ANALYSIS OF CLIMATE CHANGE INCIDENCE AND ITS IMPLICATION ON THE YIELDS OF GRAIN LEGUMES IN KADUNA STATE, NIGERIA

BY

Murtala, M.,[1*] Yusuf, Y.O.[2], Adamu, A.[3], Aminu, A.[4]

[1]Department of Geography, Sule Lamido University, Jigawa State, Nigeria
[2]Department of Geography and Env. Mgt. Ahmadu Bello University, Zaria, Nigeria
[3]Department of Geography, Bayero University, Kano, Nigeria
[4]Department of Geography, Jigawa State College of Education, Gumel, Jigawa State, Nigeria
Corresponding Author's Email: maarufmurtala@gmail.com

ABSTRACT

Increasing productivity in agriculture depends heavily on a number of factors including weather and climate conditions. Crop yield, biodiversity water use, health as well as soils are directly affected by a changing climate. Climate Change incidence is one of the major problems of Nigeria's agricultural system. This paper analyzed climate change incidence and its implication on the yields of grain legumes in Kaduna State, Nigeria. Thus, yields of grain legumes rainfall and temperature data for the periods of thirty (30) years (1987-2016) were sourced and analyzed from the National Bureau of statistics, Abuja, National Agricultural Extension and Research Liaison Services, Zaria and Nigerian Meteorological Agency, Abuja. Standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) were used to test for the normality in the seasonal rainfall series (April to October) for the study area. Similarly, relationship between Climate data (rainfall and temperature values) and cowpea yield were tested using Bivariate correlation analysis. The result revealed that Z_1 (rainfall=0.23 and temperature=0.21) and Z_2 (rainfall= -0.38 and temperature=0.88) for the study area were accepted as normal at 95% confidence level. The results of the correlation analysis indicated a positive (weak) relationship between rainfall and temperature values and yields of grain legumes. In view of this, the study recommended the need for development of comprehensive agricultural and climate change policy that takes into account the risks of grain legumes yields particularly in the study area.

Keyword: Climate change, Grain legumes, Rainfall, Temperature

INTRODUCTION

Climatic change could be viewed in either absolute or relative terms (Hulme, 2020). The weight of scientific evidence indicates that human induced global climate changes is occurring and is having biophysical, social and economic impacts at local, national, regional and global scales. It is likely to become more severe over the coming decades (Building Nigeria's Response to Climate Change, BNRCC, 2011). Like in many developing countries, climate change has become a major threat to the attainment of sustainable agricultural development in Nigeria (National Environmental, Economic and Development Study, NEEDS, 2010). Increased human activities such as fossil fuel combustion, land-use changes and agricultural activities have increased considerably and have therefore increased the amount of carbon dioxide, nitrous oxide and methane by 30%, 45% and 15% respectively, in the atmosphere. This has exacerbated the magnitude and pattern of global warming and subsequently, climate change in the country (Odekunle, 2010). The current trend of highly variable weather events has posed a great challenge to agricultural activities including grain legumes production potentials in the country generally.

Grain legumes include some of the major food and industrial crops of Nigeria (Saba, et al., 2020).The major grain legumes grown in country include cowpea, soybean, groundnut, and so on. Apart from their uses as food for man and feed for animals, the crops are used for exports, production of oil, wines and soap in many parts of the world, particularly, in the Middle East (International Fund for Agricultural Development, IFAD, 2019). Nigeria has untapped potential for increasing Gross Domestic Product (GDP) in the utilization of grain legumes (Muhammad, 2015).

At present, Nigeria is the largest producer and the consumer of grain legumes particularly cowpea worldwide, with about 5 million ha and over 2 million tones production annually and per capital consumption of about 25 to 30 kg per annum (Apata, Samuel and Adeola, 2009). A recent research carried out by Murtala (2019) has shown that grain legumes could be used to offset the major impacts of climate change because of their unique position as staple for the growing populations. Grain legumes are considered more tolerant to climate change because of their tendency to form a deep taproot (Food and Agricultural Organization, FAO, 2015). In Nigeria, particularly the study area, grain legumes are of major importance to the livelihoods of millions of people providing nourishment and an opportunity to generate income. Trading fresh produce and processed food and snacks provides rural and urban women with the opportunity for earning cash income; and as a major source of protein, minerals and vitamins in daily diets, its positive impacts on the health of women and children (Ole, Anette & Awa, 2009).

Grain legumes which traditionally have constituted an important component in the daily protein needs of most people in Northern Nigeria have shown a decline in recent years (Saba, et al., 2020). This low yield could be attributed to factors like unfavourable climatic conditions, low soil fertility, insect pests, diseases and parasitic weeds (all of which are directly attributed to the effects of climate) (International Crops Research Institute for the Semi-Arid Tropics, ICRISAT, 2017). It is therefore, obvious, that, despite the huge contribution grain legumes to national development, including the provision of food and income to the people of Northern Nigeria (Kaduna state inclusive), climate change has caused a serious decline in the yields of these valuable crops in Nigeria including Kaduna state (Abubakar and Yamusa, 2013). Climate and other factors such as soil fertility, pests and diseases are the major determinants of crop yields in agriculture. Thus, any disruption in the normal function of these factors, especially changes in the state of climate, could severely affect the yields of crops over time (Adejuwon and Ogunkoya, 2006).

An important prerequisite for efficient intensification of agricultural production is an understanding of climate-crop relationships. Although, the effects of short term weather fluctuations on yields of grain legumes have been well recognized for a long time, but they have not been well studied and understood in Nigeria, especially in Kaduna State where it is generally observed that the weather is favourable for crop production (Murtala, 2019). There have been researches on the implications of climate change on crop productions in developing countries (notable studies conducted are: Intergovermental Panel of Climate Change, IPCC, 2007; Brown 2009; Ayinde 2010; Oyerinde, Chuwang and Oyerinde, 2013, Murtala, 2019, and so on). However, these studies have not empirically established the localized incidence of climate change and its implication on yield of grain legumes particularly in Kaduna state to the best of the researchers' knowledge. This study therefore, seeks to contribute to knowledge by analyzing climate change incidence and its implication on the yield of grain legumes in Kaduna State, Nigeria.

THE STUDY AREA

Kaduna State is located between Latitudes 09° 02'N to 11° 32'N and Longitude 06° 15'E to 08° 38'E. It shares common borders with Katsina State to the North, Nassarawa State and the Federal Capital Territory, Abuja to the South, Kano and Bauchi States to the Northeast, Zamfara State to the Northwest, Niger State to the West, and Plateau State to the Southeast (Figure 1).

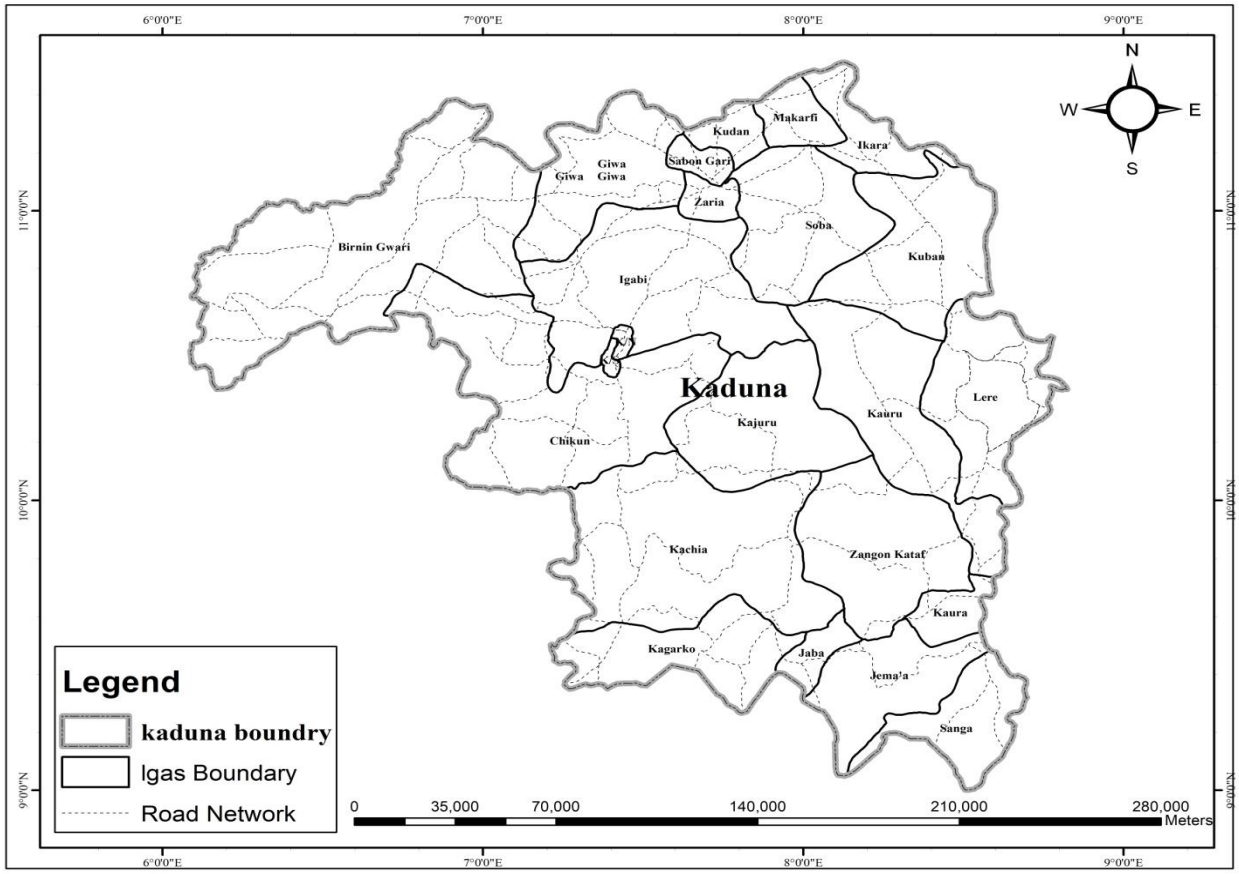

Figure 1: Study Area
Source: Adapted from Administrative Map of Kaduna State

The climate of Kaduna State is tropical wet-and-dry type (Koppens' Aw climate). The wet season lasts from April through October with a peak in August, while the dry season extends from November of one calendar-year to April of the next (Murtala, et al., 2018). The annual average rainfall varies from about 1733 mm at the extreme southern part of the zone to about 600 mm at the extreme northern part (Abaje, et al., 2016). The rainfall intensity is very high between the months of July and August (Murtala, et al., 2018). The pattern of rainfall in this region is highly variable in spatial and temporal dimensions with an inter-annual variability of between 15 and 20% (Abaje, 2016).

The climate is dominated by the influence of the relative warm and moist tropical maritime (mT) air mass, which originates from the Atlantic Ocean associated with Southwest winds in Nigeria; and the relatively cool, dry and stable Tropical continental (cT) air mass that originates from the Sahara Desert and is associated with the dry, cool and dusty Northeast Trades known as the Harmattan (Odekunle, 2010; Murtala, et al., 2018). These two air masses (mT and cT) meet along a slanting surface called the Inter Tropical Discontinuity (ITD). The movement of the ITD northwards across northern part of this zone in August (around latitude 21 to 22°N)

marks the height of the rainy season in the whole zone while its movement to the southernmost part around January/February (approximately at 6°N) marks the peak of the dry season in the zone (Abaje, et al., 2017). The movement of the ITD is very irregular, varying according to the season from 2° to 5.6° of latitude per month, and the southward retreat of the ITD is faster than its northward advance. While the northward advance is at the rate of about 160 km per month, that of the southward retreat is at about 320 km per month (Ayoade, 2005). This accounts for the rather gentle onset of the rainy season in the zone and its rather abrupt end (Abaje, 2016). The highest average air temperature normally occurs during the hot season (March to May) while the lowest average air temperature occurs during the cold season (December to February) (Abaje, et al., 2017).

The geology of the study area is underlain by gneisses, migmatites and metasediments of the Precambrian age which have been intruded by a series of granitic rocks of late Precambrian to lower Palaeozoic age (Murtala, 2019). The whole State is covered by savanna vegetation consisting of Guinea savanna and Sudan savanna with the density of trees and other plants decreasing as one move northwards. More than half of the study area is covered by ferruginous tropical soils which are mostly formed on granites and gneiss parent material, and on aeolian and many sedimentary deposits characterized by River Kaduna (Abaje, et al., 2017). Major rivers in the state therefore, include: Kaduna, Kagun, Gurara, Matsirga and Galma rivers (Murtala, 2019).

The total population of the state was put at 6,113,503, with 3,023,065 females and 3,090,434 males (National Population Commission, [NPC], 2007). The major economic activity in the state is agricultural production which is carried out mostly by smallholder peasant farmers in both the rainy and dry seasons. This is the reason why FAO (2015) observed that more than three quarters of Nigeria's agricultural area is rain fed. Increasing the potential of rain fed agriculture would make a significant impact on the food production. Thus over 90% of the population is engaged in farming activities. Others are into civil services, local trading and other menial non-agricultural occupations such as artisanship, among others. Farming activities are majorly cropping and animal husbandry and some limited finishing industrial activities. The major crops grown in the state are grains such as cowpea, millet, sorghum, maize and groundnuts, onions, cotton. Other crops cultivated are: yams, rice, soya beans and sweet potato and also in small quantities Irish potato (Murtala, 2019).

Both rainfall and dry season irrigation agriculture as well as livestock production are practiced in the study area. As a result of agricultural activities, the state has been facing a lot of environmental challenges. For example, insufficient grasses and shrubs for grazing of animals has been causing eventual famine and death of both humans and animals; deforestation is active in the region contributing significantly to climate change leading to destruction of lives and properties. However, if planning is done, these catastrophes can be averted or ameliorated. This is one of the major thrust of the present study.

MATERIALS AND METHODS

A reconnaissance survey was carried out in the study area. The main objective of the survey was for the researcher to become familiar with the study environment in terms of various agricultural activities, authorities and agencies in the study area. This study was based on secondary source of data. Grain legume particularly cowpea was scoped to be the focused of this study due to its importance in terms of consumption and high economic value, among the major grain legumes by the populace in the study area. Thus, the yield of cowpea was employed in this study, (yield/hectare) covering a period of thirty (30) years (1987-2016) obtained from the National Bureau of Statistics (NBS), Abuja, and National Agricultural Extension and

Research Liaisons Service (NAERLS), Zaria, Kaduna State, while monthly rainfall and Temperature data for the same period were obtained from the archive of the Nigerian Meteorological Agency (Nimet) (Table 1).

Table 1: Meteorological Station Kaduna State, Nigeria

Stations	Station No.	Latitude	Longitude	Altitude	Period	No. of years
Kaduna State	1007.34	10°36'N	07°27'E	644.96m	1987-2016	30

Source: Nigeria Meteorological Agency (NiMet).

The standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) statistics as defined by Brazel and Balling (1986) were used to test for the normality in the seasonal (April to October) rainfall series for the station. These are the months during which most of the stations in the state receive over 85% of their annual rainfall totals (Ati, Iguisi and Afolayan, 2007). The standardized coefficient of Skewness (Z_1) was calculated using:

$$Z_1 = \left[\left(\sum_{i=1}^{N}(x_i - \bar{x})^{3/N}\right) \Big/ \left(\sum_{i=1}^{N}(x_i - \bar{x})^{2/N}\right)^{3/2}\right] \Big/ \left(6/N\right)^{1/2} \text{ ---------- (1)}$$

and the standardized coefficient of Kurtosis (Z_2) was determined by:

$$Z_2 = \left[\left(\sum_{i=1}^{N}(x_i - \bar{x})^{4/N}\right) \Big/ \left(\sum_{i=1}^{N}(x_i - \bar{x})^{2/N}\right)^{2}\right] - 3 \Big/ \left(24/N\right)^{1/2} \text{ ---------- (2)}$$

Where $\bar{x}$ is the long term mean of x_i values, and N is the number of years in the sample. These statistics were used to test the null hypothesis that the individual temporal samples came from a population with a normal (Gaussian) distribution. If the absolute value of Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at 95% confidence level.

Trend analysis of temperature, rainfall values and grain legumes were carried out using Microsoft Excel Tool (2016). Similarly, the relationship between temperature values and the yield of grain legume (cowpea), and also rainfall and the yield of grain legume in the study area were tested using Bivariate correlation analysis. This is represented as:

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2}\sqrt{\sum(y - \bar{y})^2}} \text{ ---------- (3)}$$

Where:

r = Correlation coefficient

Where: x and y = individual observations of dependent and independent variables respectively

$\bar{x}$ and $\bar{y}$ = Mean of dependent *(x)* and independent *(y)* variables respectively.

The correlation coefficient was tested at 0.05 significance level and 95% confidence level. The decision rule is to; accept the H_O if the P-value is greater than 0.05 and reject H_O if otherwise. The yields of grain legume were used as dependent variables and rainfall and temperature values respectively as the independent variable.

RESULTS AND DISCUSSION

General Statistics of Rainfall and Temperature Data

The general statistics of rainfall and average temperature of Kaduna (1987-2016) is presented in Table 2. The results of the standardized coefficient of Skewness (Z_1) and Kurtosis (Z_2) for the station were accepted as normal at 95% confidence level. Therefore, no transformation was made to the rainfall and temperature series. Table 2 shows the general statistics.

Table 2: General Statistics of Rainfall and Temperature

Attributes	Rainfall (mm)	Temperature (°C)
Skewness (Z_1)	0.23	0.21
Kurtosis (Z_2)	-0.38	0.88
Standard Deviation	207.2	0.43
Range	787.4	2.05
Minimum	848.9	24.9
Maximum	1636.3	27

Source: Authors' Analysis

The minimum amount of rainfall (848.9mm) was recorded in 2008 while the maximum amount (1636.3mm) was recorded in 2013. Similarly, the standard deviation was 207.2 which is an indication of high rainfall variability in the study area. On the other hand, the study area recorded its annual minimum temperature of 24.9°C in 1989 while the maximum temperature (27.0°C) was recorded in 2009.

Trends of Rainfall, Temperature and Yields of Grain Legume

The result of the trend analysis of mean annual rainfall and annual yields of grain legume is presented in Figure 2. The result shows that yields of grain legume appear to be influenced by rainfall during the study period. The linear trend lines for both the mean annual rainfall and annual yield of grain legume showed an increasing trend. Increasing trends for grain legume (Y=4643.4x+540027) at the rate of 0.0428 percent per annum, while, rainfall also shows an increasing trend (Y=7.8374x+1093.8) at the rate of 0.1109 percent per annum. The increasing trend in rainfall is an indication of climate change incidence in the study area. This finding is in agreement with the result of Murtala, *et al*., (2018) that most of the synoptic stations in northern Nigeria have been witnessing increasing annual rainfall in recent years.

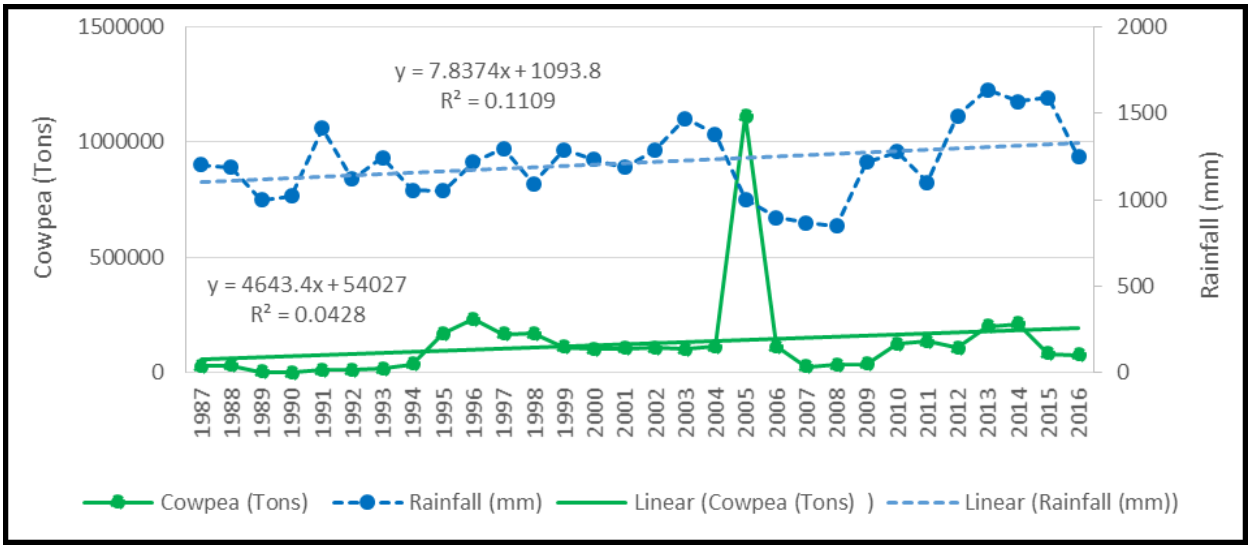

Figure 2: Trends of Rainfall and Grain Legume 1987-2016

The result of the trend analysis of average temperature and annual yield of grain legume is presented in Figure 3. The result shows that cowpea yields appear to be influenced by temperature during the study period. The linear trend lines for both the average temperature and annual yield of grain legume showed an increasing trend. Increasing trends for cowpea (Y=4643.4x+540027) at 0.0428 percent per annum and an increasing average temperature (Y=0.00266x+25.242) at 0.3042 percent per annum. The increasing temperature is also an indication of climate change in the study area. This result concurs with the findings of Abaje, et al., (2017), who found an increasing temperature for the period of 40 years (1975-2014) in Kaduna state.

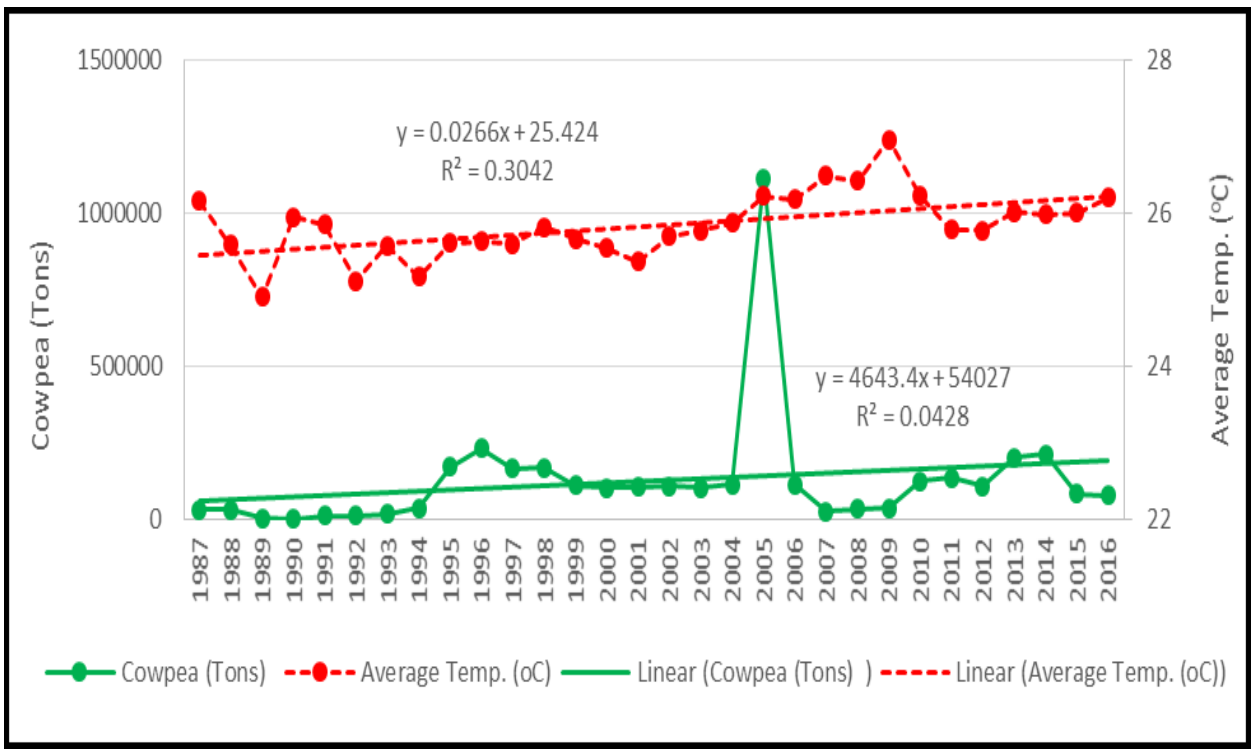

Figure 3: Trends of Average Temperature and Grain Legume 1987-2016

Relationship between Rainfall, Temperature and Yields of Grain Legume

Yields of grain legume in the study area appear to be similarly influenced by rainfall and temperature during the study period. Table 3 provides the correlation coefficient of annual rainfall values and yields of grain legume and, while Table 4 shows the average temperature and yields of grain legume in Kaduna State respectively (1987-2016).

Table 3: Relationship between Annual Rainfall and Yields of Grain Legumes in Kaduna State

Parameter	Observations	Standard Error	t Stat	P-value	F	R. Square
Intercept	30	221747.7	0.859496	0.3973	0.08723	0.0031
Rainfall (mm)		179.9628	-0.29535	0.7699		

Source: Fieldwork, 2020

The correlation analysis in Table 3 indicates the t- ratio for the average rainfall is 0.29535 with an associated P-value of 0.7699. The hypothesis is therefore accepted since p-value is greater than 0.05. This information reveals that there is no significant correlation between average rainfall values and yield of grain legume in Kaduna State. Similarly, the coefficient of determination (R^2) is 0.0031 or 0.31% indicating positive (but, weak) relationship between averages annual rainfall and yields of cowpea in the study area. The implications of this findings means there could be further decreased of this vital grain legume in the study area, which could be severe. It could result to untold hardship to the farmers and consumers in general. ICRISAT, (2017), observed that this grain legume supplies a substantial amount of the daily protein needs of most of its consumers.

Table 4: Relationship between Temperature and Yield of Grain Legume in the study area

Parameter	Observations	Standard Error	t Stat	P-value	F	R. Square
Intercept	30	2237729	-0.8387	0.4087	0.801243	0.0278
Average Temp.		86600.18	0.895122	0.3784		

Source: Fieldwork, 2020

The result in Table 4 shows that the t- ratio for the average temperature is 0.8951 with an associated P-value of 0.3784. This information reveals that there is no significant correlation between average temperature and yield of grain legume in Kaduna State. Similarly, the coefficient of determination (R^2) is 0.0278 or 2.78% indicating positive (but, very low level) relationship between averages temperature and yields of grain legume in the study area. This implies that, areas suitable for grain legumes production could be negatively affected further by this low relationship, particularly, the yield potential of grain legumes in the study area.

Thus, the relationship between annual rainfall and yields of grain legume is weak. In addition, the relationship between average temperature and yields of grain legume is also low. It is could be said that rainfall and temperature have some impact on the yield of grain legume. Low or weak relationship experienced in the study area could be as a result of the changing climatic conditions in the study area. This finding is in agreement with the result of Food and Agricultural Organization (FAO, 2017) which reported that although higher temperatures can improve crop growth, studies have documented that crop yields decline significantly when daytime temperatures exceed a certain crop-specific level. Ayanwuyi et al. (2010) also reported that temperatures, water vapour and rainfall are all factors that have effects on cowpea outputs at any stage from cultivation through the final harvest.

CONCLUSION

Based on the foregoing, there are grounds to conclude that before ascribing annual variations of a particular crop to rainfall or temperature, it must be assumed that some other climatic and biophysical factors remain constant. In view of this, it could be concluded from this result that Climate and the grains of legume (yields) particularly in Kaduna state of Nigeria, are fluctuating. As a whole, the yields indicated a low or weak relationship when correlated with annual rainfall and average temperature. Thus it could be concluded that, this weak or low relationships could be attributed to the influence of other factors, especially management practices in the study area. In view of this, there is need for the development of a comprehensive agricultural and climate change policy that takes into account the risks associated with cowpea yield among farmers. Therefore, Government policies in this area should be based on recent rainfall and temperature trends.

REFERENCES

Abaje, I.B. (2016). *Assessment of Rural Communities' Perceptions, Vulnerability and Adaptation Strategies to Climate Change in Kaduna State, Nigeria*. Unpublished PhD Thesis, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Abaje, I.B., Abashiya, M., Onu, V. & Masugari, D.Y. (2017). Climate Change Impact and Adaptation Framework for Rural Communities in Northern Nigeria. *JORIND*, 15 (2), 142-150.

Abaje, I.B., Sawa, B.A., Iguisi, E.O. & Ibrahim, A.A. (2016). Impacts of Climate Change and Adaptation Strategies in Rural Communities of Kaduna State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 9 (1): 97 – 108.

Abubakar, I.U. & Yamusa, M.A. (2013). Recurrence of drought in Nigeria: Causes, effects and mitigation. *Journal of Agriculture and Food Science Technology*, 4 (3): 160-180. Retrieved from: http://ww.ripublication.com/ijafst.htm. February 20, 2016

Adejuwon, J.O. & Ogunkoya, O.O. (2006). *Climate Change and Food Security in Nigeria.* Ile-Ife: Obafemi Awolowo University Press.

Apata, T.G., Samuel, K.D. & Adeola, A.O. (2009). Analysis of Climate Change perception and Adaptation among Arable food crop farmers in Southwestern Nigeria. *Paper presented at the conference of International Association of Agricultural Economics*, 2 – 9.

Ati, O.F., Iguisi E.O. & Afolayan J.O. (2007). Are we experiencing drier conditions in the Sudano – Sahelian Zone of Nigeria? *Journal of Applied Science Research*, 3 (12): 1746-1751. Retrieved 25 – 06 - 2009, from http: //www.insinet.net/jasr/2007/1746-1751/ pdf.

Ayanwuyi, E. K., Oguntade, F.A. & Oyetoro, J. O. (2010). Farmers perception of impact of climate change on food production in Ogbomosho Agricultural zone of Oyo State. *Nigerian Journal of Human Social Sciences*, 10 (7): 33-39.

Ayinde, O. E. (2010). Empirical analysis of agricultural production and climate change: A case study of Nigeria. *Journal of Sustainable Development in Africa*, 12 (6): 345-353

Ayoade, J.O. (2005). *Introduction to Agroclimatology* (2nd ed.). Ibadan: University Press Plc.

Brazel, S.W. & Balling, R.C. (1986). Temporal analysis of long-term atmospheric moisture levels in Phoenix, Arizona. *Journal of Climate and Applied Meteorology*, 25:112-117.

Brown, M. E. (2009). Markets, Climate Change and Food Security in West Africa. *Environmental Science and Technology*, 43, 8016-8020.

Building Nigeria's Response to Climate Change (BNRCC) Project (2011). *National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN).* Federal Ministry of Environment Special Climate Change Unit.

FAO (2015). Experts' Recommendations on Fats and oils in human nutrition. Report of Joint Export Consultation Food and Agricultural Organization Food and Nutrition paper (57): Rome.

FAO (2017). Cowpea: Post-harvest Operations. Food and Agricultural Organization, Rome, Italy.

Hulme, M. (2020). Climates Multiples: Three baselines, two tolerance, one normal. *Academia Letters*. Article 102, https://doi.org/10.20935/AL102.

Ole, M.C., Anette, M., & Awa, D. (2009). Farmer's perceptions of climate change and Agricultural strategies in Rural Sahel. *Journal of Environmental Management*, 4(3) 804-816.

ICRISAT, (2017). Agrometereology of sorghum and millet in the semi-arid tropics. *Proceedings of an International symposium*, 15-20 November 2017, ICRISAT Centre, Pantancheru, India. 322.

IPCC (2007): Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, Switzerland.

International Fund for Agricultural Development (IFAD) (2019). The Future of World Food and Nutrition Security: Investing in smallholders agriculture- an International priority. Retrieved 20-10-20 from https://www.ifad.org/en/topics/tags/food-and-nutrition-security/1952762.

Murtala, M., Iguisi, E.O., Ibrahim, A.A., Yusuf, Y.O., Abaje, I.B. & Inobeme, J. (2018). Spatio-Temporal Analysis of Rainfall Trends in Northwestern Nigeria. *Nigerian Journal of Scientific Research*, 17 (4), 389-397.

Murtala, M. (2019). *Effects of Drought on Groundnut Yields in Northwestern Nigeria*. Unpublished PhD Thesis, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Muhammad, H. (2015). *Determinations of Inputs Demand and Adoption of Grain Legumes and Associated Technologies of N2Africa in Kano State, Nigeria*. Unpublished PhD Thesis, Department of Agricultural Economics and Extension, Bayero University, Kano, Nigeria.

NPC (1991). Census News Publication, 3(1), National Population Commission. Lagos, Nigeria.

NPC (2007). Population Census of the Federal Republic of Nigeria: Analytical Report of the National Level, National Population Commission, Abuja

NEEDS (2010). Climate Change in Nigeria: Special Climate Change Unit. Final draft September, 2010: National Environmental, Economic and Development Study. Federal Ministry of Environment, Abuja, Nigeria.

Odekunle, T.O. (2010). An Assessment of the Influence of the Inter-Tropical Discontinuity on Inter-Annual Rainfall Characteristics in Nigeria. *Geographical Research,* 48(3):314 326.

Oyerinde, A.A., Chuwang, P.Z. & Oyerinde, G.T. (2013). Evaluation of the effects of climate change on increased incidence of cowpea pests in Nigeria. *Journal of Plant Protection Sciences*, 5 (1): 10-16

Saba, B.M., Ishiyaku, F.M., Tongoona, B.P., Gracen, V., Daniel, K.D., Muhammad, I. U. & Sulaiman, U. (2020). Farmers' knowledge, perception and use of phosphorus fertilizer for cowpea production in Northern Guinea savannah of Nigeria. *Heliyon Journal*, (6), 5207.