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DECADAL CHARACTERISTICS OF TEMPERATURE TRENDS OVER CONTRASTING CLIMATIC BELTS OF NIGERIA FROM 1980 – 2019.

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ABSTRACT

Rainfall and Temperature are very important elements and factors of weather and climate needed in the successful sustainable agricultural and water resource planning. Therefore, this study Examine the decadal characteristics of rainfall trends over contrasting climatic belts of Nigeria from 1980 – 2019. Rainfall and temperature data were obtained for the study from Nigerian Meteorological Agency (NiMet), Abuja while ginger yield data were collected from the experimental farms of National Root Crops Research Institute (NRCRI), Umudike, Agricultural Development Programme (ADP) and Nigerian Bureau of Statistics, Abuja. These data covered a period of 40 years (1980 -2019) and were analysed using simple linear regression, correlation and Analysis of Variance (ANOVA). Results obtained showed that the Tropical Monsoon Climate belt, there has been a steady rise from the first decade of 1980-1989 with temperature values of 26.9oC to the last decade of 2010-2019 with temperature values of 28.6oC. This represented a rise of 1.7oC. In the Warm Desert Climate, the temperature dropped from the first decade 1980-1989 to the second decade of 2000-2009 with a difference of 0.3oC. The temperature value still reduced further in the third decade with difference of 0.1oC and also in Warm Semi-arid Climate belt. Temperature increased in this belt following the pattern witnessed in the Tropical Monsoon Climate, although not with the same magnitude. The rise in temperature represented 1.2oC. Based on the results, the decadal temperature of the four climate belts are increasing in line with the global trend. WDC recorded the highest increase in rate followed by TS, TM and WSC accordingly. This study therefore recommends that, farmer education on the changing climate, and the relevance of agricultural planning to sustainable income should be championed by government and all concerned; while developing a root crop blueprint for farmers and input into farming in funds and machinery.

Keywords: Tropical Monsoon, climate belt, Temperature trends, Rainfall trends, Nigeria

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INTRODUCTION

Climate change is the world's most pressing environmental issues and among the serious natural dangers influencing all sectors of the economy around the world in the twenty- first century including agriculture which all the performance is primarily determined by the increasingly variable climate (Arbuckle *et al*., 2013, Harun *et al*., 2014). The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2013) provided clear evidence of climate change based on its obvious impact and manifestations in agricultural productivity. Generally, the impacts of climate change are projected to have enormous and devastating global consequences on the global scale, but the most adverse impacts are predicted to occur in developing countries due to their fewer resources to cope with, and adapt to, the changing conditions, which is due to their geographic location (within vulnerable and fragile environments) and their over-reliance on rain-fed agriculture, which is a climate-sensitive sector (Stern, 2007; IPCC, 2007; Omambia *et al*., 2010).

Although, the adverse effects of climate change such as high temperatures, heat waves, drought, extreme rainfall, and floods, are not new to Nigeria. The impacts of climate change are very comprehensive but its far reaching consequences are now clearly visible on agricultural sector, on which relies the food production and economy of the country. Even so, the climate projections for the 21st century and beyond, suggest that these events are likely to increase in frequency and intensity, projected increased rainfall intensity and rainfall patterns are likely to create problems for a region already affected by flooding as in southern Nigeria (Ekanem & Nwagbara, 2010). Schlenker and Lobell (2010) found higher adverse impact of climate change on millet, sorghum and maize when compared with root and tuber crops which is found to be resilient to climate change (Liu, *et al.*, 2008; Arize, Malindretos & Ghosh, 2015; Ankrah, Kwapong & Boateng, 2021).

Climate change, specifically, provides both opportunities and challenges for attaining the potential contribution of root and tuber crops for sustainable human development, and strategies are needed to address key issues in productivity; crop plant-soil/water/energy resources management, postharvest utilization, nutrition and health value addition, and trade and commercialization so that the role of root and tuber crops in ensuring sustainable development can be enhanced. Therefore, climate change may attenuate the ability of the country to achieve food and nutrition security height through weakening the sustainability of livelihoods, especially natural-based rural livelihoods and wipe-out development efforts. Global food security has become increasingly dependent on a limited number of varieties of a few major crops like rice, maize, cowpea and cassava, and in the wake of climate change, such a situation makes farmers more vulnerable with regard to their nutrition income and food security (Padulosi *et al.,* 2011). In the face of these situations, root and tuber crops play vital roles in alleviating hunger and poverty for the reason of their resilient capacity, relevant in adaptation and are able to cope with adverse changes posed by climate (Amujoyegbe *et al*., 2015).

Food and nutritional security are the major concerns in major countries of the world and many have potentials to contribute to sustainable food systems under climate change. To address the nutritional and food insecurity, it has become utmost important to diversify the present day agricultural system as well as to search for alternative food and feed ingredients. Root and tuber crops occupy a remarkable position towards food security of the developing world due to their high calorific value and superior carbohydrate content. Root and tubers are plants yielding starchy root and tuber, rhizomes, corms and stems. Root crops are edible energy-rich underground plant structures developed from modified roots while tuber crops are those crops in which the edible carbohydrate- rich storage organs develop wholly or partly from underground stems (Okigbo, 1989; Nanbol & Namo, 2019; Obisesan & Chitakira, 2020). Thus, the storage organ of root crops is of root origin while that of the tuber crops is of the stem origin. The major root crops are cassava and sweet potato while the major tuber crops are yam, cocoyam, potato and ginger. Root and tuber crops are frequently grouped together because they are bulky, perishable and vegetatively propagated (Amponsah, Hoggar, Yeboah & Asuamah, 2015; Arndt, Asante & Thurlow, 2015).

These roots and tuber crops occupy about 50 million hectares worldwide with an annual average production of 643 million metric tons (mt), 70% of which is harvested in developing countries (FAO, 1998 June accessed July). Among other things, farm households see the value of root and tuber crops in their ability to produce large quantities of dietary energy and in their stability of production under conditions where other crops may fail" (Alexandrators, 1995; Dhanker, 2018). The importance of Root and tuber crops to agriculture, food security, and income for over 2.2 billion people in developing countries cannot be over emphasized (GCP21, 2015). Many of the developing world's poorest and most food insecure especially Nigerians households look to roots and tubers as a contributing, if not the principal, source of food, nutrition, and cash income (Alexandratos, 1995; Amponsah *et al.*, 2015).

The major roots and tubers crops provide more than 50% of the total calorie requirements more than any other crop groups of Nigerians (Ukpabi, 2009). They are high yielding crop and are resistant to many pest and diseases, available all the year round, meet local food preferences, contain antioxidants that help in fighting against diseases by neutralizing free radicals, they also help in the synthesis of eye pigments and prevention of different eyesight disorder have high poverty and malnutrition reduction potentials for a developing country as Nigeria due to its low production cost (Lebot, Malapa, Molisale, & Marchand, 2013). They provide important sources of income through direct sale and value-addition via processing for food and non-food uses and play an important role in food security, nutrition and climate change adaptation. Considering all these, root and tuber crops could be the crops that will boost the food security and economic development in Nigeria in a more efficient and sustainable manner which is a prerequisite for all development. With the projected temperature increases (0.5°–1°C regardless of emission scenario) up to 2030 to 1°–2°C (very high scenario) increases by 2050, and beyond 2050 and 2°–4°C by 2090 and an increase of 25% and variability in mean annual rainfall climate change might pose a grievous threat to the production of these root and tuber crops. Since climate change does not manifest the same way throughout Nigeria based on its climatic characteristics; with heavy rainfall in the south and low rainfall in the north, and higher temperature in the north with moderate to low temperature in the south. Root and tuber crops will not be vulnerable to a particular kind of climate change. Its pattern of vulnerability will correspond to the dominance effect of climate change experienced in each climatic belt (UNPFA, 2013). Hence determining the impacts of climate change on root and tuber crops depends not only on the nature of climate change but the vulnerability of the regions and people that experience those changes (Khalaf & Urga, 2014; Mereu, Carboni, Gallo, Cervigni, &Spano, 2015; Ntiamoah, Li, Appiah-Otoo, Twumasi & Yeboah, 2022).

Vulnerability is a function of the character, scale, and rate of climate variation to which a system is exposed, its sensitivity, and adaptive capacity (Madu, 2012). The vulnerability of root and tuber crops to climate change in Nigeria is predicated on the high irregularities in rainfall characteristics such as late onset, long breaks and early withdrawal etc. and high temperature (i.e. abiotic) as well as effects arising from changes in the severity of pest pressures, availability of pollination services, and performance of other ecosystem services that affect agricultural productivity (i.e., biotic). These factors have a combined capacity of exposing these crops to different changes in climate durations and magnitude (Pelling, 2011). Thus, the vulnerability of any crop to changes in climate and other extreme climatic hazard is clearly predicated on the degree of exposures, sensitivities and adaptive capacities of the system. It is these three main elements that drive the assessment of vulnerability to natural system susceptibilities. It is on this premise that this study was proposed to ascertain the vulnerability of root and tuber crops yield to projected changes in climate in contrasting climate belts in Nigeria.

1.2 Study Area

Location and Extent

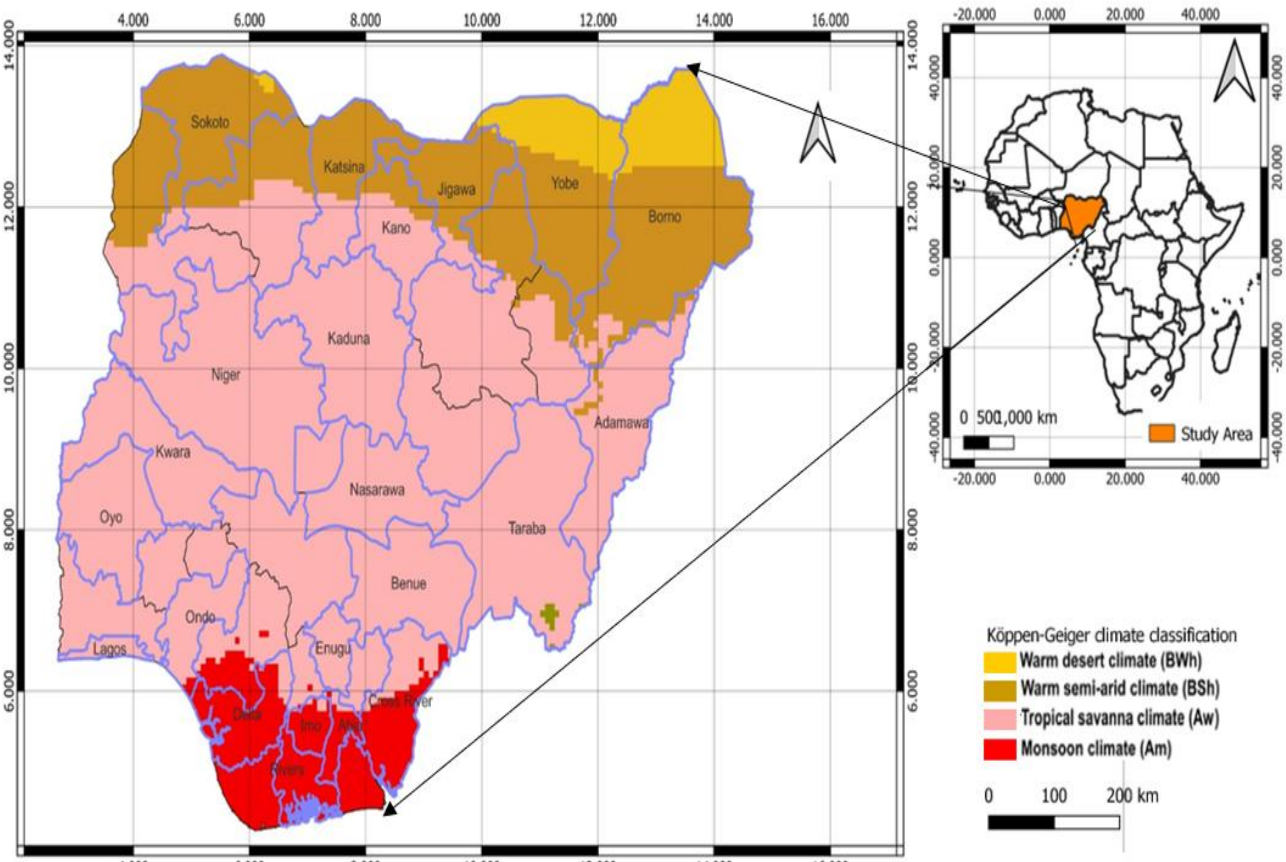

Fig.1: Map of Nigeria showing the study areas

Nigeria is a country located in West Africa along the Atlantic Ocean's Gulf of Guinea. Nigeria lies between longitudes 2°49'E – 14°37'E and latitudes 4°16'N – 13°52'N. It is bounded on the North by the Republic of Niger, East by Cameroon and West by Benin Republic while the Southern boundary is Gulf of Guinea which is an arm of the Atlantic Ocean (Ofomata, 1975). The map of Nigeria showing the selected locations from the contrasting climatic belts, is presented as figure 1

Nigeria is affected by four climate types; these climate types are distinguishable, as one moves from the southern part of Nigeria to the northern part through Nigeria's middle belt. They are; the Tropical Monsoon climate, The Tropical Savannah Climate or Tropical Wet and Dry climate, The Warm Semi-arid Climate or Tropical Dry climate is the predominant climate type, The Warm Semi-arid Climate or Tropical Dry climate is the predominant climate type.

Nigeria is covered by three types of vegetation: forests (where there is significant tree cover), savannahs (insignificant tree cover, with grasses and flowers located between trees), and montane land. (The latter is the least common, and is mainly found in the mountains near the Cameroon border.) Both the forest zone and the savannah zone are divided into three parts. Some of the forest zone's most southerly portion, especially around the Niger River and Cross River deltas, is mangrove swamp. North of this is fresh water swamp, containing different vegetation from the salt water mangrove swamps, and north of that is rain forest (Olajuyigbe & Adaja, 2014).

The Savannah zone's three categories are divided into Guinean forest-savanna mosaic, made up of plains of tall grass which are interrupted by trees, the most common across the country; Sudan savannah, similar but with shorter grasses and shorter trees; and Sahel savannah patches of grass and sand found in the Northeast (Mohammed, 2013).

1.3 Sampling Technique

The longitudinal, correlational and purposive research designs were employed in this study and the target population of interest comprises farmers selected from one local government across each of the states of study in Nigeria minding the climatic belts. One local government area in each state was purposively selected from the contrasting identified climatic belts in the country following Koppen’s Classifications. In order to determine the vulnerability of root and tuber crop to climate change, data on farmers awareness on root and tuber crops exposure, sensitivity and adaptive capacity to climate change were collected and the Taro Yamane (1967) formula was applied to arrive at a cumulative sample size of 400 respondents for this study, and the proportion equation was used to determine the number of respondents reached in each sample location. Purposive sampling technique was employed to select farmers in the respective local government selected from each state. The states are selected for better spatial spread, taking into consideration insecurity and areas well known for roots and tuber crops production. Since each of the root and tuber crops perform differently in contrasting climatic belts of Nigeria. For adequate distribution of questionnaire, the proportional allocation method was applied as stated above. The data were from all the Meteorological Stations in the selected states in the contrasting climatic and from questionnaires.

1.4 RESULTS

Table 4.8 revealed the decadal pattern of temperature across the climatic belts for four decades.

In the Tropical Monsoon Climate belt, there has been a steady rise from the first decade of 1980-1989 with temperature values of 26.9^{o}C to the last decade of 2010-2019 with temperature values of 28.6^{o}C. This represented a rise of 1.7^{o}C. However, the difference between the first (1980-1989) and second decade (1990-1999) was just a 0.3^{o}Crise. The second decade (1990-1999) had a degree temperature difference of 0.4^{o}C from the third decade (2000-2009). A deviation from normal is witnessed in temperature between the third (2000-2009) and last (2010-2019) decades with a temperature difference of (1^{o}C). In the Tropical Savanna Climate, a similar occurrence was to the pattern as observed in the Tropical Monsoon Climate. However, the difference between the first (1980-1989) and second decade (1990-1999) was just a 0.1^{o}C rise. The second decade (1990-1999) had a degree temperature difference of 0.9^{o}C from the third decade (2000-2009). A departure in temperature is witnessed between the third (2000-2009) and last (2010-2019) decades with a temperature value difference of (1.1°C).

In the Warm Desert Climate, the temperature dropped from the first decade 1980-1989 to the second decade of 2000-2009 with a difference of 0.3°C. The temperature value still reduced further in the third decade with difference of 0.1°C. However, at the last decade (2010-2019), the temperature increased with 0.9°C. In this climate belt temperature seemed less erratic, although high. Technically, there are factors that have sustained the hotness of this belt; chief amongst them is the Sahara Desert.

Table 1 Decadal characteristics of Temperature (°C) across the climatic belts in Nigeria

Decades	TM	D/Change	TS	D/Change	WDC	D/Change	WSA	D/Change
1980-89	26.9		26.9		28.4		25.4	
1990-99	27.2	-0.3	27.0	-0.1	28.1	0.3	25.6	-0.2
2000-09	27.6	-0.4	27.9	-0.9	28.0	0.1	26.0	-0.4
2010-19	28.6	-1	28.8	-1.1	28.9	-0.9	26.6	-0.6

N:B: TM=Tropical Monsoon; TS=Tropical Savanna; WDC= Warm Semi-Arid Climate; WDC=Warm Desert Climate; D/change=detected change..

Source: Author's data analysis

Finally, we have the Warm Semi-arid Climate belt. Temperature increased in this belt following the pattern witnessed in the Tropical Monsoon Climate, although not with the same magnitude. The rise in temperature represented 1.2°C. However, the difference between the first (1980-1989) and second decade (1990-1999) was just a 0.2°Crise. The second decade (1990-1999) had a degree temperature difference of 0.4°C from the third decade (2000-2009). A rise in temperature is observed between the third (2000-2009) and last (2010-2019) decades with a temperature difference of (0.6°C). It is crucial to realise that the temperature is highest at the Warm Desert Climate belt and quite lowest in the Warm Semi-arid Climate belt. The reason for this may be linked to the effect of the Jos plateau and lapse-rate assumptions. Nevertheless, the Tropical Monsoon Climate had a relatively very high mean annual cum decadal temperature. The factors that possibly accounts for these changes in the climate belt's temperature may be linked to the flaring of gas, illegal refining activities in the area, deforestation and urbanisation (Okonkwo, 2015).

Figure 1revealed the decadal temperature patterns for the identified climate belts in the country. Clearly the Warm Semi-arid Climate poses the coolest of the temperatures in the study areas. The temperature in this belt has also been increasing from the first decade. The highest temperature occurred in the last decade (2010-2019) with a temperature of 26.6°C. However, the Warm Desert Climate had the highest temperature values that reached its peak of 28.9°C in the last decade. Interestingly, the temperature of the same belt dropped from 28.4°*C* in the first decade to 28°C in the third decade. The temperature conditions in the Tropical Monsoon and Tropical Savanna appear identical although the one of the Tropical Monsoon appeared more erratic particularly in the last decade which had a 1°C change from 27.6°C.

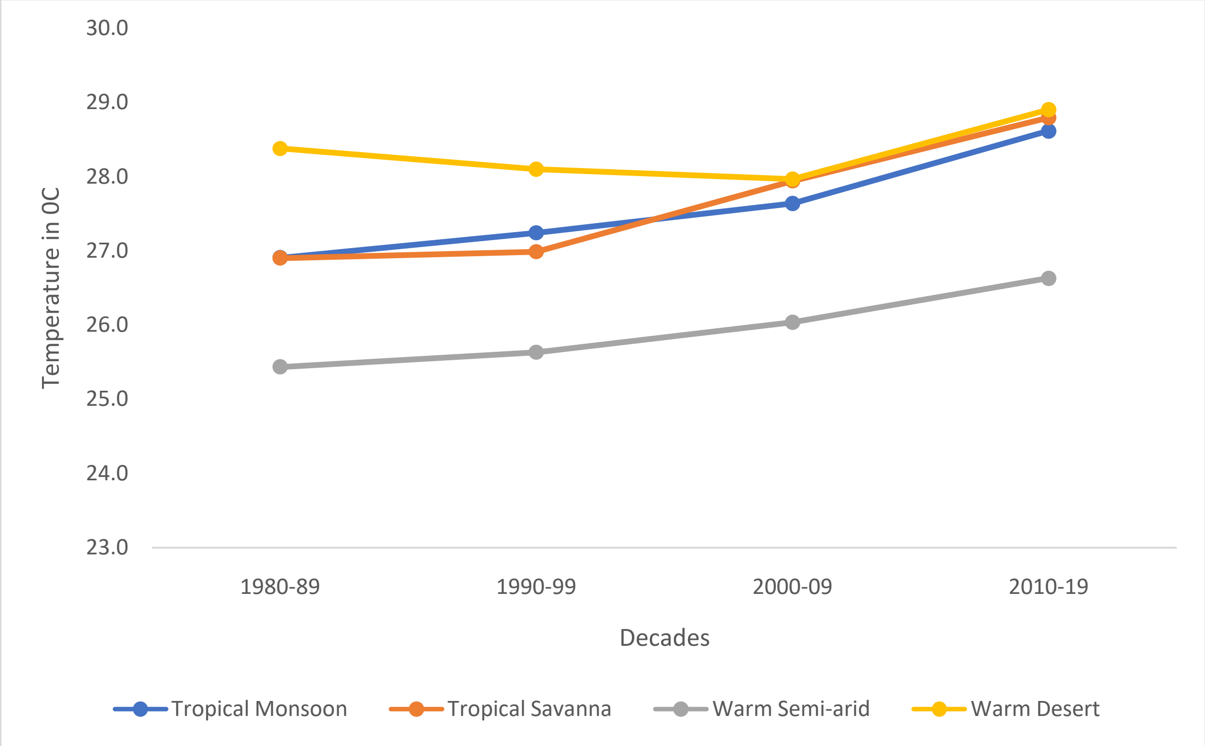

Figure 2 Decadal temperature distribution in the different climate belts of Nigeria

Source: Author's data analysis

The temperature data presented in figure 2 shows that in the Tropical Monsoon Climate belt, temperature ranged from 25.6^{o}C in July to 27.5 in May. The months of June July August, appear cooler due to the effect of the rainy season in this belt at this period of the year. The Tropical Savanna Climate belt observed the highest temperature a little differently from the Tropical Monsoon Climates'. In this belt the highest temperature was encountered in the months of March and April, with 28.5^{o}C and 28.7^{o}C respectively. The coolest temperature was recorded in September with a mean monthly temperature of 26.1^{o}C. In the Warm Semi-arid Climate, April also recorded the highest temperature of 29.5^{o}C. The coldest month was the month of January with a temperature of 23^{o}C.

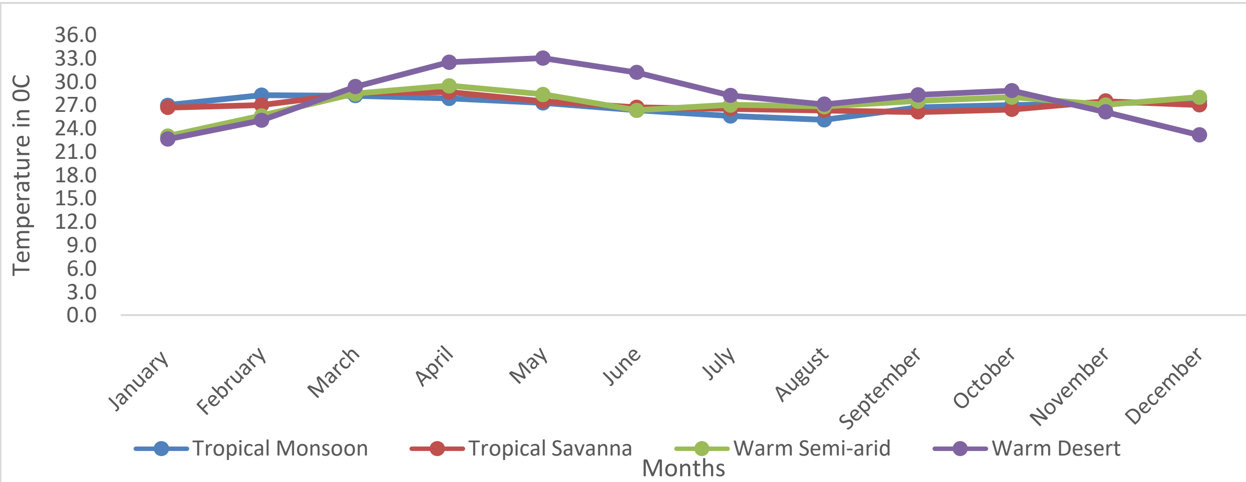

Figure 3 Mean monthly temperature distribution across the climate belts of Nigeria

Source: Author's data analysis

The adducible reason for this low temperature in January is the closeness of the region to the Sahara Desert and the cold tropical continental air mass which is more boisterous at that time of the year thereby affecting temperature of the area. This same condition applies to the Warm Desert Climate, which also had its coldest mean monthly temperature in the month of January (22.6^oC).

Figure 3 presented the detected changes in the monthly mean temperatures for the various climatic belts. A represents the Tropical Monsoon Climate, B represents the Tropical Savanna Climate, C represents the Warn Semi-arid Climate, and D represent the Warm Desert Climate. The detected changes are a compare between the four decades under review for each of the climate belts. The first decade being 1980-1989, second is 1990-1999, the third being 2000-2009 and the last decade is the 2010-2019. In the figure, the decades are denoted with different colours as shown in the keys. In the Tropical Monsoon Climate, it is clear that all the months of the year were higher than the mean temperatures for each of the decades.

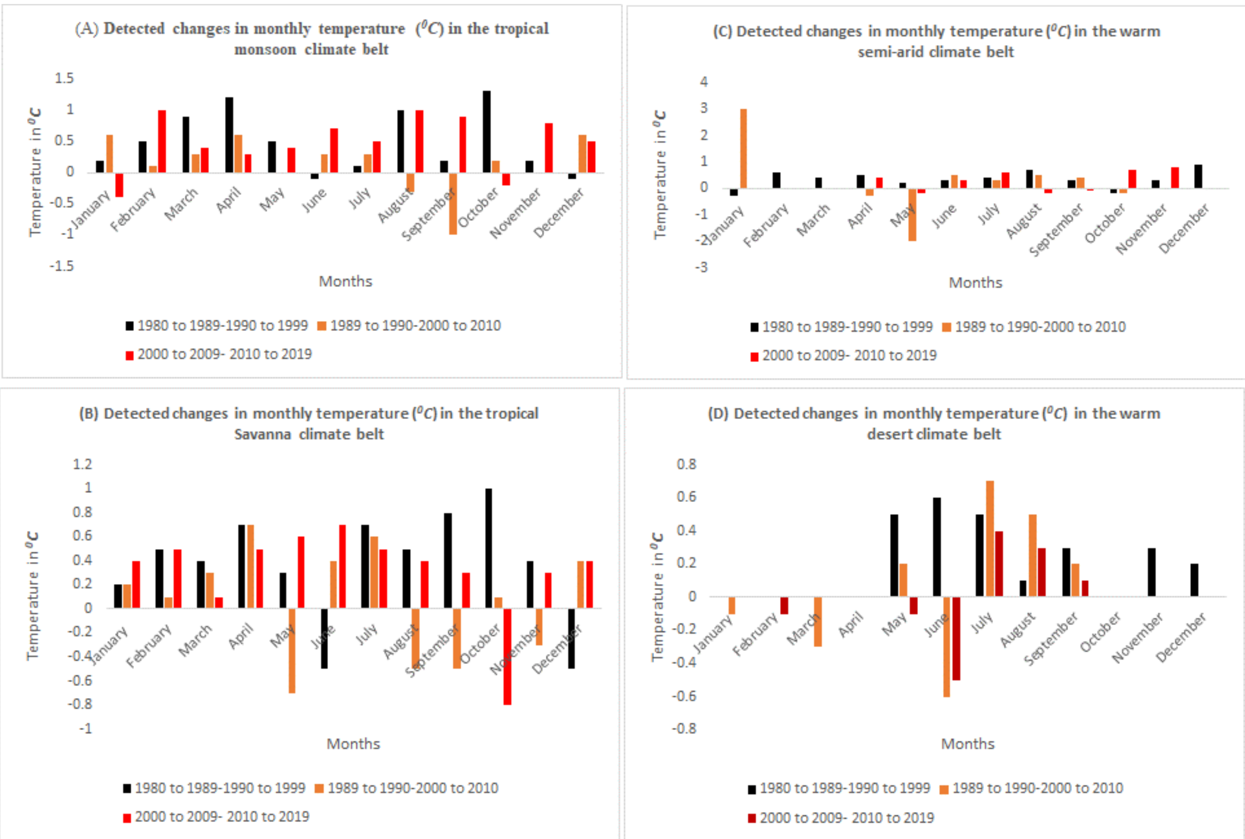

Figure 4: Detected changes in monthly temperature (^{o}C) in the various climate belts

Source: **Source: Author's data analysis**

However, for the difference between the first decade (1980-1989) and second decade (1990-1999) shows that October was remarkable for being the averagely hottest month with a temperature difference of 0.9^{o}C, same can be said of April although it was lower with a 0.1^{o}C relative to that of October. The cold month was December with a temperature difference of 0.2^{o}C. This coldness could be attributed to the harmattan effects that prevail in the area at this time of the year. The other decades followed about the same trend of being hotter than the previous decades. Nevertheless, the months of September was very cold in the third decade 2000-2009 when compared to the second decade 1989-1999, with a temperature of 1^{o}C. In the Tropical Savanna belt, the temperatures in all the decades were generally erratic. Although the temperature suggests that it was mostly rising than reducing. The month of October was the hottest month when compared between the first 1980-1989 and second decade1990-1999 with a temperature of 1^{o}C and the coldest month was December with a temperature of 0.6^{o}C. The same can be said of other decades with hot temperature across the months, although with varying magnitudes. However, October appear to be cold in the last decade (2010-2019) when compared to the third decade (2000-2009), with a temperature of 1^{o}C.

In the Warm Semi-arid Climate, January was very hot (2.1^{o}C) and May was cold (1.8^{o}C) in the third decade (2000-2010). Other periods although showed signs of hotness, they were relatively negligible, with temperature changes ranging from 0.1^{o}C to 0.5^{o}C respectively in detected differences between decadal monthly temperatures. The same can be said of the Warm Desert Climate although the month of June was a critically cool month in the first (1980-1989) and third (2000-2009) decades. On the other hand, the month of May was hottest in the first decade (1980-1989).

Table 2, reveals the ANOVA computations for differences in the seasonal mean temperature in the study area. The Year was classed into four seasons and thereafter denoted acronymically using the first letters of the months of the year. The seasons were the December January and February (DJF), March April and May (MAM), June July and August (JJA), then September October and November (SON). The essence here was to see if there have been differences in the patterns of temperature values within the seasons of the year. It is also imperative to understand that whereas the first two seasons are critical for the planting and growth of root and tuber crops in Nigeria, the last two are critical for the maturity, harvest and storage of root and tuber crops in Nigeria. For the Tropical Monsoon, all the seasons appeared to have been significantly different at $p<0.05$. In the Tropical Savanna belt all the other seasons of the year were significantly different at $p<0.05$, but DJF was not significant at $p>0.05$. This could be possibly caused by the closeness of the region to the region where the tropical continental air mass prevails at the time of the year. In the Warm Semi-arid Climate, it was MAM that was not significant at $p>0.05$. The other seasons of the year were significant at $p<0.05$. Finally, the Warm Desert Climate had all seasons of the year statistically significantly different at $p<0.05$ except DJF season that was not significant at $P>0.05$

Table 2: Seasonal differences in temperature across the climate belts in Nigeria

		Tropical Monsoon				
Months	Groups	Sum of Squares	Df	Mean Square	F	Sig.
DJF	Between	900365.22	3	123	10.2500	.000
	Within	854565.2	116	12		
MAM	Between	808765.17	3	181		.000
	Within	762965.15	116	15	12.0667	
JJA	Between	717165.13	3	103	5.7222	.012
	Within	671365.10	116	18		
SON	Between	625565.08	3	134	6.3810	.010
	Within	579765.05	116	21		
		Tropical Savanna				
DJF	Between	672639.08	3	89	1.4127	1.04
	Within	586730.77	116	63		
MAM	Between	500822.47	3	112		.034
	Within	414914.16	116	19	5.8947	
JJA	Between	329005.85	3	193		.041
	Within	243097.54	116	45	4.2889	
SON	Between	157189.23	3	123	7.2352	.020
	Within	71280.926	116	17		
		Warm Semi-arid Climate				
DJF	Between	980364.23	3	108	9.8182	.000
	Within	744455.67	116	11		
MAM	Between	508547.11	3	192		.231
	Within	272638.55	116	79	2.4304	
JJA	Between	636729.99	3	134		.003
	Within	199178.56	116	14	9.5714	
SON	Between	830564.006	3	117		.005
	Within	624455.698	116	15	7.8000	
		Warm Desert Climate				
DJF	Between	718557.39	3	161		.067
	Within	662659.08	116	97	1.6598	
MAM	Between	830354.01	3	110	5.0000	.001
	Within	774455.7	116	22		
JJA	Between	606760.77	3	143	3.7632	.051
	Within	550862.47	116	38		
SON	Between	494964.16	3	119	4.9583	0.041
	Within	439065.85	116	24		

DJF=December, January, February; MAM=May, June, July; JJA=June, July, August; SON=September, October, November.
Source: Author's data analysis

Figure 5 reveals the time series plot for rainfall in the Tropical Monsoon Climate belt. The plot yielded a model with an R^2 0.6 and Y=1.85x + 2269.5. The model revealed a quasi-decadal pattern with no much noticed anomaly or deviation. Also, figure 5howed that there are some inherent anomalies in the rainfall distribution. Particularly, 1986 was exceptionaly dry and represented the year with the driest rainfall with anormaly value of -350mm. In figure 5 the temperature timeseries plot is presented. In the figure the temperature ranges between 26°C to 30.5°C. The temperature appeared to be on the increase contineously, although with some anomalies. There are two deviations within the continum, as seen in the year 1995 and 2004. In figure 5 showed the anormalies in the temperature data, where 1995 and 2002 were very cool with the temperature anomalies of -1.5°C respectively.

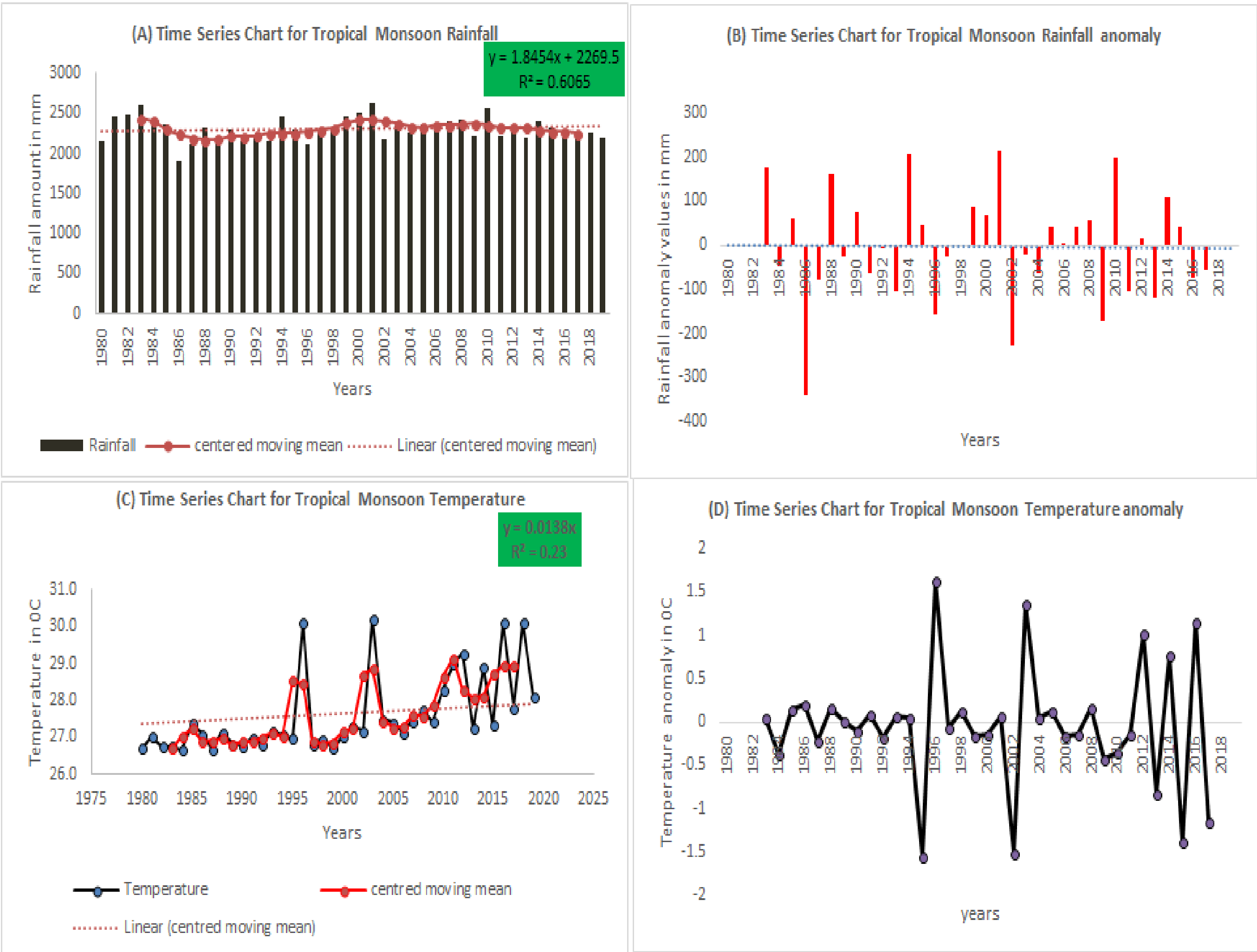

Figure 6: Rainfall and temperature time series and anomaly plots for the Tropical Monsoon Climate belt.

Source: Author's data analysis

Figure 7 reveals the time series plot for rainfall in the Tropical Savanna Climate belt. The plot yielded a model with an R^2 0.046 and Y=58.15x. The model revealed a quasi-decadal pattern with no much anomaly or outliers. On the other hand, figure 7 showed that there are some inherent anomalies in the rainfall distribution. Particularly, 1996 was abnormaly dry and represented the year with the driest rainfall with anormaly value of -45mm. In figure 7. The temperature timeseries plot is presented. In the figure the temperature ranges between 26°C to 29.5°C. The temperature appeared to be on the increase contineously, although with some anomalies. There are two deviations within the continum, as seen in the year 2016 and

2018. In figure 7 showed the anormalies in the temperature data, where 2013 and 2015 were very cool with the temperature anomalies of -0.13^{o}C and 0.15^{0}C respectively.

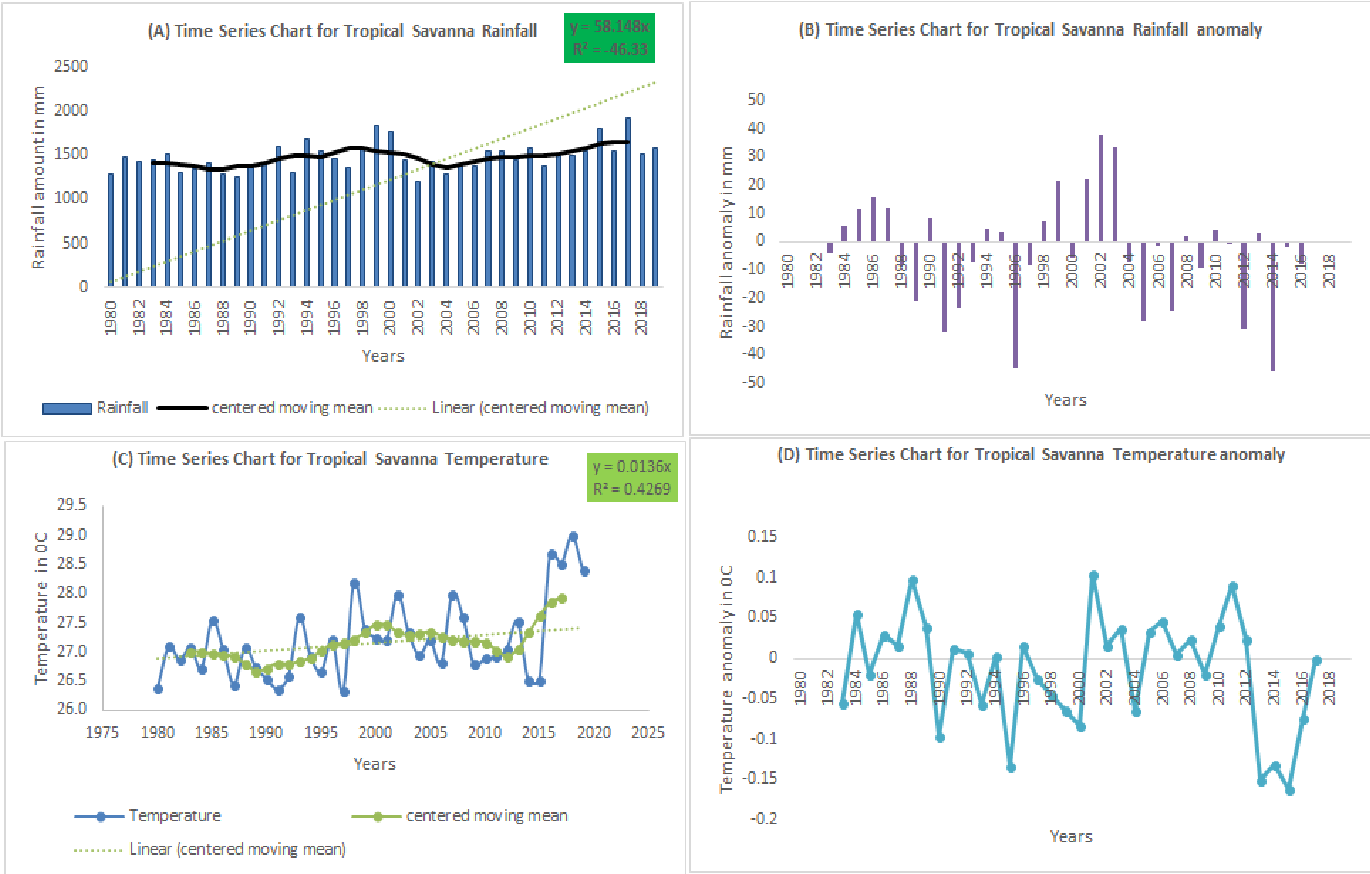

Figure 7: Rainfall and Temperature time series and anomaly plots for the Tropical Savanna Climate belt.

Source: Author's data analysis

Figure 8 eveals the time series plot for rainfall in the Warm Semi-arid Climate belt. The plot yielded a model with an R^2 0.7 and Y=35.05x. The model revealed a quasi-decadal pattern with two peaks. While, figure 8 showed that there are some inherent anomalies in the rainfall distribution. Particularly, 1995 was abnormaly dry and represented the year with the driest rainfall with anormaly value of -48mm. In figure 8 the temperature timeseries plot is presented. In the figure the temperature ranges between 26^{o}C to 28^{o}C. The temperature appeared to be on the increase contineously, although with some anomalies. There is one peak within the continum, as seen in the year 2010. In figure 8 showed the anormalies in the temperature data, where 2010 was very cool with the temperature anomaly of - 0.15^{o}C.

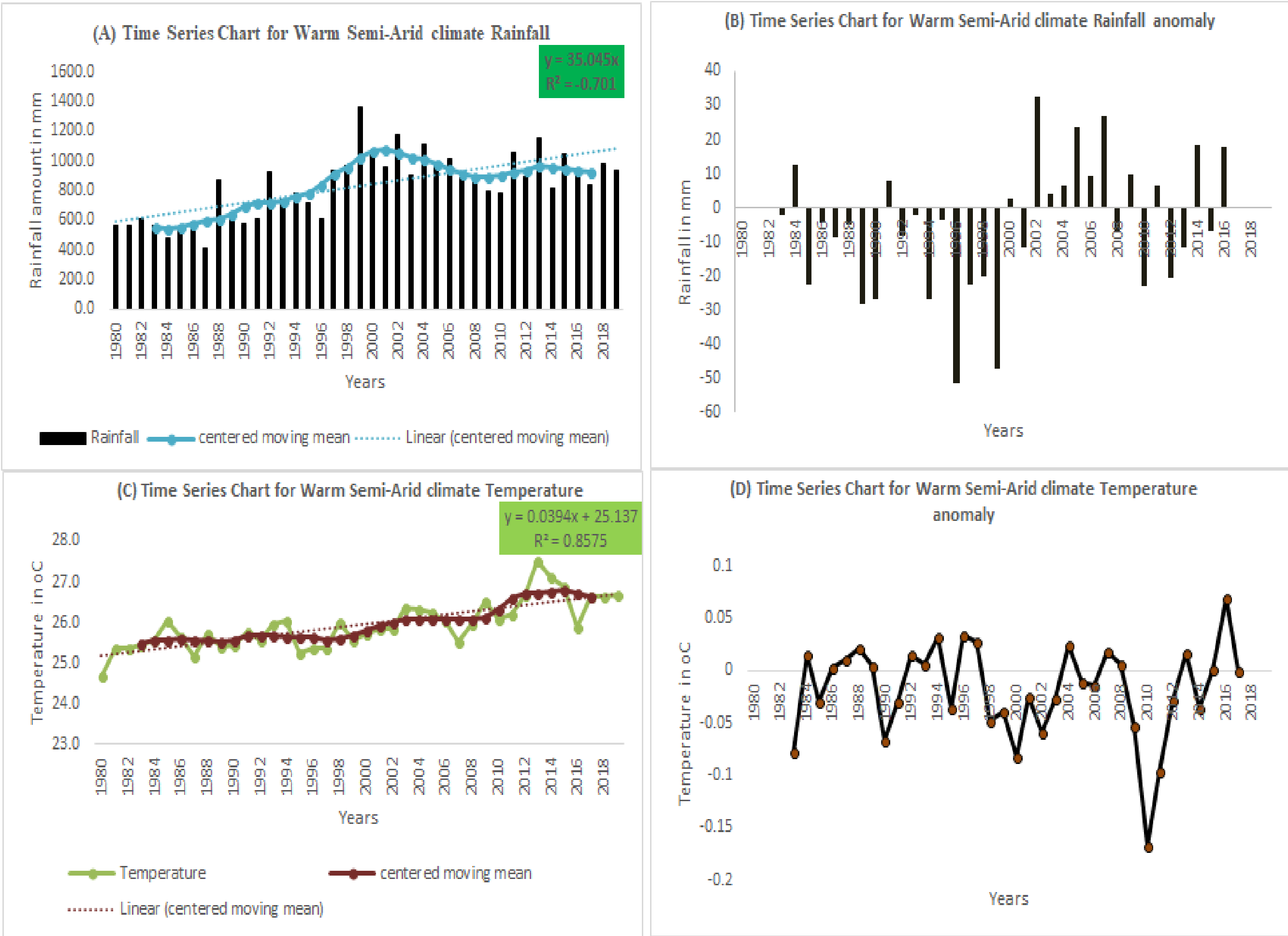

Figure 8: Rainfall and Temperature time series and anomaly plots for the Warm Semi-arid Climate belt.

Source: Author's data analysis

Figure 9 reveals the time series plot for rainfall in the Warm Desert Climate belt. The plot yielded a model with an R^2 0.55 and Y=1.17x +692.73. The model revealed a quasi-decadal pattern with two peaks. However, figure 9 showed that there are some inherent anomalies in the rainfall distribution. Particularly, 2000 was abnormaly dry and represented the year with the driest rainfall with anormaly value of -212mm. In figure 9 the temperature timeseries plot is presented. In the figure the temperature ranges between 26.5°C to 31.5°C. The temperature appeared to be on the increase contineously, although with some anomalies and a decade long consistent temperature distribution. There is three peaks within the continum, as seen in the years 1988 (30.5°C) 1997 (30.7°C) and 2017 (31°C). Figure 9 showed the anormalies in the temperature data, where 1997 was very hot with the temperature anomaly of 2.5°C.

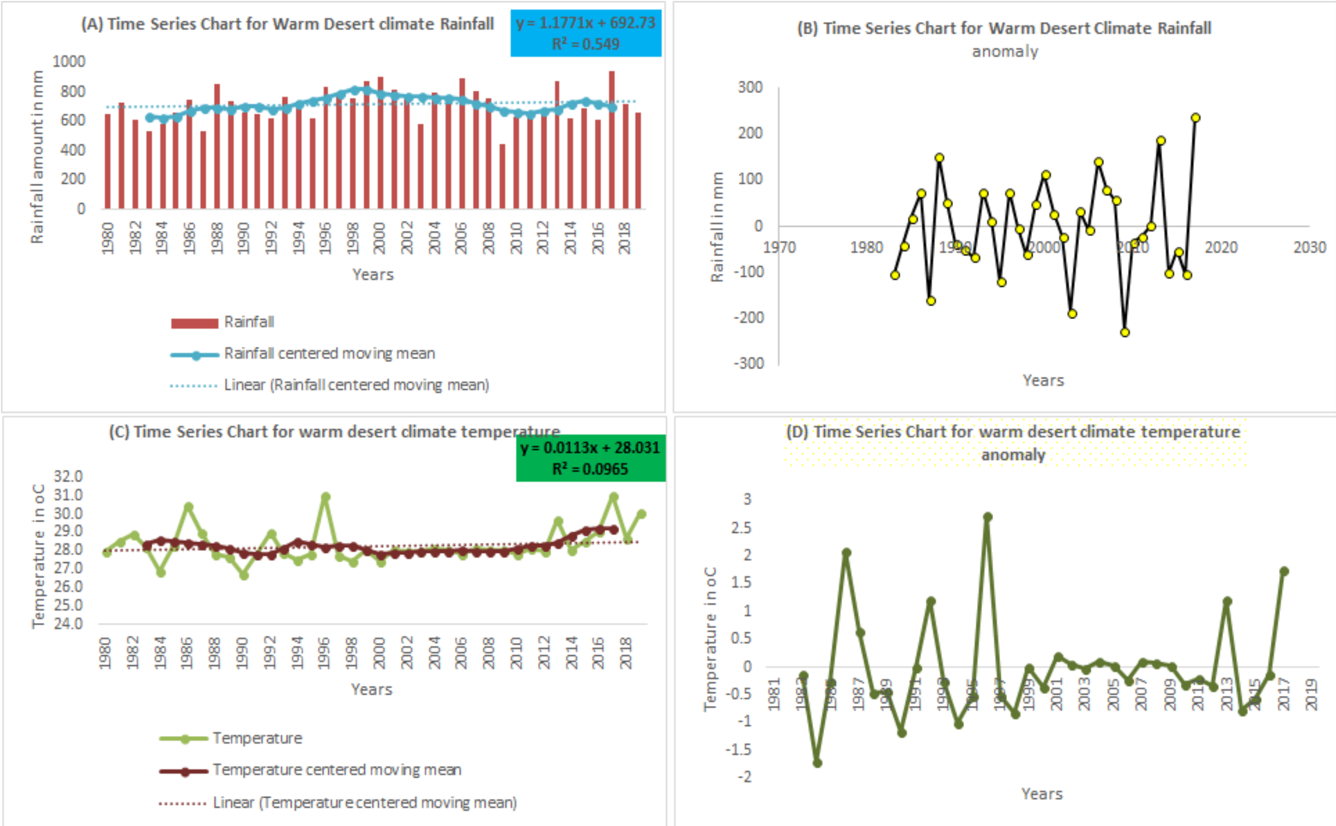

Figure 9: Rainfall and temperature time series and anomaly plots for the warm desert climate belt.

Source: Author's data analysis

CONCLUSION AND RECOMMENDATION

The climate variables have a variable pattern which account for the variations in the yield of these crops in the contrasting climate belt of Nigeria. Decadal temperature characteristics were examined with the following conclusion; Temperature has greater effects on yield performance on root and tuber crops. This does not in any way rule out the role of other parameters in influencing the yield performance of root and tuber crops. The decadal temperature of the four climate belts are increasing in line with the global trend. WDC recorded the highest increase in rate followed by TS, TM and WSC accordingly. The result reveals that root and tuber crops yield will show different yield behaviour in the different decades as a result of differences in the annual climate condition.

1. This study recommends that, climate smart agriculture should be encouraged. The crops and planting seasons should be conditioned to align with these seasons. This is a short term advice. On the long run, improvement in the agricultural practice and technology for farming is greatly needed.
2. This study therefore recommends that, farmer education on the changing climate, and the relevance of family planning to sustainable income should be championed by government and all concerned; while developing a root crop blueprint for farmers and input into farming in funds and machinery.

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