THE EFFECTS OF RAINFALL VARIABILITY ON CROP-YIELD IN GIWA LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

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ABSTRACT
The impact of rainfall parameters on selected grains' yield in a tropical setting was examined. The study design involved the collection and analyses of data on rainfall parameters and maize, sorghum and millet yield at Giwa LGA in Kaduna State for 30 years (1991-2021); data was collected from NiMet station at Nigerian College of Aviation Technology (NCAT), Zaria and Monitoring and Evaluation Unit (MEU) of Kaduna State Agricultural Development Project (KADADP), Kaduna state respectively. The data was analyzed using correlation and regression analysis to establish cause and effect relationship between rainfall parameters and yield of selected grains in the study area. The relationship between rainfall variability and grains' yield revealed that the effect of length of rainy season, onset, cessation date and volume of rainfall on maize yield revealed the values of 0.694, 0.979, 0.334 and 0.667 respectively. This indicate that 69%, 97%, 33% and 66% of the variation in maize yield in Giwa LGA is explained by rainfall parameters. Furthermore, the effect of length of rainy season, onset, cessation date and volume of rainfall on millet yield revealed the value of 0.519, 0.989, 0.196 and 0.224 respectively. This indicate that 51%, 98%, 19% and 22% of the variation in millet yield in Giwa LGA is explained by rainfall parameters. Also, the effect of length of rainy season, onset, cessation date and volume of rainfall on sorghum yield revealed the value of 0.833, 0.852, 0.570 and 0.735 respectively. This indicate that 83%, 85%, 57% and 73% of the variation in sorghum yield in Giwa LGA is explained by rainfall parameters. The study recommends the application of irrigation technology, use of appropriate management practices that ensured moisture conservation and improved crop species with shorter growing periods/less moisture consumption as adaptive measures to the changing rainfall pattern within the study area.

INTRODUCTION

Agriculture is an essential sector of every economy with high capacities for employment generation, food security and poverty reduction (Momoh, 2016). It remains the chief source of livelihood for most pastoral families in developing countries. In Sub – Saharan Africa, agriculture provides employment to more than 70% of the population and contributes about 26.5% of gross domestic product (GDP) and about 60% export earnings (Kazoka, 2013). In Nigeria, the agricultural sector which is predominantly subsistence-based and primarily rain-fed, employs about 70% of the population and contributes about 40% to the GDP (Mkonda and He, 2017)). However, these potentials remain largely untapped, as the region experiences unstable rainfall patterns due to climate change which ultimately results in uneven and declining yields of staple food crops with significant effects on household food security (Omoyo et al, 2015)

Rainfall is the most important climatic factor that effects agricultural activities particularly in the tropical region; it provides the water that serves as a medium through which nutrients are transported for crop development. Hence, insufficient water supply has adverse effects on efficient crop growth, resulting in low productivity (Ndamani and Watanabe, 2015). Rainfall can vary considerably even within a distance of few kilometers and on different time scales, thereby determining the farming system, timing of farming operations, the crops that can be grown, the sequence and the yield (Hamzat et al, 2017). Rainfall variability therefore has been observed to be a critical threat to sustainable agricultural production.

In Nigeria, erratic and prolonged delays in rainfall have been observed to significantly influence its overall food production, particularly cereals (maize, sorghum, millet rice and many others) crops, which form the major staple food nationwide (Sani and Chalchisa, 2016). Other negative effects of variability in rainy season onset, cessation dates and duration include the transmission of vector-borne diseases and insect pests, since the life cycle of these disease transmission-vectors is sensitive to the variability and changes in temperature and rainfall (Manzanas et al, 2014; Wang et al, 2019). The evaluation of the effects of the onset, cessation dates and duration of the rainy season on crops yield and the identification of effective adaptation approaches employed to improve crop production is therefore crucial to the success of agricultural activities within the country (Leonard et al, 2015).

The rainfall characteristics of Nigeria have been examined by (Itiowe et al, 2019) for changes (prevailing trend) and the results show that there has been a progressive early retreat of rainfall over the whole country spanning up to half a century now and consistent with this pattern, there has also been a significant decline in rainfall frequency, the number of rain days in September and October which

respectively coincide with the end of the rainy season in the northern parts of the country.
Against this backdrop, this research was aimed at examining specifically the effect of rainfall variability on the yields of maize, sorghum and millet in Giwa L. G. A., Kaduna State and identifying the most effective adaptation strategies adopted in the area.

STUDY AREA
Giwa, a Local Government Area in Kaduna State, Nigeria, is located between Latitudes 10º50´ N and 11º30´ N and Longitudes 7º00´ E and 7º47´E as presented in Figure 3. It has a total area of about 2,066km^2 (Ochiche et al, 2013). It is bordered by Funtua Local Government Area of Katsina State in the north, Birnin-Gwari in the west, Zaria in the east and Igabi Local Government in the south (Fig 1).
Giwa experiences a typical tropical continental climate with seasonal regimes of oscillating cold to hot and dry to humid seasons. The area experiences the Aw (tropical wet and dry) climate type according to Koppen's climatic classification scheme. The mean annual rainfall varies from 1005 to 1012mm (ZEMDA, 2017). The type of rainfall experienced in Giwa is generally convective. The mean atmospheric temperature of Giwa ranges between 39℃ and 41℃ in the raining season while during the hamattan, it drops to between 27℃ and 32℃. However, at evening, temperatures may drop to as low as 25℃ at this period.

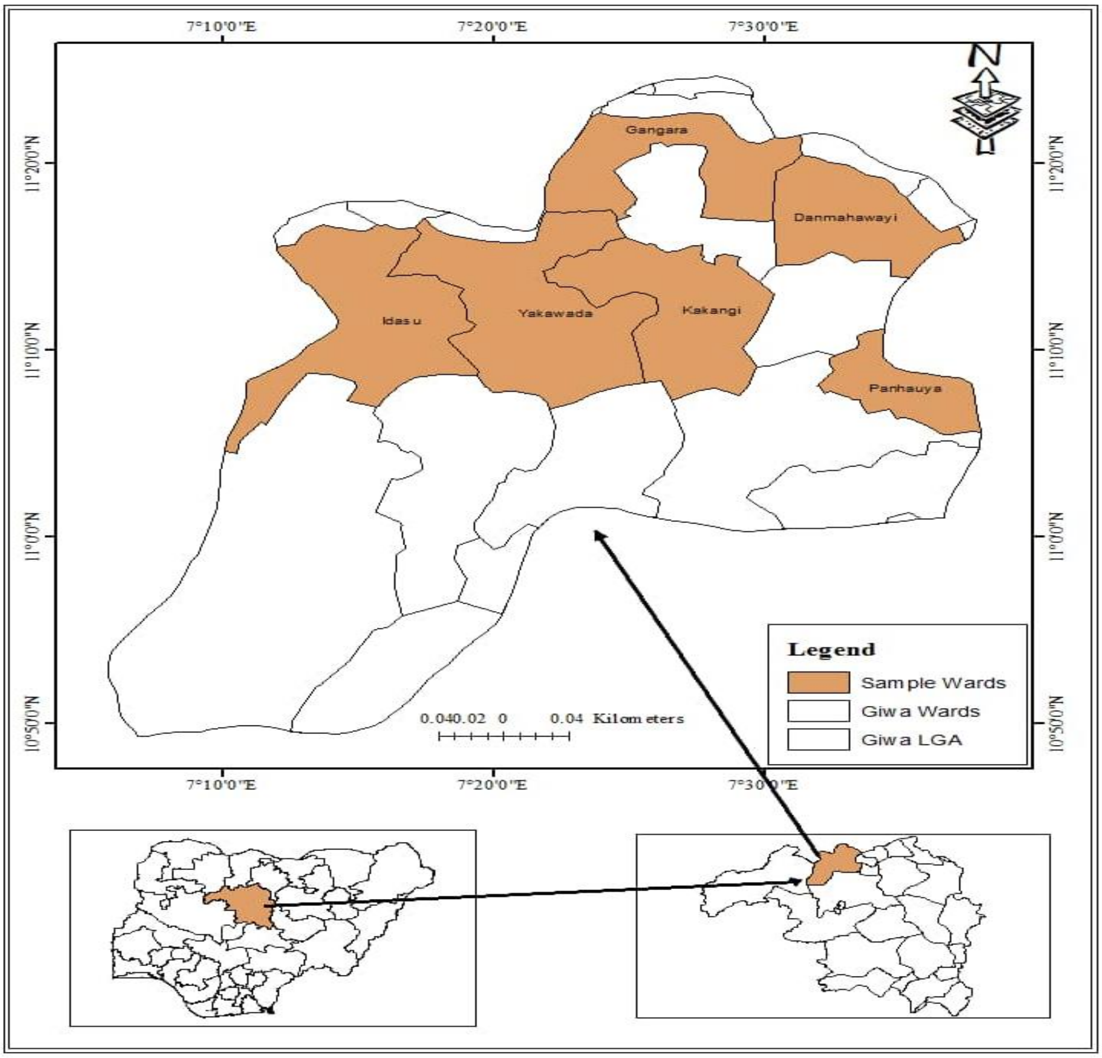

Figure 1: Giwa LGA showing sample wards.

Giwa Local Government Area lies in the northern guinea Savanna type of vegetation which is typified by tall grass and short scattered trees and shrubs; a product of tropical wet-dry climate which is transitional between that of the hot desert and the tropical forest. The general vegetation of Giwa is referred to as the northern guinea savanna, implying wood land vegetation characterized by well-developed grass layer and the existence of the indigenous *Faidherbia albida* (acacia), *Adansonia digitata* (baobab), *Balanites aegypt*iaca (aduwa) and *Isobelina doka* trees (Bishop, 2018).

METHODOLOGY
Giwa Local Government Area was purposively selected for this research because of its prominence in

the production of maize, sorghum and millet. Multi-stage sampling technique was adopted for this study. Monthly rainfall records (mm) for Giwa Local Government Area for thirty (30) years (1990-2020) was obtained from the Institute for Agricultural Research (IAR), A. B. U., Zaria, while the yearly yield of maize, sorghum and millet (tons/ha) in the study area for the study period was obtained from the Monitoring and Evaluation Unit (MEU) of Kaduna State Agricultural Development Project (KADADP), Kaduna state. The population figure was obtained from the National Population Commission (NPC) and projected to 2020.

The parameters of rainfall considered for this study are the rainy season onset and cessation dates, total annual rainfall and number of rainy days in the hydrological growing season and length of raining season for each of the thirty years of investigation. Using the projected population figure, 400 copies of questionnaire were administered to key farming households purposively in 6 selected wards of the LGA. The sample sizes for the selected wards are as shown in Table 1.

Table 1: Samples Size for Selected Wards

S/No.	Selected wards	1991 population	2020 projection	Sample size
1	Danmahawayi	8,069	15,132	47
2	Gangara	20,850	39,099	122
3	Idasu	9,457	17,735	55
4	Kankagi	7,088	13,292	42
5	Panhauya	11,927	22,366	70
6	Yakawada	10,952	20,538	64
	Total	**68343**	**128,162**	**400**

The crops and rainfall data were converted to common base (log 10) using MINITAB software. This was so because the yield of crops was measured in tons per hectare (tons/ha) and rainfall in millimeter (mm). The Mann-kandall was used to examine the trends in onset dates, cessation dates, and length of rainy season, total annual rainfall and number of rainy days.

The relationship between the obtained rainfall parameters and crop yield was measured using correlation and multiple linear regression, using the Statistical Package for Social Scientists (SPSS), VERSION 20.0.

RESULTS AND DISCUSSIONS

Availability of Extension Services and Membership of Cooperative in the Study Area

It is apparent from Table 2 that majority of the respondents about (44.8%) stated that they do not get extension services, 36.0% acknowledged that they get the service quarterly, 10.3% affirms twice a year while 9.0% stated that they have contact with extension workers thrice in a year. This implies that the farmers do not get enough extension services in the study area. Also findings reveal that most grain farmers (86.6%) are members of a cooperative society while 13.4% responded in the negative, that they do not belong to any type of cooperative society. This implies that more than half of the respondents get funded by a cooperative, which will affect the farmers' ability to adapt to rainfall variability mitigation strategies.

Table 2: Membership of Cooperative and Visit of Extension Workers

Extension Workers	**Frequency**	**Percentage**
Yes	346	86.6
No	54	13.4
Total	**400**	**100**
Visit		
Twice a Year	41	10.25
Trice a year	36	9.0
Quarterly	144	36.0
No visit	179	44.75
Total	**400**	**100**

The findings of Nzeadibe et al. (2011), Idrisa et al.., (2012) and Otitoju, (2016) identified that poor extension services, lack of Information and appropriate adaptation option and credit to buy necessary resources and technology hinder climate change adaptation. Extension services have played a key role in promoting agricultural productivity in developing countries, and their role in promoting various adaptations to climate change is no less important. For example, Mizina et al., (1999) stated that given regional differences in climatic impacts, local experiments, as well as ensuring information flows, need to be encouraged. Customarily, extension services have generally been in the purview of services provided by government given that agricultural research is typically a public good. However, private and non-governmental agencies (or the formation of research cooperatives) do play a significant role in some countries. According to Evenson (1997), numerous studies, for example, in India, Kenya, and Burkina Faso have shown that there is strong evidence to link extension services with awareness and knowledge of agricultural practices.

Sources of Information in the Study Area

The sources of information for farmers in the study area are revealed in Table 3. The Table reveals that majority of the respondents (34.5%) get their information on rainfall variability and adaptation strategies from the television while a few (2.0%) get the same information from friends. This agrees with the findings of (Ayinde et al, 2010), Failure to implement adaptation options and poor agricultural performances by many African farmers has been blamed on lack of information and resources.

Table 3: Sources of Information and Types of Information Derived in the Study Area

Source	**Frequency**	**Percentage**
Television	138	34.5
Radio	212	53
Newspaper/magazine	29	7.25
Mosque/church	13	3.25
Friend	8	2.0
Total	**400**	**100**
Information Derived		
New varieties of seeds	121	30.3
Availability of fertilizer	191	47.8
Packaging and processing	47	11.8
Cultivation methods	29	7.3
Climate change	12	3.0
Total	**400**	**100**
Any Form of Training		
Yes	248	62.7
No	152	37.3
Total	**400**	**100**

Regarding the type of information, 47.8% of the farmers get information about the availability of fertilizer, 30.3% get information about new varieties of grain seed, 11.8% get information on packaging and processing, 7.3 get information on cultivation methods while 3.0% gets information about climate change. Farmers in Giwa LGA also get formal training on grains production as 62.7% of the respondents agreed to this view.

Pattern of Rainfall in the Study Area

Onset Date in the Study Area

The onset of rainfall can be described as the possible start of rainfall in a year. The trend of onset date for the years under study was analyzed and the result is presented in Figure 2.

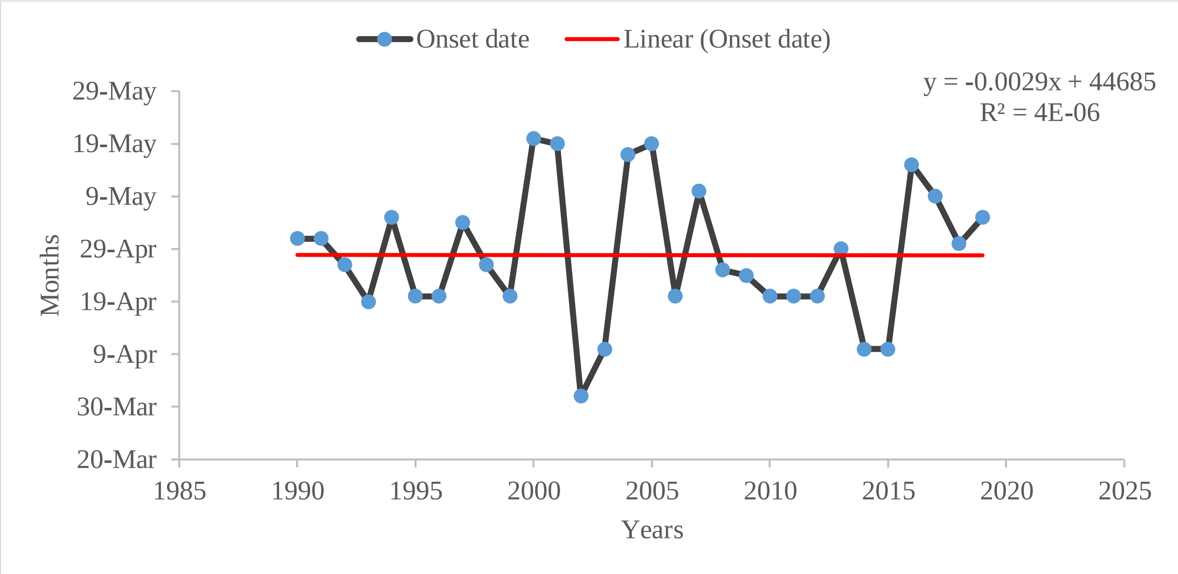

Figure 2: Onset Days in the Study Area

It is obvious from Figure 2 that the earliest onset dates for rainfall in the study area was 1st April (2002), the latest onset was 20th May (2000), while the mean onset for the period reviewed was 25th April. This signify that the onset dates have been erratic for the year under study. This agrees with the findings of (Elisha et al, 2020) who stated that the onset date of rainfall in Katsina LGA of Katsina state has also been erratic.

Cessation Date of Rainfall in the Study Area

The cessation date is a period that is characterized by the end of rainfall. The cessation date of the year under study was analyzed and the result is presented in Figure 3.

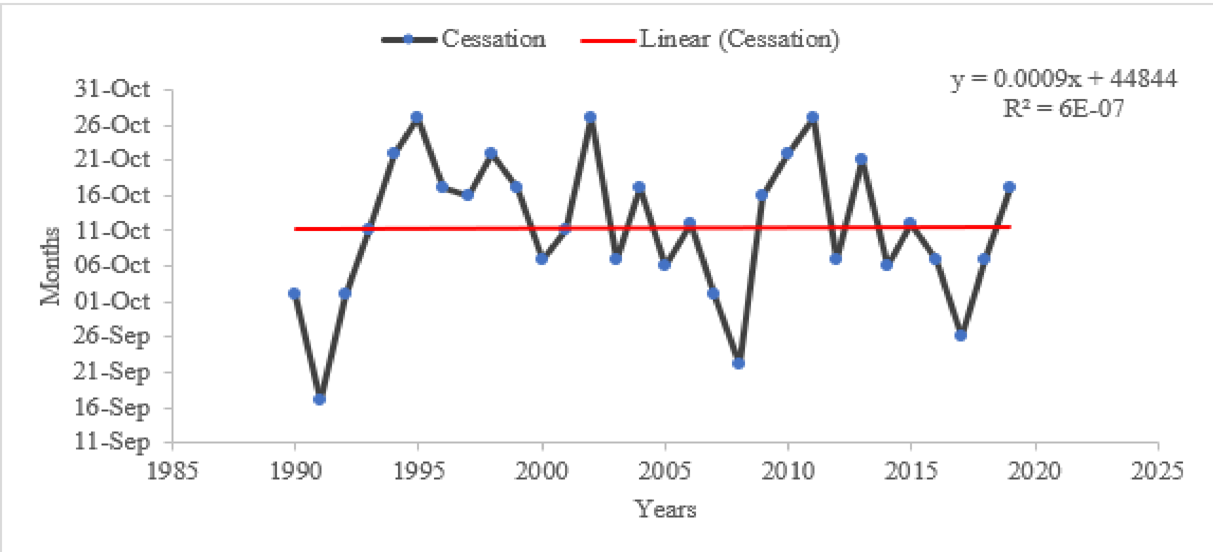

Figure 3: Cessation Date for the Study Area

It is evident from Figure 3 that the earliest cessation date for rainfall in the study area was 17th September 1991, the latest cessation was 27th October 2011, while the mean cessation for the period reviewed was 7th October. This implies that the cessation dates of the study area have been inconsistent for the year under study. This result affirms the findings of (Elisha et al, 2020) who stated that the cessation dates of rainfall in Katsina LGA of Katsina state has also been unpredictable.

Rainy Season Duration in the Study Area

The data on the length of rainy season was collected, analyzed and is presented in Figure 4.

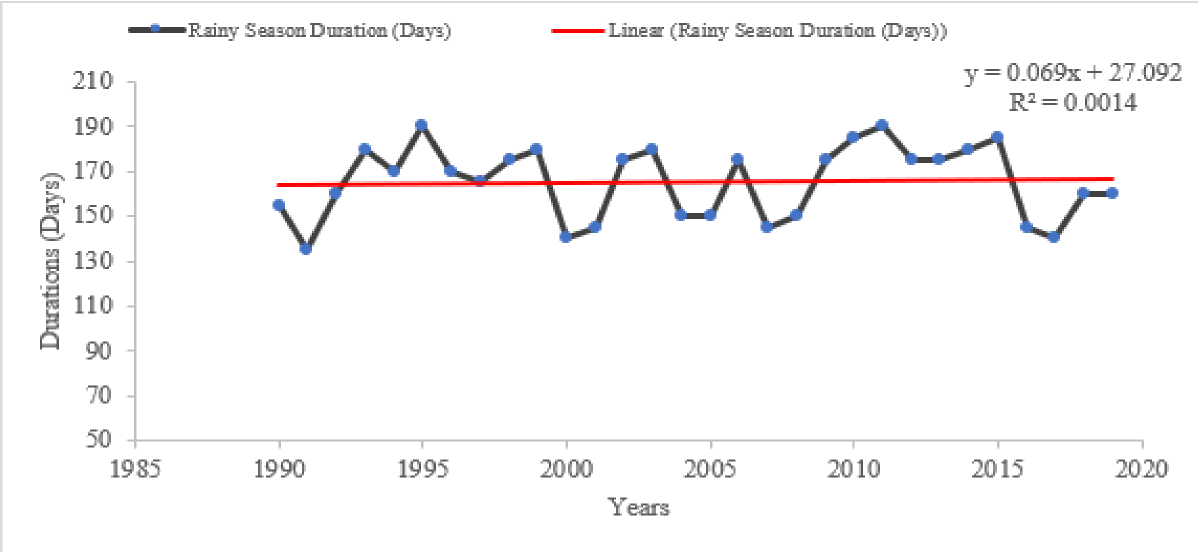

Figure 4: Rainy Season Duration of the Study Area

It is evident that 1991 has the least number of rainy days of 135 days while 2011 had the highest number of rainy days of 190 days within the study period. The mean duration of wet season under the year of study was 165 days with a standard deviation of 26days. The implication of the result in Figure 4 is that rainfall duration in the study area often lasts for 4-6 months which is a good duration recommended for both grain farming as opined by the International Institute for Tropical Agriculture (IITA). The above fact is further supported by the work of Food and Agriculture Organization (FAO, 2019) on crop water needs.

Annual Amount of Rainfall in the Study Area

The amount of rainfall is an important factor in successful crop production and the annual amount of rainfall is the average amount of precipitation a region receives. The amount of rainfall received in the study area is presented in Figure 5. It is evident from Figure 4.8 that 2008 has the least amount of rain with 1117.3mm while 2011 had the highest amount of rain with 1358.1mm under the study period. The mean duration of wet season under the year of study was 165 days with a standard deviation of 26 days. This implies that the annual amount of rainfall received in the area is sufficient for the farming of the selected grains in the study area. This is because the minimal range of 480 – 880mm of well distributed rainfall is adequate for the selected grains depending on the variety (Yashima et al, 2024).

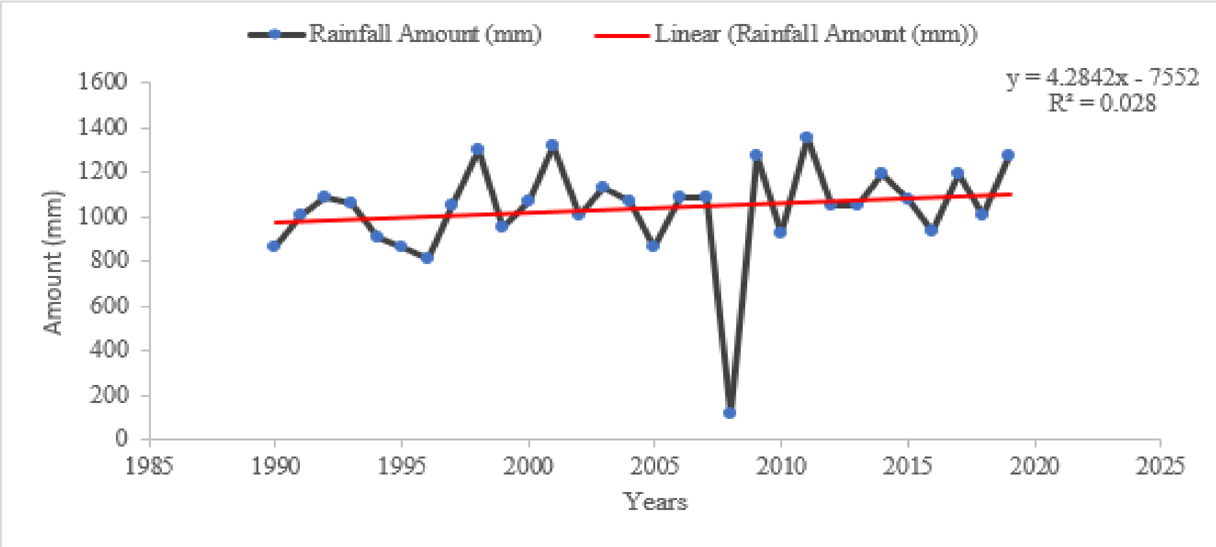

Figure 5: Amount of Rainfall in the Study Area

Relationship between Rainfall Parameters and Maize Production in the Study Area

The relationship between rainfall parameters (length of rainy season, onset dates, cessation dates and amount of rainfall) and maize was analyzed and the result is presented in Table 4.

Table **Error! No text of specified style in document.**: Relationship between Rainfall Parameters and Maize Field in the Study Area

Parameters	Standard coefficient
Length of rainy season	0.694
Onset dates	0.979
Cessation dates	0.334
Volume of rainfall	0.667

Table 4 reveals that the effect of length of rainy season, onset, cessation date and volume of rainfall on maize yield revealed the value of 0.694, 0.979, 0.334 and 0.667 respectively. This indicate that 69%, 97%, 33% and 66% of the variation in maize yield in Giwa LGA is explained by rainfall parameters. This shows that rainfall parameters in the study area increases maize yield with onset date having the most effect of 97%. This is supported by the findings of Traore *et al.*, (2013), who reported variability in crop yields as a result of rainfall onset and cessation in Mali.

Relationship between Rainfall Parameters and Millet Production in the Study Area

The relationship between rainfall parameters (length of rainy season, onset dates, cessation dates and amount of rainfall) and millet was analyzed and the result is presented in Table 5.

Table 5: Relationship between Rainfall Parameters and Millet Field in the Study Area

Parameters	Standard coefficient
Length of rainy season	0.519
Onset dates	0.989
Cessation dates	0.196
Volume of rainfall	0.224

Table 5 reveal that the effect of length of rainy season, onset, cessation date and volume of rainfall on millet yield revealed the value of 0.519, 0.989, 0.196 and 0.224 respectively. This indicate that 51%, 98%, 19% and 22% of the variation in millet yield in Giwa LGA is explained by rainfall parameters. This shows that rainfall parameters in the study area increases millet yield with onset date having the most influence of 98%. This corroborates the findings of Omoyo et al, (2015) who revealed that rainfall parameters impact the yield of millet positively.

Relationship between Rainfall Parameters and Sorghum Production in the Study Area

The relationship between rainfall parameters (length of rainy season, onset dates, cessation dates and amount of rainfall) and sorghum was analyzed and the result is presented in Table 6.

Table 6: Relationship between Rainfall Parameters and Sorghum Field in the Study Area

Parameters	Standard coefficient
Length of rainy season	0.833
Onset dates	0.852
Cessation dates	0.570
Volume of rainfall	0.735

Table 6 reveals that the effect of length of rainy season, onset, cessation date and volume of rainfall on sorghum yield revealed the value of 0.833, 0.852, 0.570 and 0.735 respectively. This indicate that 83%, 85%, 57% and 73% of the variation in sorghum yield in Giwa LGA is explained by rainfall parameters. This shows that rainfall parameters in the study area increases sorghum yield with onset date having the most influence of 85%. This implies that sorghum thrives well even when rainfall amounts increases. This result agrees with the findings of (Ati, and Akinyemi, 2018) who affirmed that rainfall variability influence the yield of sorghum in Kaduna State.

CONCLUSION

From the results obtained, it is concluded that farmers are aware of the climate change phenomenon which was made available to them through radio stations and other media of information. There is a concern that rainfall amount has been decreasing over time while temperatures have increased. Drought years are becoming more frequent than before, resulting in food shortages in the area. While this could also be due to other factors, trends of rainfall, temperature and dry spells provide evidence that rain-fed agriculture in the study area is vulnerable to the impact of rainfall variability. While both minimum and maximum temperature trends have increased as a result of increasing temperature and rainfall variability, farmers seem to experience variation in grains yield especially when there is obvious fluctuation in rainfall. It affects their crops yield and productivity in general. As the rainfall increases, crop yield increases and vice versa.

REFERENCES

Ati, M. H., and Akinyemi, M. (2018). A Comparism of Sorghum Yield between Local Varieties in Turare, Katsina State and Sorghum Hybrids from IAR Zaria, Kaduna State.

Ayinde, O.E., Adewumi, M.O., Olatunji, G.B., and Babalola, O.A. (2010) Determinants of Adoption of Downy Mildew Resistant Maize by Small-Scale Farmers in Kwara State, Nigeria. *Global Journal of Science Frontier Research* 10(1)

Bishop, S. (2018). *Effects of Rural Outward Migration on Agricultural Activities in Giwa Local Government Area of Kaduna State Nigeria*. Department of Geography and Environmental Management, Faculty of Physical Science, Ahmadu Bello University, Zaria, Nigeria.

Elisha, I., Joseph D. A., and Solomon U., N., (2020). Trends in rainfall onset, cessation and length of growing season and its implication on sorghum yield in Katsina State, Nigeria. *Gombe Journal of Geography and Environmental Studies*: 1(3).

FAO, (2019). Crop Water Need; Crops Need Water for Transportation and Evaporation.

Hamzat, M. O., Ojo, O. I. and Onifade, T. B. (2017). Impact of Weather Variability on Yam Yield in South Western Nigeria. SSRN *Electronic Journal,* 1:1-18.

Idrisa, Y. (2012) Analysis of Awareness and Adaptation to Climate Change among

Farmers in the Sahel Savannah Agro-0ecological Zone of Borno State, Nigeria. *British Journal of Environmental and Climate Change* 2(2)

Kazoka, H. M. (2013). *Farmers Adaptation to Rainfall Related Climate Variability Risks and Their Implication on Food Security in The Semi-Arid Sikonge District in Tanzania.* M. Sc Thesis in Agricultural Economics, Sokoine University of Agriculture, Morogoro, Tanzania.

Manzanas, R., Frias, M. D., Cofino, A. S,. and Gutierrez J. M. (2014). Validation of 40-year multimodal seasonal precipitation forecasts: the role of ENSO on the global skill. *Journal of geophysics.* 1708-17.

Mizina, S.V., Smith, J.B., Gossen, E, Spiecker, K.F. and Witkowski, S.L. (1999) An Evaluation of Adaptation Options for Climate Change Impacts on Agriculture in Kazakhstan. *Scopus*

Mkonda, M. Y., and He, X. (2017). *Yields of the Major Food Crops: Implications to Food Security and Policy in Tanzania's Semi-Arid Agro-Ecological Zone.* Sustainability, 9(8), 1490.

Momoh, A. O. (2016). *Analysis of Production Efficiency and Profitability of Maize Farmers in Giwa Local Government Area of Kaduna state, Nigeria.* Published M. Sc. Dissertation, Ahmadu Bello University, Zaria.

National Population Commission (NPC), (2009). *1991 Population Census Report for Kaduna State, Nigeria*. htt:/www.population.gov.ng/index.php/Kaduna-state.

Ndamani, F. And Watanabe, T. (2015*). Influences of Rainfall on Crop Production and Suggestions for Adaptation.* International Journal of Agricultural Sciences, 5 (1):367-374

Nzeadibe, C., Egbule, C., Chukwuone, N. and Agu, V.C. (2011) Indigenous Innovations for Climate Change Adaptations in the Niger Delta Region of Nigeria. *Environment, Development and Sustainability* 14(6)

Ochiche C. A., Ajake A. O. and Okpilia F. I. (2013). Spatiotemporal Distribution of Rural Market in Bewarra Local Government Area of Cross River State, Nigeria. *Journal of Humanities and Science*. 16 (3), 104-112

Omoyo, N. N., Wakhungu, J. and Oteng'i, S. (2015). *Effects of Climate Variability on Maize Yield in the Arid and Semi-Arid Lands of Lower Eastern Kenya*. Agriculture & Food Security, 4 (8): 43-54.

Otitoju, M.A. (2016) Climate Change Adaptation: Uncovering Constraints to the use of Adaptation Strategies among Food Crop Farmers in Southwest Nigeria using Principal Component Analysis (PCA) *Cogent Food and Agriculture* 2(1)

Sani, S. and Chalchisa, T. (2016). Farmers' Perception, Impact and Adaptation Strategies to Climate Change among Small Holder Farmers in Sub- Saharan Africa: a systematic review. *Journal of Resources Development Management*, vol 26. Pgs 1-8

Traore, B., Corbeels, M., Van, W. M. T., Rufino, M. C., and Giller, K. E. (2013). Effects of climate variability and climate change on crop production in southern Mali. *European Journal of Agronomy*: 49(1) 115-125.

Wang, Y., Zhang, J., Song, G., Long, Z. and Chen, C. (2019). Impacts of recent temperatures rise on double-rice phenology across Southern China," *International Journal of Plant Production*, 13 (1):1–1

Yashima, R., Terata, Y., Sakamoto, K., Watanabe, M., and Takeshita, K. (2024) *Paraburkholderia largidicola* sp. nov., a gut symbiont of the bordered plant bug *Physopelta gutta, International Journal of Systematic and Evolutionary Microbiology*, 74(6)

Zazzau Emirate Development Association (ZEMDA), (2017)