 2 shows that majority (32%) are within the household size of 6-10, followed by 31% (16-20 household size); 19% (11-15 household size) and 9% fell within the range of 1-5 household size.

Table 2: Demographic characteristics of the farmers

Distribution of Farmers by Level of Education		
Highest Educational Level	**Respondents**	**Percentage**
Primary	180	50
Secondary	136	38
Tertiary	31	9
Others	13	3
Total	**360**	**100**
Household Size of the Farmers		
Household Size	**Respondents**	**Percentage**
1 – 5	32	9
6 – 10	115	32
11 – 15	81	22
16 – 20	112	31
21 – 25	10	3
26 & above	8	3
Total	**360**	**100**
Farmers' Years of Residency		
Years of Residency	**Respondents**	**Percentage**
20 – 30	119	33
31 – 40	60	17
41 & above	181	50
Total	**360**	**100**

Source: Fieldwork 2023

Table 2 shows that 33% of the farmers had lived in the study area for the period of 20–30 years, while 50% had lived in the study area for over 41 years.

Figure 4 shows that 95% of the farmers were aware of climate change in the study area; 4% were not aware, while 1% were indifferent about their awareness of climate change in the study area.

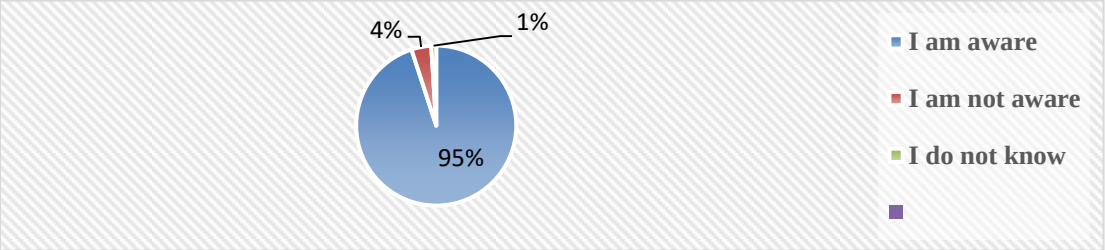

Figure 4: Farmers Awareness of Climate Change
Source: Field Work 2023

On the farmers' years of awareness on climate change issues (Table 3), 21% of the farmers were aware of climate change for less than 5 years; 22% for about 6-10 years; 21% for about 11-15 years; 26% had been aware of climate change for about 16-20 years, while about 10% had been aware of climate change for at least 21 years.

Table 3: Farmers Years of Awareness of Climate Change

Awareness (Years)	Respondents	Percentage
Less than 5 years	75	21
6 – 10	79	22
11 – 15	72	21
16 – 20	94	26
Above 21 years	40	10
Total	**360**	**100**

Source: Field work 2023

The farmers' perception of onset, cessation, number of rainy days and effectiveness of rainfall and temperature in the study area are presented in Table 4.

Table 4: Farmers' Perception of Onset, Cessation, Number of Rainy Days and Effectiveness of Rainfall and Temperature in the study area

	Weather and Climate Change Indices	Mean ($\bar{\chi}$)	SD
A.	Rainfall onset is now coming late compared to the past ten years	4.5	2.12
B.	Rainfall cessation is now earlier than before	4.3	2.07
C.	Number of rainy days/months/years is increasing	4.4	2.09
D.	The yearly rains are not supporting crop production as before	4.2	2.04
E.	Rainfall amount compared to the past ten years is decreasing every year	4.1	2.02
F.	The weather is becoming drier	3.6	1.89
G.	The changing climate has led to crop infestation and disease by pest	4.3	2.07
H.	The changing climate is affecting human and animal health	4.6	2.14

***Average Mean ≥ 3.0**

Source: Field Work 2023

The result shows that an appreciable number of the farmers (4.5$\bar{\chi}$) affirmed that rainfall onset is now coming late compared to the past ten years. Significant number (4.3$\bar{\chi}$) perceived that rainfall cessation is now earlier than before. Most of the farmers (4.4$\bar{\chi}$) perceived that the number of rainy days is increasing in the study area. Furthermore, the farmers (4.2$\bar{\chi}$) perceived that the yearly rains no longer support effective crop production as before. An above average (3.6$\bar{\chi}$) of the farmers agreed that temperature is increasing in the study area. Majority of the farmers (4.3$\bar{\chi}$) agreed that the changing climate has led to crop infestation and disease by pest. While the majority also perceived (4.6$\bar{\chi}$) that the changing climate is affecting human and animal health in the study area.

Farmers perception of the effects of climate change on crop production

The farmers' perception on the main effects of climate change on crop yield is presented in Table 5. The result shows that majority of the farmers (4.3$\bar{\chi}$) agreed that insufficient food supply in the recent years is one of the effects of climate change on crop production.

Table 5: Farmers' Perceived Effects of Climate Change on Crop Production

	Variables	Mean ($\bar{\chi}$)	SD
A	Insufficient/shortage of food supply in recent years	4.3	2.07
B	Agricultural drought and insufficient water for irrigation and domestic uses in recent years	4.2	2.04
C	Increase in crop infestation by pests and crop diseases	3.6	1.89
D	Shift in crop(s)/species cultivated	4.2	2.04
E	Flooding of farmlands and residential areas	3.8	1.94
F	Increase in poverty, migration and clashes with cattle herdsmen and villagers	3.9	1.97
G	Decrease in crop yield	4.1	2.02

***Average Mean ≥ 3.0**

Source: Field work 2023

Table 5 further shows that majority of the farmers (4.2$\bar{\chi}$) stated that agricultural drought and insufficient water for irrigation and domestic uses are part of the effects of climate change in the study area. The farmers (3.6$\bar{\chi}$) perceived that there is an increase in pests and crop diseases which destroys plants thereby causing poor yield

and crop failure. An appreciable number of the farmers (4.2$\bar{\chi}$) perceived that shift in crops/species cultivated in the study area is an effect of climate change on crop production (Table 4).

The farmers (3.8$\bar{\chi}$) perceived that flooding of farmlands and residential areas is an effect of climate change (Table 4). Majority of the farmers (3.9$\bar{\chi}$) observed that climate change has led to increase in poverty, migration and clashes with cattle herdsmen and villagers (Table 4). Table 4 shows that majority of the farmers (4.1$\bar{\chi}$) agreed that climate change leads to decrease in crop yield.

Farmers' sources of information about climate change issues in the study area

The result on the sources of information about climate change (Fig.5) shows that majority of the farmers (48%) got information about climate change issues through personal observation of the environment and 27% through interacting with friends.

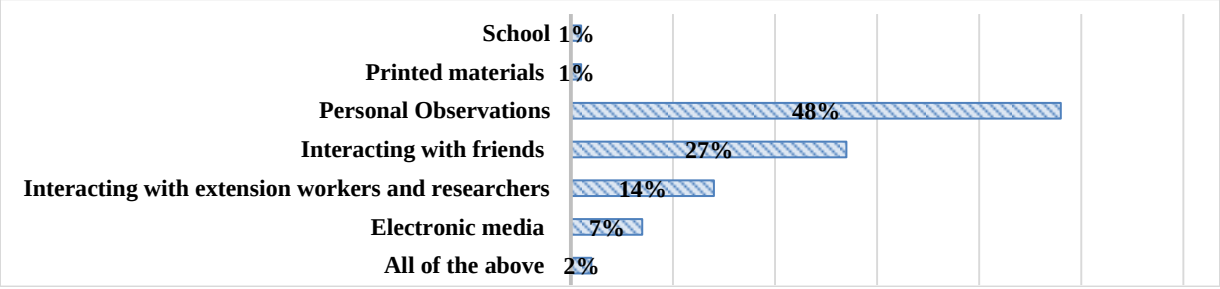

Fig. 5: Farmers Sources of Information on Climate Change Issues
Source: Field work 2023

Farmers' Resilience strategies to climate change

The resilient strategies used by the farmers in the study area are presented in Table 6.

Table 6: Climate Change Resilient Strategies

S/N	Resilient Strategies	Always	Rarely	Not at all	$\bar{\chi}$	Rank
1	Early and late planting	289	52	11	2.7*	5
2	Use of organic manure	148	176	44	2.3	7
3	Use of inorganic fertilizer	156	170	34	2.3	7
4	Use of well acclimatized varieties	296	57	7	2.8*	3
5	Planting of cover crops	265	75	20	2.6*	6
6	Use of irrigation system/water storage	52	84	224	1.5	15
7	Use of chemicals e.g. herbicide, insecticides	174	97	89	2.2	9

8	Increase in number of weeding	166	119	75	2.2	9
9	Use of early maturing crop varieties	327	31	2	2.9*	2
10	Preservation of seedlings for planting	300	51	9	2.8*	3
11	Mixed farming practices	128	139	93	2.0	11
12	Changing the timing of land preparation	129	131	100	2.0	11
13	Changing harvesting dates	100	122	138	1.8	14
14	Loans, grants and subsidies	111	148	101	2.0	11
15	Mixed cropping	359	8	1	3.0*	1

Source: Fieldwork, 2023
***Significant Resilience Strategies ($\bar{\chi} \geq 2.5$)**

Table 6 presented a summarized 15 coping strategies employed by farmers to improve their resilience to climate change resilience impacts in Apa LGA. The result revealed that six (6) of the resilient strategies were "highly adopted" by the farmers as reflected in their mean score values of ≥2.5. The most significant resilience strategies to climate change used by the farmers in the study area are mixed cropping (ranked 1), use of early maturing crop varieties (ranked 2) and use of crop varieties that are well acclimatized (ranked 3) with a mean score ($\bar{\chi}$ =3.0), ($\bar{\chi}$ =2.9) and ($\bar{\chi}$ =2.8) respectively. These results emphasized the need for diversification to new plant species and varieties that would have higher resistance to anticipated temperature increase and reduced rainfall which could enhance crop production and food security.

DISCUSSION

The perception that the TAR is increasing agree with the findings which reported that TAR is increasing in Sokoto State[16]. The result also agrees with the study which reported that theTAR of Sokoto State was characterized by inconsistencies and inter-annual variability, although increasing[17]. Temperature plays a significant role in agriculture. In general, higher temperature is associated with higher radiation and higher water use.

That majority of the farmers were male might be because, male have a dominant role to play in the family as household heads in providing the households basic needs such as food. In some parts of Africa, including Nigeria, womenfolk are often deprived of property rights owing to social barriers. As a result, they tend to have lesser capabilities and resources than men [18].

Education has a positive and highly significant relationship and investment in indigenous and emerging climate change resilience practices. This is to be expected as educated farmers may better understand and process information provided by different sources regarding new farm technologies, thereby increasing their allocation and technical efficiency[19].

The result shows that large family size to some extent translates to higher use of family labour in the farming activities. Majority of the farmers in Benue State are small-scale farmers who rely on the use of unpaid family labour and traditional farm implements [20]. That majority (50%) had lived above 41 years in the study area agrees

with the study of [21] which reported that the longer a farmer lives and farms in an environment, the more experienced and knowledgeable he will be about the environment.

Farmer's awareness of change in climate attributes (temperature and precipitation) is important to resilience decision making. The awareness of climate problems and the potential benefits of acting is an important determinant of adoption of agricultural technologies. Farmers' awareness and perceptions of climate change on agriculture positively and significantly affect their decisions to adopt viable resilience measures[22]. Farmers' perception and years of awareness of climate change have positive effect on the resilience strategies used by the farmers[23].

The fact that majority of the farmers characterized the climate of the study area as having late onset and early cessation agrees with the study of [24] which stated that the semi-arid region of Northwest Nigeria is experiencing late onset and early cessation of rains which affects crop production. Farmers in Kano State perceived late onset and early cessation of rainfall[25].

Remarkable continuous downward trend in annual rainfall amounts in Benue State was observed between 1990-2018[8]. The result that the yearly rains no longer support effective crop production agrees with the study of [24] which observed that the rainfall amount in the northwest zone of Nigeria is decreasing with an increasing temperature which has eventually shortened the growing season of crops.

The fact that majority of the farmers have perceived higher temperature for at least 10 years agreed with the findings of [26] which reported that food crop farmers in south-west Nigeria perceived that there was higher temperature, decreased rainfall and erratic rainfall in southwest Nigeria.

Food supply and security is clearly threatened by climate change due to the instability of crop production[23]. This confirmed the findings of this study which stated that climate change is affecting adequate food supplies. [27] highlighted the implications of climate change on food security and livelihood and recommends viable resilience strategies by farmers and stakeholders in order to ensure food security in northern Nigeria. The result further confirmed the report which emphasized that climate change poses multiple challenges on food productivity and production which stands to undermine the four dimensions of food security in different ways: food availability, food access, food utilization and food stability[28].

The result that climate change caused agricultural drought and insufficient water for irrigation and domestic uses aligns with the findings of [29] who reported that climate change has led to the annual reduction in the total available water in the Sokoto Rima river basin. Many rivers in Nigeria have been reported to have dried up or are becoming more seasonally navigable [24]. Climate change has forced grain farmers to shift from the cultivation of maize and sorghum to millet as a result of late onset of rains and frequent agricultural drought [17].

The result of increase in crop infestation by pests and crop diseases showed a consensus with the findings which stated that climate change has led to the increase in pests and diseases in crops and livestock, as well as in soil loss[30]. These can hinder storage when the need arises because of temperature increase. The result on flooding of farmlands and residential areas agrees with the study which reported that farmlands in South-south of Nigeria have been subjected to seasonal flood events during and after every rain throughout the period of 2011 and 2012[31].

Intensive rainfall has led to severe erosion which has affected farmlands; submerge crops, livestock and death of some people thereby causing crop failure, shortage of food and poverty[32].

The result of increase in poverty, migration and clashes with cattle herdsmen and villagers confirmed the projection which stated that hundreds of millions of people might need to flee their homes as a result of climatic and environmental pressure between now and 2050 [26]. Climate change has prompted frequent migration and clashes with cattle herdsmen and villagers in northern Nigeria. Such emigration gives rise to social effects like loss of dignity, social values and increasing spate of communal clashes among herdsmen and farmers [24].

The result on decrease in crop yield agrees with the projection which stated that food security will be compromised by projected yield declines especially in Sub Saharan Africa and Asia where most of today's food insecure live [27]. Climate change poses a great threat to human security through decreasing crop yields, contributing to increased hunger [19]. The findings on the most resilient strategies adopted by the farmers in the study area corroborated with the strategies put forward which advocated for the use of indigenous resilience strategies as a means of meeting the four pillars of the FAO on food security [33].

CONCLUSION

This study assessed farmers' perceived effects on crop production and resilient measures towards ensuring food security in Benue State. The results showed that climate change is evident in the study area via late onset and early cessation of rainfall and increasing trends in rainfall and temperature. Climate change has negatively impacted on crop production. Findings showed that majority of the farmers are aware of climate change issues; Personal observation was the major source of information on climate change issues; mixed cropping, use of organic and inorganic manure and the use of improved seed varieties are the main resilient strategies among others the farmers are using in the study area.

SIGNIFICANCE STATEMENT

The feedback provided by this study will considerably improve the farmers' understanding of climate change and will significantly improve the farmers' resilience strategies. The findings and recommendations of this research will go a long way to assist the farmers in understanding the climatic characteristics of the study area and how to respond to the current upsurge in climate change. In addition, the findings of this research would enrich the existing literature on the effects of climate change on agricultural activities in the semi-arid regions. In the same vein, the research will assist the government, research institutes and policy makers to reflect on the national policy or planning framework needs or issues critical to farming communities.

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