



EFFECT OF CLIMATE CHANGE ON AGRICULTURAL OUTPUT IN WUKARI LOCAL GOVERNMENT AREA OF TARABA STATE, NIGERIA

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Abstract

Climate change has become a global enigma and monster, its effects on economic activities cannot be overemphasized. The purpose of this study is to investigate the effect of climatic and anthropogenic factors (temperature change, rainfall variability, deforestation and flood) on agricultural output in Wukari Local Government Area of Taraba state. The study adopted the Andrew Fisher's formula to determine the sample size. Descriptive analysis and Cobb-Douglas production function was adapted to estimate the effects of temperature, rainfall, deforestation, flood, fertilizer and pesticide on agricultural output in the study. Findings revealed that temperature, deforestation and flood have negative significant effect on agricultural output, while rainfall, fertilizer and pesticide positively and significantly impacted agricultural output in Wukari. Therefore, the study recommended that Government should establish a National Climate Change Commission to oversee climate change issues at national and local level. Government should provide early information on rainfall and develop flood detection system to guide farmers on best cropping seasons as well as construction of dams that will trap excess water during years of heavy rainfall. Also, Government should evolve policies that will alleviate the cost of

essential inputs (fertilizers and pesticides) that will enable farmers to obtain more output and equitable return from their harvest. Government should train and fund experts to develop technology capable of diminishing the negative impacts of temperature through development of drought resistant seedlings and animals. Government and NGO should aggressively campaign against deforestation and incentivize citizens to plant trees and preserve existing forest.

Key words: climate change, temperature, rainfall, deforestation, flood and agricultural-output

INTRODUCTION

Climatic and anthropogenic conditions such as temperature change, rainfall variability, deforestation, floods, droughts, desert encroachment as well as heat waves has assumed alarming proportion nowadays in our environment in Nigeria most especially the North Eastern part of Nigeria where Wukari Local Government area is located. Climate change refers to long-term variation in temperatures and weather patterns (US EPA, 2016). Such variations are connected to human anthropogenic activities (Idowu, et al. 2011). Human activities have been the major causes of climate change, mainly due to deforestation, urbanization, burning of fossil fuels, industrializations etc. (Kaur, 2017). Climate changes have direct impact on environment in any country and environments have direct linkage with production activities which is the spirit of economic activity (Nasir, et al. 2024). Wukari local government area is obviously battling with this natural cum manmade disaster threatening her existence. The aggregate effect of climate change on agricultural output will probably exhibit negative influence in the long run. Climate change is expected to increase the atmospheric severity of weather condition, bringing damage on properties and infrastructure thereby leading to productivity loss, mass migration and security threats (USDA, ERS 2022). Wukari has witnessed severe flooding, drought and severe heat waves as a result of rise in sea level occasioned by global warming which has damaged homes, farm and infrastructure all over the local government, For example, Wukari local government had experienced frequent rain storm in quick succession and late and shorter duration of rain fall is becoming the order of the day in recent years as well as severe heat wave during dry seasons. In Nigeria, mostly in the Northern part, desert encroachment occasioned by deforestation has reduced the volume and fertility of arable land used for agricultural activities, the resultant effects are food insecurity, unemployment and retard growth (Amadi, et al 2019).

Over the years, the Wukari Local Government Area economy is ravaged and engulfed with insecurity which has led to massive destruction of properties and loss of lives (Amadi, et al 2019). This situation is compounded with climate change characterized with desert encroachment, floods, droughts and heat waves which undoubtedly and absolutely affect output

and productivity. This obvious appearance of global warming in Wukari local government is associated with strange plant and animal diseases depleting output and productivity. It was observed literally last year 2024, rain fall started properly by July and stopped by October, just four months cycles instead of the usual 7 months raining season. Climate change is likely to amplify the severity of extreme weather condition, bringing damage on agricultural products, properties and infrastructure thereby leading to productivity loss (USDA, ERS 2022; Kaur, 2017).

In spite of technological improvements (use of improved seedlings, breeds, fertilizer, pesticides and herbicides) crops and animals yields have not being encouraging, the question is what is responsible for the significant reductions in crops and animals yield? Extreme weather condition could be responsible for the erratic crops and animals yield in Wukari local government area. Therefore, the study is aimed at evaluating the effect of climate and anthropogenic factors impacting agricultural output in Wukari Local Government Area of Taraba State, Nigeria.

Objectives of the study

The main objective of the study is to examine the effect of climate and anthropogenic factors on agricultural output in Wukari Local Government Area. While the specific objectives are to:

1. Investigate the effect of annual rainfall on agricultural output in Wukari Local Government Area.
2. Examine the effect of annual temperature on agricultural output in Wukari Local government Area.
3. Examine the effect of deforestation on agricultural output in Wukari Local Government Area.
4. Investigate the effect of flood on agricultural output in Wukari Local Government Area

LITERATURE REVIEW

Climate change is a long-term change in weather patterns that characterize a region or the whole world over a significant period of time (Mahato, 2014). According to Naresh (2012) climate change is apparently seen as the major threat to food security and sustainability of agriculture. In the long run, climate change affects agriculture in many ways which include quality and quantity of crops and livestock in terms of productivity, growth rate, photosynthesis etc (Mahato, 2014). The effects of climate change on agriculture depend on the rate and

sternness of the change, as well as the degree to which farmers and ranchers can adapt (Gowda, 2018).

Nasir et al, (2024) examine the impact of temperature and rainfall on agricultural production in the southern part of Bangladesh. The objective of this study is to demonstrate the standard of living of agricultural households and investigate the associations between the production of rice and some key environmental variables. This study was conducted using a well-structured questionnaire for data collection after Aman season in 2023 and quantitative approach for identifying the impact of temperature and rainfall on agricultural production. This study used descriptive analysis and Cobb-Douglas production function for determining impact of temperature and rainfall on agricultural production. According to the analysis, nearly all farmers are small-holders, with 53.5% earning between 1,000 and 15,000 BDT annually, 32% cultivating property under lease, and only 26% cultivating their own land. The main findings are that the temperature has a large negative impact on production, which is -0.200 meaning that 1 percent increase in the temperature lead to a 0.200 percent decrease in agricultural output. Rainfall has also a negative impact of -0.071 indicates that 1 percent increase in the rainfall reduces agricultural production of 0.071 percent. Besides these, fertilizer, pesticide, irrigation and labor force positively affect the crop yield. Land area and seed usage are statistically insignificant in rice production in southern region of Bangladesh. The results of the study clearly show that rainfall and temperature have statistically significant and negative impact on the gross return on production in the southern region of Bangladesh. Also, Hossain et al., (2019) also examine the impact of climate change on rice production in Khulna district, Bangladesh and the study revealed a statistically significant increasing trend in both temperature and total rainfall on rice production, while relative humidity showed a decreasing trend. Despite this, there was a positive trend observed in bright sunshine, although it was relatively weak.

Wang et al. (2024) examine the interconnection between agricultural production and government-led poverty reduction, with annual rainfall considered an influential factor of climate change in China, utilizing a Meta-frontier entropy network dynamic Directional Distance Function (DDF) within an exogenous Data Envelopment Analysis (DEA) model, they categorize China's 27 provinces into southern and northern regions according to the Qinling-Huaihe line for a comparative study of environmental, economic, and governmental efficiency. This innovative approach overcomes the limitations of previous static analyses. The findings reveal that Rainfall, as an exogenous variable, significantly affects agricultural production efficiency and the overall efficiency in both southern and northern regions increases when accounting for rainfall.

Idowu et al. (2011) examined the effect of climate change in Nigeria and emphasized that Climate change is an adverse environmental occurrence that is causing huge anxiety all over the globe. Climate change and global warming if left unrestrained will cause adverse effects on livelihoods in Nigeria, such as crop production, livestock production, fisheries, forestry and post-harvest activities, because the rainfall regimes and patterns will be altered, floods which devastate farmlands would occur, increase in temperature and humidity which increases pest and disease would occur and other natural disasters like ocean and storm surges, which not only damage Nigerians' livelihood but also cause destruction to life and property, would occur. They refer climate change as some anomalies in the climate system that is connected to human activities.

Naeem (2012) examined the impacts of climate change on economic growth for selected Asian countries during the period 1972-2009. A growth model was developed by incorporating temperature and precipitation as proxies for climate change in the production function and a fixed effect model (FEM) and seemingly unrelated regression (SUR) have been used to estimate the model. The results revealed that economic growth is negatively affected by changes in temperature, precipitation and population growth whereas urbanization and human development stimulate economic growth. The results also indicate that agriculture is the most vulnerable sector to climate change and manufacturing is the least affected sector. Similarly, Ogbuabor & Egwuchukwu (2017) examined the impact of climate change on Nigerian economy employing the ordinary least squares (OLS) estimation technique and data spanning from 1981-2014. Changes in annual rainfall, carbon emission and forest depletion were used to proxy climate change. The results revealed that both in the long-run and short-run, carbon emissions affect growth adversely. In addition, forest depletion impacts negatively on growth in the short-run. These results imply that Nigerian government should evolve and implement policies to curb carbon emissions and forest depletion. In particular, a National Climate Change Commission is required in Nigeria to deal with all climate change issues.

Seo et al. (2009) examined the effect of climate change on agricultural productivity. Utilizing the Ricardian method of how climate change affects net revenue per hectare for four most important crops (namely rice, coconut, rubber, and tea) in Sri Lanka. The study emphasized more on the precipitation effect on crop production due to the higher range of precipitation across the country although the limited range of temperature variation allowed only a simple test of temperature impacts in the study. The result revealed that the effects of increase in precipitation are predicted to be beneficial to all crops tested and the benefit ranged from 11% to 122% of the current net revenue of the crops in the model. On the other hand, the impacts of increase in temperature were predicted to be injurious to the economy and the loss

ranged from –18% to –50% of the current agricultural productivity. In the People’s Republic of China Zhai et al. (2009) analyzed the long-run effect of climate change on agricultural output and trade using the CGE model as well as simulation settings of how global warming affects agricultural output up to 2080. The result revealed a decline share of agriculture in GDP revealing the general impact of climate change on agricultural productivity.

Bedane (2022) investigate the impact of rainfall variability and crop production on vertisol in the central highland of Ethiopia. The study collected and described 39 years of rainfall data using the Markov chain model. Based on the rainfall probability levels at different threshold values, the length of the dry and wet spells and the length of the growing period were determined. The study revealed that the short rainy season rainfall (February to May) is unreliable for growing crops at Ghinchi as opposed to other highland areas of Ethiopia. The major crop growing season is therefore confined to periods of the long rainy season (weeks 22nd to 39th, or 28th May–30th September). The water balance for the study area indicates that the moisture availability index is greater than 0.5, and potential evapotranspiration is lower than precipitation during these months.

Parry et al. (2007) projected that a decline in water supplies stored in glaciers and snow cover will result in water scarcity. If global average temperature increases by 1.5-2.5°C then approximately 20-30 per cent of plant and animal species will face the danger of extinction. An increase of temperature in the range of 1-3°C has the potential to increase food production but an increase in temperature beyond that would result in a decline in food production. A rise in sea surface temperature of 1-3°C would cause more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation. Sea level rise will negatively affect the coastal wetlands, including salt marshes and mangroves.

Renee (2019) examined how climate change could affect 22 different sectors of the economy under two different scenarios: if global temperature rose by 2.8°C from pre-industrial level by 2.10°C, and if they increase by 4.5°C. The study projected that if the higher temperature scenario prevails, climate change impacts on the 22 sectors could cost the United State of America \$520 billion each year. If the United State of America can keep to 2.8°C, it would cost \$224 billion less. In any case, the U.S stands to suffer large economic losses due to climate change.

METHODOLOGY

Description of the Study Area

Wukari Local Government Area is situated in the southern senatorial district of Taraba State, Nigeria. Span an area of 4308 square kilometers, positioned between 7.51⁰ North latitude

and 9.47⁰ East longitudes (source). It shares boundaries with Ukum Local Government Area of Benue state to the south, and bordered by other local government such as Ibi in the West, Gassol in the North and Donga in the East. According to 2006 Nigeria census, the total population of Wukari is 238,283, projected population of 384, 289 in 2026 and comprising 113,998 female and 124,285male (NPC, 2025). The major crops cultivated are rice, bean, maize, yam, potatoes and vegetables, while common livestock are goat, cow, pig and fowl.

Sampling Technique and Sample Size

Due to limitations in time and resources (finance and manpower), it was impossible to include all farmers and herders in the study area. The study employed descriptive survey design which enabled the study to gather data using questionnaire. The population of the study is not known because Wukari Local government Area is predominantly occupied by unregistered farmers. Since the population is unknown, the study adopted the Andrew Fisher's formula to determine the sample size.

$$\text{Sample size} = \frac{(z\text{-score})^2 \times \text{Std Dev} \times (1 - \text{Std Dev})}{(\text{Confidence interval})^2}$$

The study chooses 95% confidence level, a standard deviation of 0.5 and a confidence interval (margin of error) of $\pm 5\%$. A standard deviation of 0.5 is a safe choice since the population is unknown (Kibuacha, 2021). Substituting the values in the formula:

$$\begin{aligned} \text{Sample size} &= \frac{(1.96)^2 \times .5 \times (1 - .5)}{(0.05)^2} \\ &= \frac{3.8416 \times .25}{(0.0025)} \\ &= 384.16 \end{aligned}$$

Therefore, the sample size for the study is 385 which consist of farmers and herders in ten political wards of Wukari L.G.A of Taraba State.

The study used proportional sampling method which involves dividing population into subgroup (strata) and selecting respondents from each subgroup in proportion to its size in the total population. The reason for the choice of the sampling method is because Wukari Local Government Area is densely populated with farmers and herders, but there is no officially registered number of farmers and herders in the LGA.

The study used semi close ended questionnaire which allowed the respondents to provide for detailed, contextualized responses beyond the predefined options. This hybrid approach provides a balance of quantitative data from closed questions and qualitative insights from open questions, offering a flexible guided framework for data collection in surveys and interviews.

A total of 385 copies of the self-designed questionnaire was distributed by the selected researcher assistant to the study respondents. A total of 346 copies were distributed to crop farmers and 39 copies also given to livestock farmers in the ten political wards of Wukari Local Government Area of Taraba state. According to Taherdoost (2022) a questionnaire acts as an effective assessment instrument that enables gathering of information by incorporating questions that cover multiple dimensions. The data collection method used for this study involved face-to-face interviews.

The study assessed the content validity using a painstaking structured questionnaire in consonant with research questions and research objectives as prepared by the researchers to accurately cover all relevant concept of the subject matter designed to measure. To validate the precision of the questionnaire, a pilot survey was conducted. The questionnaire passed various modifications based on professional advice and were pretested and concluded after required corrections were made. To guarantee optimal use of the questionnaire in term of data collection, processing and analysis, a pretest was carried out for proper identification of any possible challenges before the beginning of the real survey. Also, an important phase of the study is the data editing and coding which constitutes vital step in data processing. Consequently, data entry using the Microsoft excels and SPSS software was carried out to give better output.

Table 1: Size of Sample

Political Ward	Sample Size
Puje	30
Avyi	29
Akwana	35
Bantaje	44
Chonku	44
Hospital	29
Jibu	44
Kente	44
Rafin Kada	42
Tsokundi	44
Total	385

It is important to note that the initially collected information in local units was converted into standard international units after necessary adjustment to enable the study use the adopted regression method.

Model Specification

The dependent variable used in study is the quantity of agricultural output measures in bags and number of harvested live stocks. While the independent variables are temperature (TPR), rain fall (RFL), Deforestation (DFR), Flood (FLD), Pesticides (PST) and fertilizer application (FTA). According to Basak et al. (2013) extreme temperature, deforestation, flood and low rain fall have negative impact on agricultural output, whereas fertilizer and pesticides application is expected to exhibit positive impact on agricultural output.

To determine the factors affecting agricultural output, the Cobb-Douglas production function was incorporated. The aim is to find out if climate change affects agricultural production in Wukari Local government area of Taraba state.

The Cobb-Douglas production function equation is thus:

$$Y=AL^{\beta}K^{\alpha} \dots\dots\dots (1)$$

Where:

Y= Agricultural output

A = Factor productivity

L = Labor input

K =Capital input

β = Share of labor for output

α =Share of capital for output

The Cobb-Douglas Production Function used in this study is as follows:

$$Y=ATPR^{\beta_1}RFL^{\beta_2}DFR^{\beta_3}FTA^{\beta_4}PST^{\beta_5}LAF^{\beta_6} \dots\dots\dots (2)$$

According to Montakim (2020) as cited in Nasir et al (2024) in order to solve the Cobb-Douglas production function using the ordinary least squares (OLS) technique, the function is transformed into the logarithmic form.

$$\ln AOT=\beta_0+\beta_1\ln TPR+\beta_2\ln RFL+\beta_3\ln DFR+\beta_4\ln FTA+\beta_5\ln PST+\beta_6\ln LAF+\varepsilon \dots\dots\dots (3)$$

Where,

AOT = Agricultural output

TPR =Temperature

RFL=Rainfall

DFR = Deforestation

FLD = Flood

FTA = Fertilizer Application

PST = Pesticides Application

β_0 =constant

The β values (β_1, \dots, β_6) represent the elasticity of agricultural output with respect to the corresponding inputs. The summation of ($\beta_1 + \beta_2 + \dots + \beta_6$) values represent the degree of returns to scale (Gujrati, 2004).

- Decreasing return to Scale (DRS): this occur when ($\beta_1 + \beta_2 + \dots + \beta_6$) < 1 , that is when an increase in all inputs by the same quantity causes a less than proportional increase in total output
- Increasing return to scale (IRS) this occur when ($\beta_1 + \beta_2 + \dots + \beta_6$) > 1 , that is when an increase in all inputs by the same quantity result to more than proportional increase in output.
- Constant return to scale (CRS) this occur when ($\beta_1 + \beta_2 + \dots + \beta_6$) $= 1$, that is when an increase in all inputs by the same quantity result to increase in output in the same amount (proportionate).

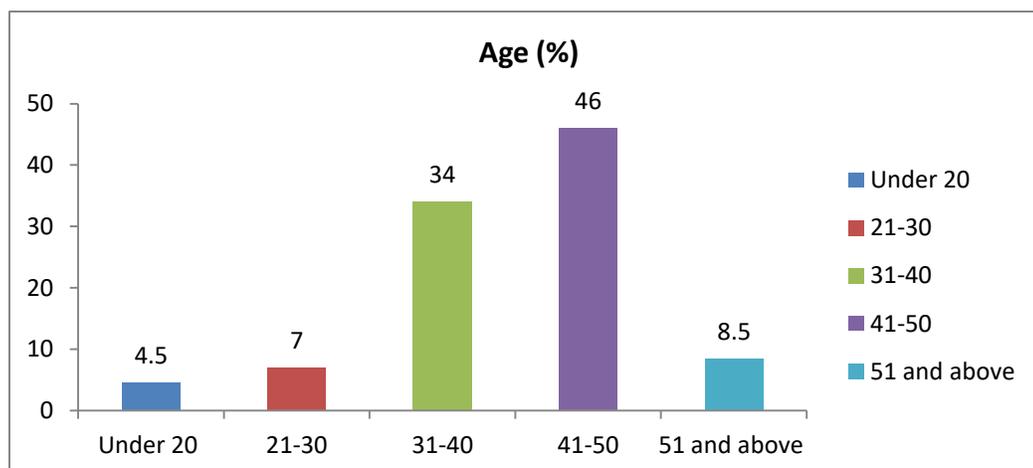
RESULTS AND DISCUSSION

Farmers' Age

Countries with more energetic young population have the advantage for growth by engaging them in different sector. They work more efficiently and accurately than an old or child as well as capable of working for a long period of time.

In this study, figure 1 show that farmers under twenty (20) years and between 21 and 30 old are 4% and 7% of the respondents respectively. From 31-40, 41-50 and 50 above are 34%, 46% and 9% of the respondents respectively. The results found that most of the farmers were between the range of 41-50 years. The study reveals that most of working aged respondents are engaged in agriculture and 87 percent of the farmers are between aged 21 years to 50 years.

Figure 1: Farmers' Age

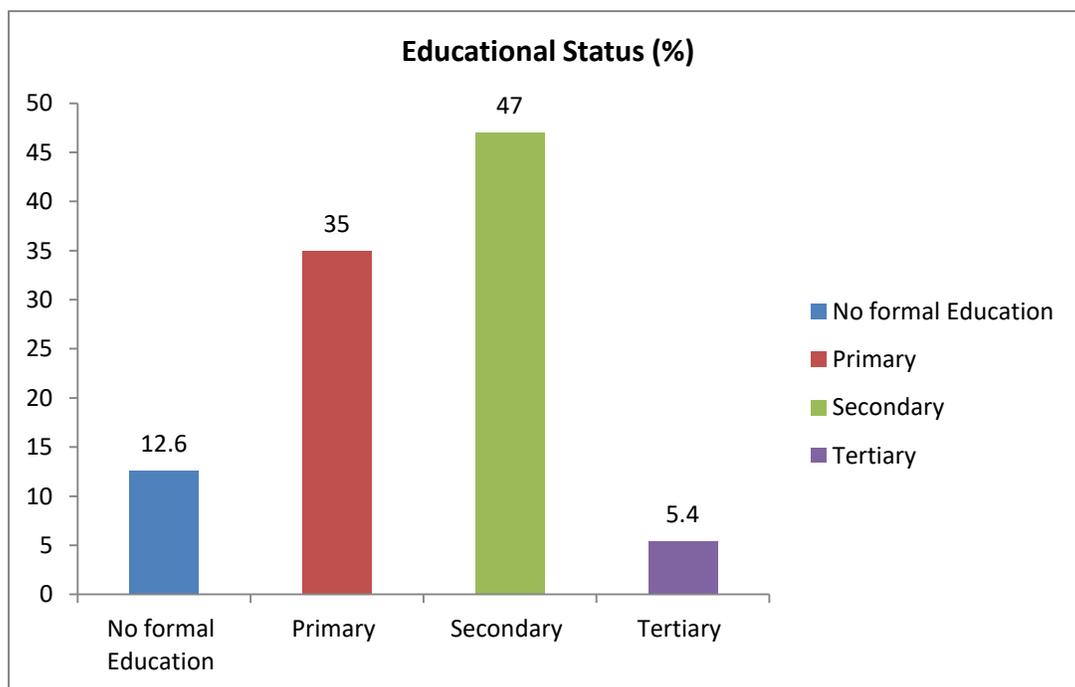


Farmers' Education

The important of education in shaping and fostering the capacity of individuals cannot be over emphasized. However, education among farmers holds significant importance in embracing new technologies and innovations among farm practices, as well as tackling daily family challenges.

Figure 2 below revealed that 12.6 percent of the farmers have no formal education while 35 percent have primary education. 47 percent of farmers have secondary school certificate and 5.4 percent farmers have tertiary education in the study area.

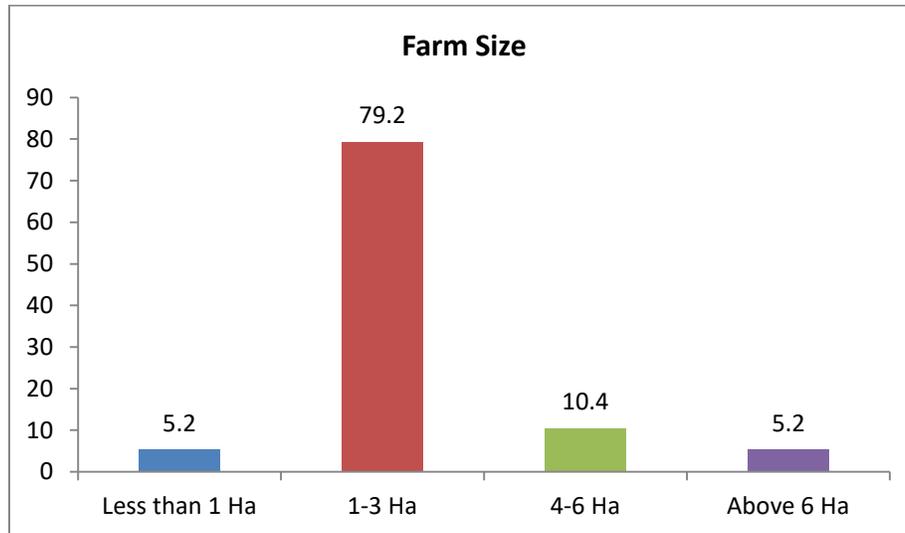
Figure 2: Farmers' Educational Status



Farm size

Because of how highly mechanized commercial farms are, the farmer in the area were majorly subsistence farmers who cultivate land mainly to feed themselves and their families, with little surplus for sale. Figure 3 shows the size of land being cultivated by different respondents in the study area. 79.2 percent of the farmers cultivate 1-3 hectares of land. The smallest number of respondents (5.2 percent) cultivated less than 1 hectare and above 6 hectares. 10.4 percent of respondents cultivate in the range of 4-6 hectares of land. The study found that all the farmers in the area are small holder farmers (Small: less than 4 hectares).

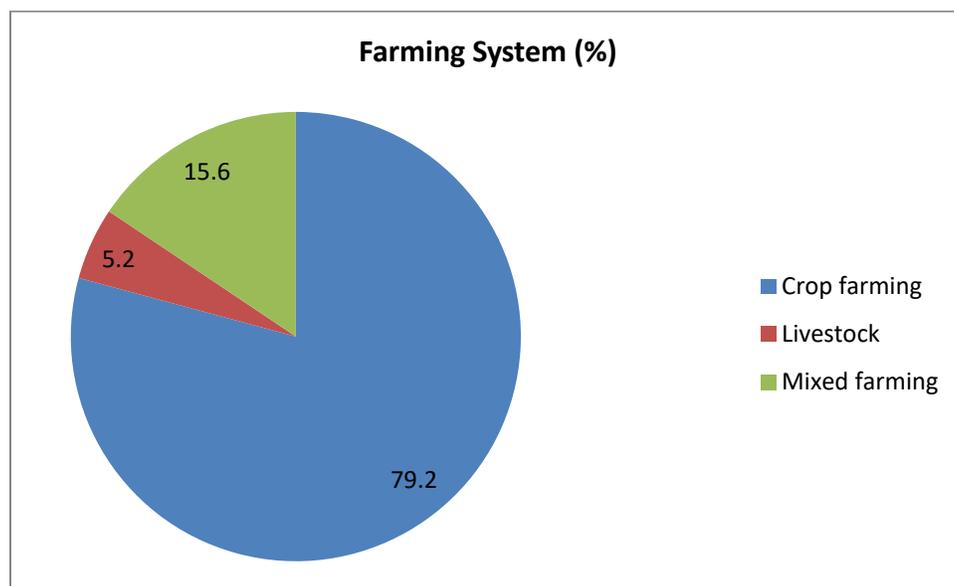
Figure 3: Farm Size



Farming System

Generally, the study area is dominated with crop farmers with little Livestock and mixed farmers. Figure 4 below shows that 79.2 percent of the respondents are crop farmers. 5.2 percent and 15.6 percent of the respondents are Livestock and mixed farmers respectively.

Figure 4: Farming System

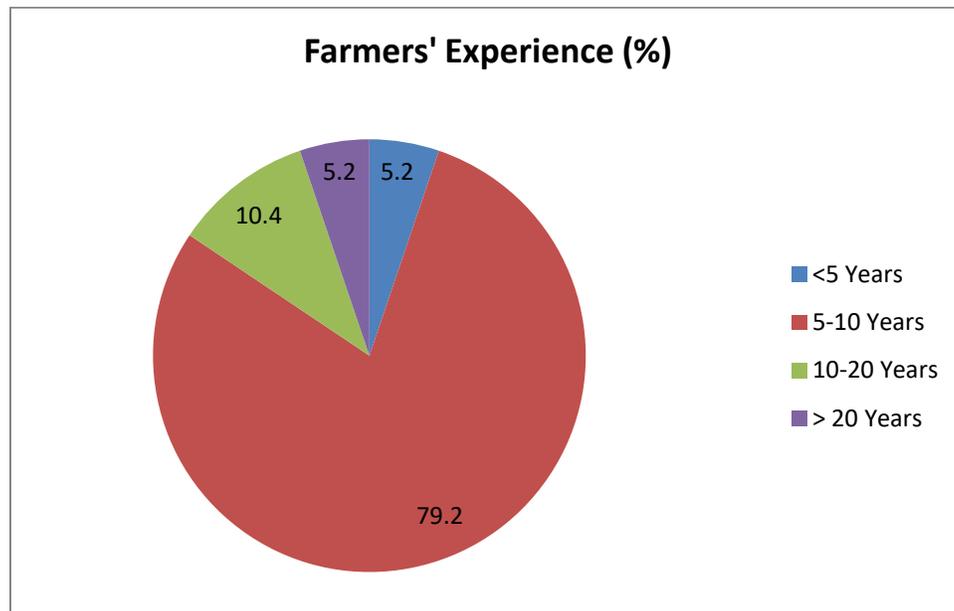


Farmers' Experience

An experienced farmer adopts the necessary knowledge and skills to effectively and efficiently operate various farming practice such as tilling of land, planting, application of

pesticides and fertilizers, keeping of farm records, etc compared to an inexperienced farmer. Figure 5 shows that 79.2 percent of the farmers have 5-10 years working experience in farming. 10.4 percent of the farmers have been farming between 10 to 20 years. Coincidentally, 5.3 percent of the farmer had less than 5 year and above 20 years' experience in farming activities. The study found that majority of the farmers in the area have experienced farmer.

Figure 5: Farmers' Experience



Farmers Annual Income

Generally, farmers' incomes are categorized into different types such as low-income, middle-income, and high-income earners. In this study, there is no clear boundary between the incomes farmers earn annually. Figure 6 below shows that 46.4 percent of the farmer's annual income is in the range of 201 thousand to 300 thousand in the study area. And between 100 thousand to 200 thousand incomes is earned by 13.3 percent of the farmer. While 25.3 percent of the farmers earned between 301 thousand to 400 thousand Naira incomes per annum. Also, only 6 percent, 7.2 percent and 2.8 percent respondents earned annual income in the range of less than 100 thousand, 401 thousand to 500 thousand and above 500 thousand naira respectively. The study found that majority of the farmers in the study area are low income earners, meaning that on average they earn between 17 thousand and 25 thousand naira monthly which is far below the monthly minimum wage approved by government in 2024.

Figure 6: Farmers' Annual Income

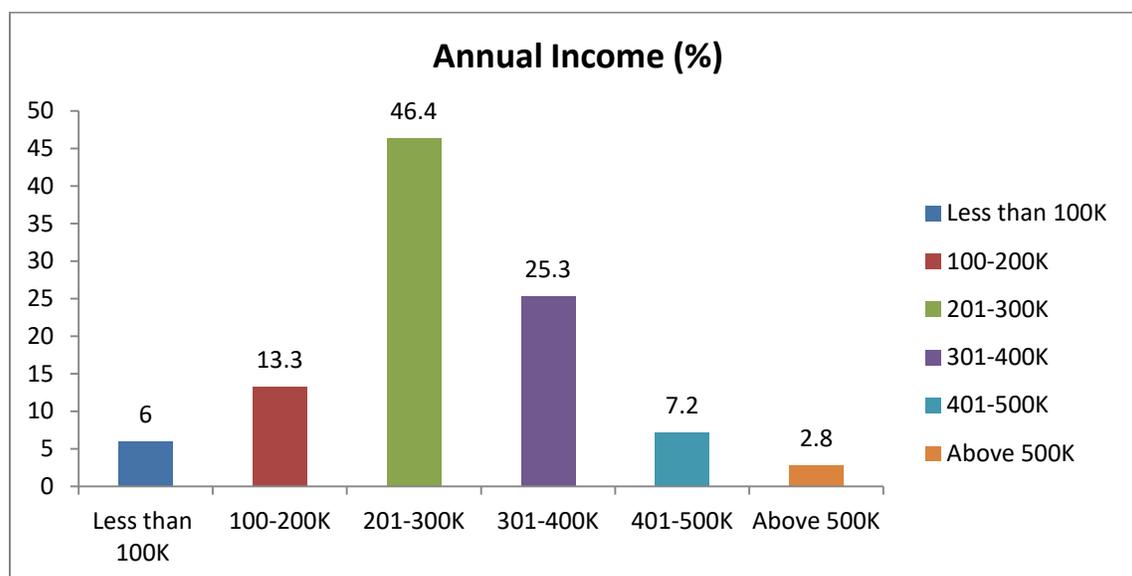


Table 2: OLS estimates

Dependent Variable: lnAOT				
Variable	Coefficient	Std. Error	t-statistics	prob.
lnTPR	-0.025	0.003	-8.333	0.001
lnRFL	0.031	0.015	2.113	0.007
lnDEF	-0.570	0.243	-2.345	0.031
lnFTA	0.227	0.111	2.045	0.053
lnPST	0.029	0.008	3.623	0.012
lnFLD	-0.096	0.118	-0.813	0.172
C	39.060	4.608	8.476	0.001
F.value: 25.91 p = 0.000 R ² : 0.661 adj R ² : 0.642 D.W: 1.49				

In this study, table 2 above shows the estimated impact of climate change variables on agricultural output in Wukari local government area of Taraba state based on data collected from 385 farmers.

F-value: 25.91; R square value: 0.661; and Adj R²: 0.642. The OLS result shows that the overall regression model is statistically significant since $p=0.000$. The Adj R-squared value is 0.642. This suggests that approximately 66% of the variations in agricultural output were explained by the independent variables temperature (TPR), rainfall (RFL), deforestation (DEF), flood (FLD), fertilizer (FTA) and Pesticides (PST). While remaining 34% variations were affected by some other variables outside the model. The table also shows that the Durbin Watson test value (1.49) is greater than R² (0.661). Since the value of Durbin-Watson test is greater than R²

hence OLS result is not spurious. The table also confirms that F test value is 25.91 with a significance of prob. Value of 0.000 demonstrating that the model is statistically significant.

The estimated results of agricultural output in Wukari Local government area of Taraba state, Nigeria using the Cobb-Douglas production function shows that five parameters, namely temperature (TPR), rainfall (RFL), fertilizer (FTA) Deforestation (DEF) and Pesticides (PST) indicate that coefficients of these five independent variables are statistically significant since, $p=0.001, 0.007, 0.03, 1, 0.053, 0.012$ respectively. Meanwhile, coefficient of flood (FLD) is not statistically significant because of $p=0.172$ respectively. It is obvious that temperature, deforestation and flood have a significant negative impact on agricultural output, while rainfall, fertilizer and pesticide have a positive impact on agricultural output.

Returns to Scale

Return to scale describe how output changes when all inputs are increased or decreased proportionally in the long run (Ahuja, 2009). From the above table it is evident that the sum of the coefficients is less than 1, which represents the law of diminishing returns. From above table the study found that $\beta_1+\beta_2+\beta_3+\beta_4+\beta_5+\beta_6=0.108$, which means that by holding technology constant, an increase in all inputs by the same amount will reduce agricultural output by the less proportion. Since we have seen that F value with a significance of 0.000, this indicates that overall model is statistically significant that means all the variables have a significant impact on agricultural output simultaneously.

Individual Test of Variables

- **Temperature (TPR)**

The regression coefficient of temperature rate displayed a negative and significant relationship at 5% level of significance. It indicates that holding all other factors constant, 1 percent increase in temperature (severe heat and severe cold) will lead to agricultural output to decrease by -0.025. The consequences of the finding is that as temperature increase there is that tendency that the soil will lose it moisture and the fertility of the soil will drastically reduce thereby reducing output. Severe temperature makes plants and animals to wither, shrink or dry up from lack of water. The result is in agreement with studies conducted by Nasir, Shahriar and Sohag (2024), Ogbuabor and Egwuchukwu (2017), Renee (2019) and Parry et al (2007).

- **Rainfall (RFL)**

The regression coefficient of rainfall is significant at 5% level of significance. The coefficient shows a positive impact of rainfall on output. It indicates that considering all other factors

constant, 1 percent increase in rainfall will increase yield by 0.031 percent. This also means that 1 percent decrease in rainfall will decrease agricultural output by 0.031 percent. The implication is that adequate rainfall provides water to plants and animals for hydration. It helps plants for nutrient transportation and photosynthesis. Rainfall is crucial for plant germination, overall growth and output. Inadequate rainfall has been one of the factors responsible for low agricultural productivity in Wukari. It was observed literally last year 2024, rain fall started properly by July and stopped by October, just four months cycles instead of the usual 7 months raining season. This according to the farmers has depleted output. Nasir, Shahriar and Sohag (2024), Ogbuabor and Egwuchukwu (2017), Renee (2019) and Parry et al (2007) studies are in consonant with the study result.

- **Deforestation (DEF)**

The regression coefficient of deforestation is significant at 5% level of significance. The coefficient shows a negative impact of deforestation on agricultural output. It indicates that considering all other factors constant, 1 percent increase in deforestation will decrease yield by 0.570 percent. Deforestation exposes the soil to erosion, which wash away the soil nutrient for plant to grow. Making land less fertile, increasing desertification, disrupting climate and ecosystem, leading to less oxygen and more extreme weather, ultimately decreasing plant and animal productivity and survival. The implication of the finding is that as the forest is depleted without due afforestation, rainfall will reduce, temperature will increase severely and plant soil will be exposed to erosion which adversely affect plant growth and output. Nasir, Shahriar and Sohag (2024), Ogbuabor and Egwuchukwu (2017), Renee (2019) and Parry et al (2007) studies are in consonant with the study result

- **Fertilizer (FTA)**

The regression coefficient of fertilizer is statistically significant at 5% level of significance. The regression coefficient of fertilizer is positive, 0.227. It indicates that considering all other factors constant, 1 percent increase in fertilizer will increase the agricultural output by 0.227 percent. The result is in alignment with Nasir et al (2024) study. Fertilizer as a product of technology is inevitably an important factor in production function of agricultural output as stated in the Cobb-Douglass production function. The implication of the finding is that as more fertilizers are applied, vital nutrient such as Nitrogen (for leave), Phosphorous (for roots, flowers, seeds), and Potassium (for overall plant strength and water movement) are supplied and replenished. It will also enhance plant growth and yield, improve plant health, improve soil fertility and increase plant quality which translates to increase in output.

- **Pesticides (PST)**

The regression coefficient of pesticide is also significant at 5% level of significance. The coefficient displayed a positive relationship, 0.029. This indicates that 1 percent increase in pesticides will increase the gross output by 0.029 percent considering all other factors constant. The implication of the result is that as farmers increase the application of pesticides, crops and animals will be protected from pests which will boost yields, improve quality, and lower labor costs. The result is also in corroborates the study conducted by Nasir et al (2024).

- **Flood (FLD)**

The regression coefficient of flood is statistically insignificant at 5% level of significance. The regression coefficient is negative, -0.096. It indicates that holding all other factors constant, 1 percent increase in flood will decrease the gross output by 0.096. Ogbuabor and Egwuchukwu (2017) study align with the findings of study. Although, the effect is insignificant, but its general effect is detrimental on plant and animals, mainly by causing oxygen deprivation in the root zone, which disrupts essential physiological processes like respiration and photosynthesis as well as nutrient deficiency, toxin accumulation and energy crisis on plants and animals.

CONCLUSION

In this study, the researchers investigated the effect of climate change (Temperature, rainfall, deforestation and flood) and various inputs (fertilizer and pesticides) on agricultural output in Wukari local government area in Taraba state, Nigeria. The Cobb-Douglas production function was adapted to estimate the effects of temperature, rainfall, deforestation, flood, fertilizer and pesticide on agricultural output in the study area, The findings of the study show that all the variables significantly affect agricultural output, except flood (FLD) that is insignificant. In analyzing the regression results, it became obvious that environmental factors, particularly temperature, rainfall and deforestation, play an essential role in determining agricultural output in Wukari local government. However, flood, although important, do not exhibit the same level of significance as environmental factors in this study. The estimated results reveal that temperature (TPR), deforestation (DFR) and flood (FLD) are found to have a negative relationship with agricultural output. On the other hand, rainfall (RFL), fertilizer (FTA) and pesticide (PST) display a positive relationship with agricultural output. In course of the study, majority of the survey respondents lamented about the high cost and unavailability of essential agricultural inputs in the area.

RECOMMENDATIONS

- Nigerian government should develop and implement policies to curb flood and forest depletion. Specifically, a National Climate Change Commission is required in Nigeria to deal with all climate change issues.
- Government should use a predictable technology to track flood and rainfall as well as construction of dams that will trap excess water during years of heavy rainfall.
- Government should evolve policies that will alleviate the cost of essential inputs such as fertilizers and pesticides that will enable farmers to obtain a more output and equitable return from their harvest.
- Temperature now has become a monumental issue for Wukari as it is increasing every year. Government should train Experts that develop technology capable of diminishing the negative impacts of temperature either by developing drought resistant seedlings and animals.
- Serious campaign against deforestation should be embarked upon by the government and NGO'S enlightening citizens to plant trees and the need to preserve existing forest.

SCOPE FOR FURTHER STUDY

In view of the scope and limitations of this study, some issues related to the study were not attempted but were felt. Therefore, further research should explore on effect of climatic and anthropogenic factors on agricultural storage and food supply.

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