Vol. 10(5), pp. 54-63, June 2018
DOI: 10.5897/IJWREE2018.0783
Article Number: F4A5A9A57570
ISSN: 2141-6613

http://www.academicjournals.org/IJWREE

ACADEMIC JOURNALS
expand your knowledge

International Journal of Water Resources and Environmental Engineering

Full Length Research Paper

Effect of climate variability on the yield of crops in Ondo State, Nigeria

Obafemi O. Olubanjo[1*] and Adebolu E. Alade[2]

Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Ondo State, Nigeria.

Received 3 May, 2018; Accepted 30 May, 2018

Climate change influences crop yield vis-à-vis crop production to a greater extent in countries like Nigeria where agriculture depends largely on natural circumstances. This study assesses the effect of observed climatic variables (rainfall, temperature and relative humidity) on yield of major crops which are divided into two groups, tuber crops (cassava and yam) and fruits (pepper and tomatoes) in Ondo State Nigeria. Crop yield and climatic data were obtained from Ondo State Agricultural Development Project (ADP), Ondo State for a period of nineteen years (1996 - 2014). These data were analyzed using SPSS 16.0 and Microsoft Excel in order to evaluate the effect of climate on the yield on reference crops in Ondo State, Nigeria. Multiple regression, trend analysis, and ANOVA techniques were used to analyze the data. The study showed that the rainfall range for the nineteen years was 1013.08 mm; temperature range was 5.14°C and relative humidity range was 11.55%. Variations in rainfall, temperature and relative humidity were found to have effects on cassava, yam, pepper and tomatoes yield by 20.7, 18.6, 26.8 and 15.5%, respectively. It was then recommended among other things that the extension agents should work with the Nigeria meteorological agency to advice farmers in the State in order to use cropping calendar in accordance with the weather forecast since temperature, rainfall and relative humidity had little effect on cassava, yam, pepper and tomatoes yield in Ondo State.

Key words: Climate, rainfall, temperature, relative humidity, Ondo State.

INTRODUCTION

Agriculture is the growing, processing and distribution of food and other products through intensive plant cultivation and animal husbandry in and around cities. It includes green belts around cities, farming at the city edge, vegetable plots in community gardens and food production in thousands of vacant inner - city lots (CFSCNAAC, 2003). In agriculture the choice of what to produce and how to produce is determined by the culture, traditions, market, water supply, climate, soil condition, plot size and distance from home (AbdulAziz, 2002; Wiebe, 2003). In view of the foregoing, climate has been undoubtedly identified as one of the fundamental factors that determine both crop cultivation and livestock keeping.

The variability of rainfall, temperature and relative humidity has been a topical issue in a sustainable

*Corresponding author. E-mail: olubanjoobafemi@gmail.com.

environment as the crop yield and production is very important to the economy and livelihood of the people of Nigeria and also the world at large. The sub-humid climatic zone of Africa permits the cultivation of a variety of crops in a pattern that emerged in earlier centuries in response to local conditions (Onyekwelu et al., 2006, Ziervogel et al., 2008). It follows therefore that any change in climate may have effect in agricultural sector in particular and other socio-economic activities in general.

Climate change could have both positive and negative impacts and these could be measured in terms of effects on crop growth, availability of soil water, soil fertility and erosion, incidents of pests and diseases, and sea level rise (Onyekwelu et al., 2006; Ziervogel et al., 2008; Semenov, 2009; Butterworth et al., 2010). Temperatures throughout Nigeria are generally high with annual mean of about 27°C while diurnal variations are more pronounced than seasonal differences (Salami and Matthew, 2009). During wet seasons, major portion of the country comes under the influence of moisture-laden tropical maritime air. Spatial variability is evident in the irregular distribution of rainfall at both short-time scale and average conditions while the temporal variability tends to be greater in the Northern and Southern parts of the country (Olaniran, 1991b, Omotosho and Abiodun, 2007; Odiana and Ibrahim, 2015).

The regularity of drought periods has been among the most notable aspects of Nigerian climate in recent years, particularly in the drier regions in the north (Olaniran, 1991a; Salami and Matthew, 2009; Osang et al., 2015). These drought periods are indications of the great variability of climate across tropical Africa and the most serious effects of which are usually felt at the drier margins of agricultural zones or in the regions occupied primarily by pastoral groups. The high degree of spatial variability of Nigerian rainfall is associated with the intense randomness of the convective process, which is the dominant rain-producing mechanism in the country with the attendant effects on local features such as topography, vegetation and land cover type among others (Adefolalu, 1986; Omotosho and Abiodun, 2007). The relationship between climate change and food security is complex. Many factors influence food security, which means that often the link is not even made between failed crops and changing weather patterns. One of the problems of farming is the frequent complete loss of crops due to adverse weather conditions or pests. Changing weather patterns or extreme weather events, such as floods or droughts, can have negative consequences for agricultural production (Tadross et al., 2005; Misselhorn, 2005; Ziervogel et al., 2008; Mthulisi, 2013, IPCC, 2014). Rural communities' dependent on agriculture in a fragile environment are continuously facing an immediate risk of increased crop failure and loss of livestock. Consequently, there is less access to food, which forces the price of the little available food product out of reach of the common man. This translates to secondary effect on the living standard of farmers, fishers and forest-dependent people who are already vulnerable to poor living conditions.

Few studies have been done in Ondo State, Nigeria to investigate the pattern and trend of rainfall, temperature, relative humidity and other parameters on yield of cassava, yam, pepper and tomato. However, previous records show that very few of them have intensively examined the relationship between climate change and crop production. Moreover, different crops might be affected non-uniformly. In order to ensure food security in south-western Nigeria, a region that feeds more than 45% of the nation's population, there are needs to examine the trends in the climate of this region, therefore, the purpose of this research is to determine the co-efficient of variation in climatic variables and examine the effect of climatic variables on crop yield in Ondo State, south west, Nigeria.

MATERIALS AND METHODS

The study area

Ondo State is located in the south western part of Nigeria, with the capital city in Akure as shown in Figure 1. It has acoordinates of 7°10′N 5°05′ E; this means that the states lies entirely in the tropics. It is classified as wetland of flat terrain whose hydrological cycle is generally affected by its location. Ondo State has a population of 3,440,000 estimated by the 2006 population census. The soil of the study area is a sandy clay loam soil according to USDA textural classification of soil. Ondo state has a land area of about 15,500 km^2 and is situated in the western upland area within the humid region of Nigeria. The general elevation is 300 to 700 m. Local peaks rise to 1000 m; other hill-like structures which are less prominent rise only a few hundred meters above the general elevations (Fasinmirin and Konyeha, 2009).The pattern of rainfall is bimodal, the first peak occurring in June and July, and the second in September, with a little dry spell in August (Fasinmirin, 2009). The mean annual rainfall ranges from 1300 to 1500 mm. More than half of humid zone of Nigeria is covered by Pre-Cambrian basement complex, principally composed of metamorphic and igneous materials (Asiwaju–Bello, 1999). The soils are light textured, fine sandy loam to fine sandy clay loam. The soil is moderately well supplied by organic matter and nutrients. Moisture holding capacity is moderately good. The soil of the environment is however subject to seasonal water logging for varying periods, but generally it becomes dry during the dry seasons which fall within November and March (Fasinmirin and Konyeha, 2009). Agriculture is the main occupation of the people of Ondo states, and it is the major source of income for many in the states. Agriculture provides income and employment for more than 75% of the population of the people.

Some of the agricultural produce is: Cash crops such as Cocoa, Oil Palm, Kolanut, Plantain, Bananas, Cashew, Citrus and Timber; Arable /Food Crops such as Rice, Yam, Cassava, Maize and cowpea.

Data collection and analysis

Temperature, precipitation, and solar radiation are the three most widely used climate variables to assess climate change and its impact. However, solar radiation has a closer positive correlation with maximum temperature. In general, higher solar radiation leads

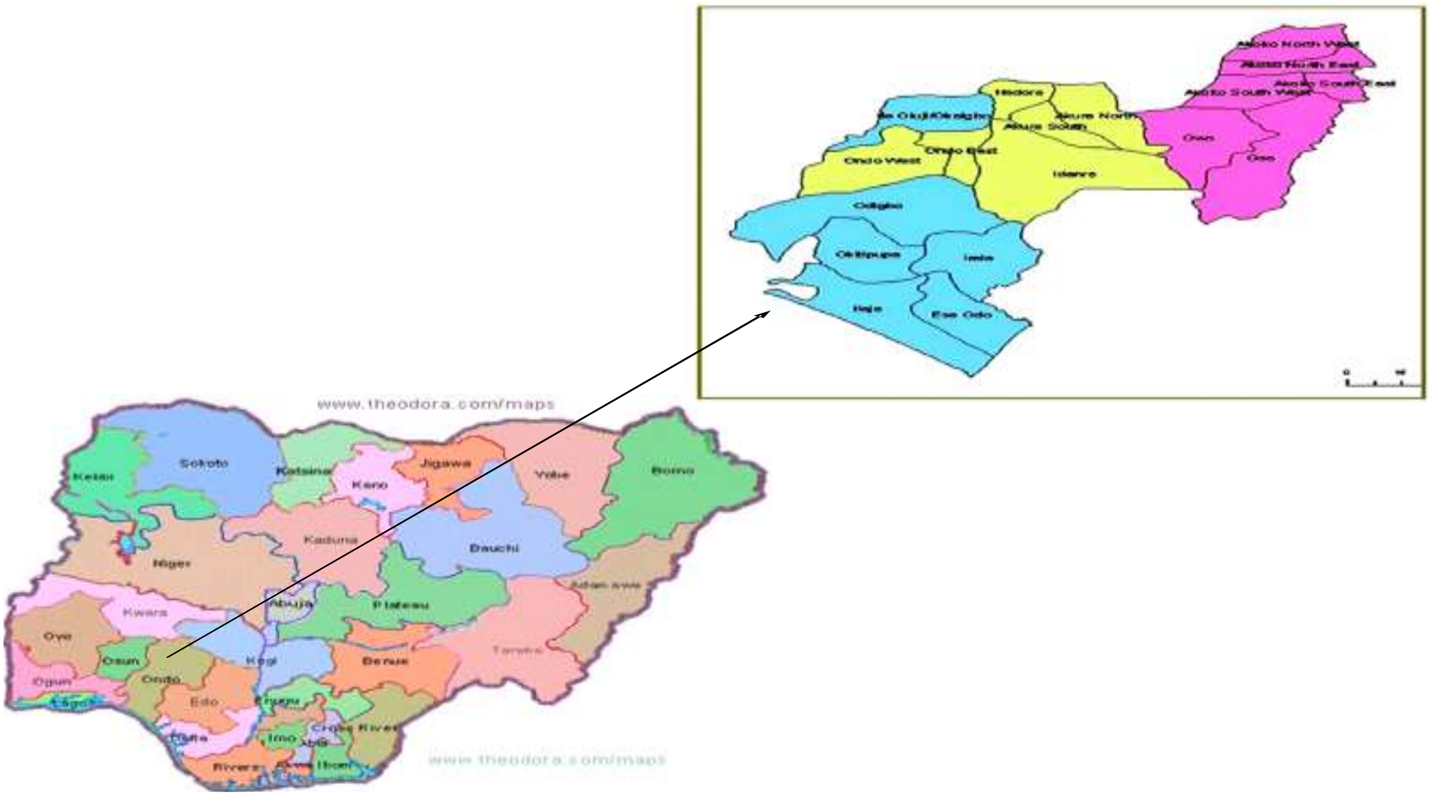

Figure 1. The study area.
Source:www.theodora.com/maps

to a higher maximum temperature and lower solar radiation leads to a lower minimum temperature because of radioactive cooling (Peng et al., 2004). This shows the direct correlation between temperature and solar radiation. Therefore, to overcome the possible correlation among the independent variables, this study considers only temperature, rainfall and relative humidity. Rainfall is the most important form of precipitation in terms of meeting water requirement of agricultural crops.

Secondary data on average climatic variables such as (temperature, relative humidity, rainfall) from 1996 to 2014 for Ondo state in the South-western Nigeria were obtained from the Agro-climatological department of the Agricultural Development programme (ADP), Akure, Ondo State, crop yield data were also collected. The limitations of the crop-yield data availability and accessibility influenced the selection of the period for the climatic variability study. The yield/production rates for some common staple food crops (cassava, yam) and fruits (Pepper and Tomato) in the region were obtained from Akure Agricultural Development Programme Office, Ondo State. In order to adequately examine the response of different classes of food crops to varying climatic conditions, the crops under investigation were grouped into two classes as follows: Tubers (Yam and Cassava), and fruits (Pepper and Tomato) all expressed in metric tons per hectare (mt/ha). The mean annual temperature, rainfall and relative humidity were computed from the climatic data collected.

Data obtained from the experiments were analyzed using Statistical Package for Social Sciences (SPSS). Both descriptive and multiple regression were employed in data analysis while simple correlation, stepwise multiple regressions and analysis of variance (ANOVA) were used in showing the relationship between climatic parameters and crop yield and showing the trend and variation in crop yield. These statistical techniques were employed in the analysis of both crop yield data and climatic parameters because of their peculiarity in revealing the relationship and variation among variables

The regression model is specified thus:

$$Y = f(X_1, X_2, X_3) \quad (1)$$

$$Y_t = \beta + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + e_{it} \quad (2)$$

Where: Y = Crop output (mt); β_1 ,β_2 and β_3 = Coefficient of variables X_1, X_2 and X_3 respectively; X_1 = Annual mean rainfall; X_1 = Mean temperature; X_1 = Mean temperature and e =unexplained variables.

RESULTS AND DISCUSSION

Table 1 and Figure 2 show the descriptive analysis of cassava output and yield data in Ondo State from 1996 to 2014. Out of the four selected crops, Cassava has a total sum of production of 38745.35 mt and a mean value of 2039.23 mt. This shows that within the years under study, Cassava had the highest yield value. 2014 recorded the highest cassava yield of 23.86 mt/ha compared with the previous year which recorded a yield of 23.41 mt/ha. The table also shows that the mean annual rainfall increased from 1880.20 mm to 2002.41 mmin 2014, relative humidity reduced from 78.30 to 77.40%, minimum

Table 1. Showing the mean annual temperature, rainfall, Relative humidity, cassava output and yield in Ondo State, Nigeria (1996-2014).

Year	Rainfall (mm)	Relative humidity (%)	Minimum temperature (°C)	Maximum temperature (°C)	Cassava output (mt)	Cassava yield (mt/ha)
1996	1834.63	76.46	19.63	32.75	1320.5	16.25
1997	2011.14	73.43	20.14	29.08	1535.63	17.5
1998	1818.26	81.68	18.58	31.2	1459.9	17.29
1999	1740.71	77.87	18.37	32.1	1437.32	17.02
2000	1932.63	77.06	20.17	31.7	1178.64	17.08
2001	1433.38	78.07	18.18	24.85	1354.12	17.52
2002	1495.85	76.49	20.67	31.7	1357.14	17.49
2003	14966.86	73.57	20.28	31.89	1212.08	18.42
2004	1384.34	76.51	20.62	31.34	1737.69	18.4
2005	1640.2	77.29	21.66	31.55	1871.42	18.94
2006	1835.66	77.7	19.36	31.46	2182.28	21.11
2007	1974.11	75.51	20.36	31.89	2360.98	21.92
2008	1738.46	70.13	20.79	31.75	2412.83	20.45
2009	1566.65	76.36	21.11	30.8	2678.23	22.3
2010	2222.59	77.2	20.8	32.5	2899.63	22.66
2011	2397.42	76.2	20.4	30.1	2989.87	22.72
2012	1729.6	77.7	20.12	30.7	2894.75	22.96
2013	1880.2	78.3	20.4	30.5	2942.31	23.41
2014	2002.41	77.4	20.1	30.64	2920.03	23.86

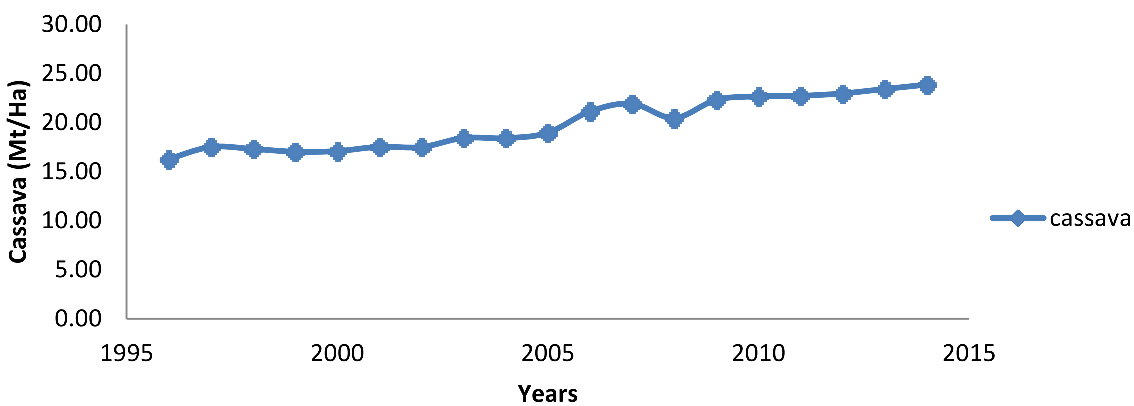

Figure 2. Trend line showing the trend in cassava from 1996 to 2014 in Ondo State, Nigeria.

temperature reduced from 20.40 to 20.10°C and maximum temperature increased from 30.50 to 30.64°C. The increase in yield recorded may be as a result of the increase in rainfall and maximum temperature. Year 1996 recorded the lowest Cassava yield of 16.25 mt/ha; the year 1997 recorded an increase in yield from the 16.25 to 17.50 mt/ha, also mean annual rainfall increase from 1834.63 mm to 2011.14 mm, relative humidity reduced from 76.46 to 73.43%, minimum temperature increased from 19.63 to 20.14°C and maximum temperature reduced from 32.75 to 29.08°C. The increase in yield recorded in 1997 may be as a result of the increase in rainfall and minimum temperature.

Table 2 and Figure 3 show the descriptive analysis of yam products yield data in Ondo State from 1996 to 2014. Out of the four selected crops, Yam has a total sum of production of 31600.79 mt and a mean value of 1663.20 mt. This shows that within the years under study, after cassava, yam had the next highest yield value. Year 2014 also recorded the highest Yam yield of 19.27mt/ha compared with the previous year which recorded a yield of 18.97mt/ha. The table show that in 2014 mean annual rainfall increased from 1880.20 to 2002.41 mm, relative humidity reduced from 78.30 to77.40%, minimum temperature reduced from 20.40 to 20.40°C and maximum temperature increased from 30.64 to 30.64°C.

Table 2. The mean annual temperature, rainfall, relative humidity, yam output and yield in Ondo State, Nigeria (1996-2014).

Year	Rainfall (mm)	Relative humidity (%)	Minimum temperature (°C)	Maximum temperature (°C)	Yam output (mt)	Yam yield (mt/ha)
1996	1834.63	76.46	19.63	32.75	1054.69	13.78
1997	2011.14	73.43	20.14	29.08	1075.78	13.83
1998	1818.26	81.68	18.58	31.2	1014.7	13.85
1999	1740.71	77.87	18.37	32.1	1046.74	13.82
2000	1932.63	77.06	20.17	31.7	1000	13.16
2001	1433.38	78.07	18.18	24.85	1060.36	13.2
2002	1495.85	76.49	20.67	31.7	1186.12	14.47
2003	14966.86	73.57	20.28	31.89	1212.08	14.75
2004	1384.34	76.51	20.62	31.34	1447.98	14.9
2005	1640.2	77.29	21.66	31.55	1508.62	15.41
2006	1835.66	77.7	19.36	31.46	1733.17	15.4
2007	1974.11	75.51	20.36	31.89	2000.74	15.63
2008	1738.46	70.13	20.79	31.75	2194.56	17
2009	1566.65	76.36	21.11	30.8	2253.54	17.2
2010	2222.59	77.2	20.8	32.5	2287.67	17.3
2011	2397.42	76.2	20.4	30.1	2415.99	18.14
2012	1729.6	77.7	20.12	30.7	2353.8	18.66
2013	1880.2	78.3	20.4	30.5	2384.9	18.97
2014	2002.41	77.4	20.1	30.64	2369.35	19.27

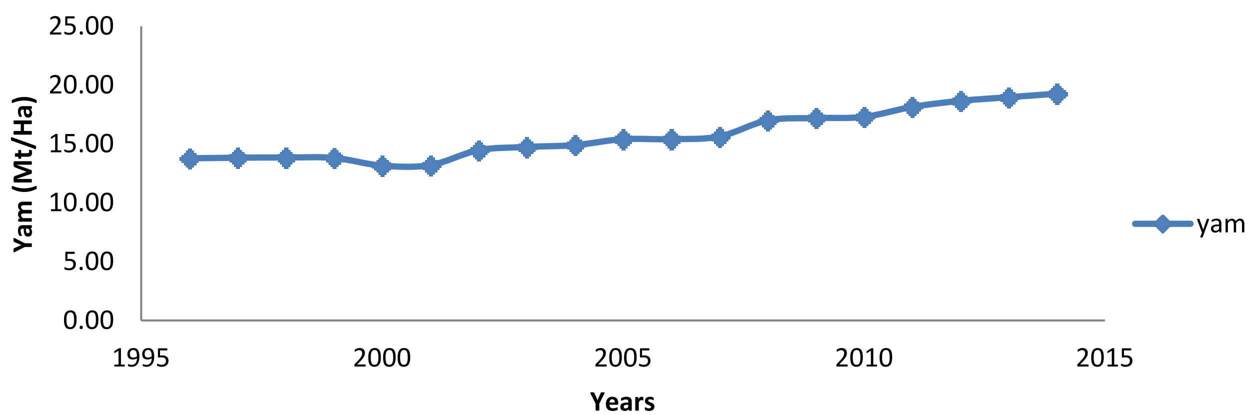

Figure 3. Trend line showing the trend in yam from 1996 to 2014 in Ondo State, Nigeria.

The increase in yam yield recorded in year 2014 may be as a result of the increase in rainfall and maximum temperature from year 2013. Year 2000 recorded the lowest yam yield of 13.16 mt/ha, the year before recorded a slight increase in yield 13.82 mt/ha, also annual mean rainfall increase from 1740.71 to 1932.63 mm, relative humidity reduced from 77.87 to 77.06%, minimum temperature increased from 18.37 to 20.17°C and maximum temperature reduced from 32.10 to 31.70°C in year 1999 and 2000, respectively. The reduction in yield recorded in year 2000 may be as a result of the reduction in relative humidity and maximum temperature.

Table 3 and Figure 4 show the descriptive analysis of pepper products yield data in Ondo State from year 1996 to 2014. Out of the four selected crops, pepper has a total sum of production of 222.19 mt and a mean value of 11.70 mt. This shows that within the years under study, pepper had the second lowest yield value. Year 2007 also recorded the highest pepper yield of 4.96 mt/ha compared with the previous year which recorded a yield of 1.44 mt/ha. The table shows that in 2007, mean annual rainfall increased from 1835.66 to 1974.11 mm, relative humidity reduced from 77.70 to75.51%, minimum temperature increased from 19.36 to 20.36°C and

Table 3. Trend line showing the trend in pepper from 1996 - 2014 in Ondo State, Nigeria.

Year	Rainfall (mm)	Relative humidity (%)	Minimum temperature (°C)	Maximum temperature (°C)	Pepper output (mt)	Pepper yield (mt/ha)
1996	1834.63	76.46	19.63	32.75	11	0.73
1997	2011.14	73.43	20.14	29.08	3.32	1.01
1998	1818.26	81.68	18.58	31.2	7.2	1.42
1999	1740.71	77.87	18.37	32.1	4.06	1.06
2000	1932.63	77.06	20.17	31.7	17.71	1.06
2001	1433.38	78.07	18.18	24.85	18.06	1.1
2002	1495.85	76.49	20.67	31.7	18.64	1.12
2003	14966.86	73.57	20.28	31.89	21.23	1.19
2004	1384.34	76.51	20.62	31.34	22.62	1.24
2005	1640.2	77.29	21.66	31.55	22.18	1.35
2006	1835.66	77.7	19.36	31.46	28.32	1.44
2007	1974.11	75.51	20.36	31.89	19.56	4.96
2008	1738.46	70.13	20.79	31.75	3.9	1.4
2009	1566.65	76.36	21.11	30.8	4.17	1.47
2010	2222.59	77.2	20.8	32.5	5.24	1.54
2011	2397.42	76.2	20.4	30.1	3.16	2.2
2012	1729.6	77.7	20.12	30.7	4.2	1.83
2013	1880.2	78.3	20.4	30.5	3.68	1.89
2014	2002.41	77.4	20.1	30.64	3.94	1.95

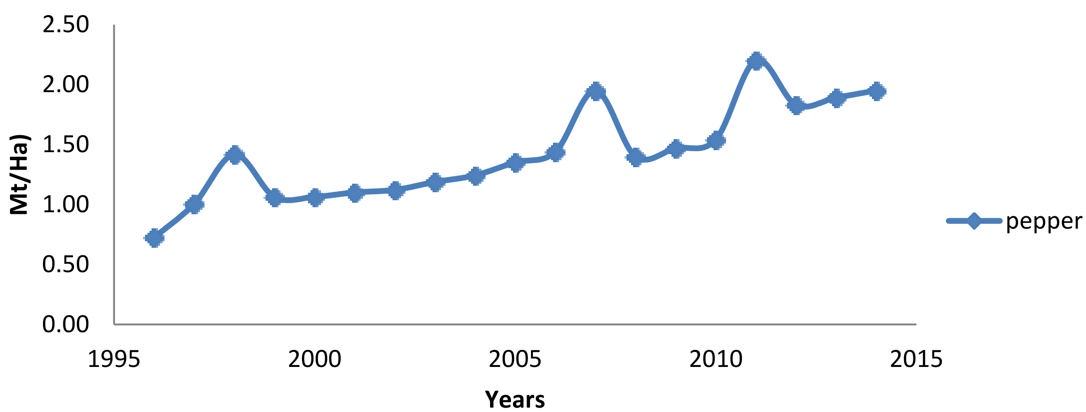

Figure 4. Trend line showing the trend in pepper from 1996 to 2014 in Ondo State, Nigeria.

maximum temperature increased from 31.46 to 31.89°C. The increase in pepper yield recorded in year 2007 may be as a result of the increase in rainfall, increase in minimum and maximum temperature from year 2006 to 2007. Year 1996 recorded the lowest yam yield of 0.73 mt/ha; the next year recorded an increase in yield from the 0.73 to 1.01 mt/ha, also annual mean rainfall increase from 1834.63 to 2011.14 mm, relative humidity reduced from 76.46 to 73.43%, minimum temperature increased from 19.63 to 20.14°C and maximum temperature reduced from 32.75 to 29.08°C. The increase in yield recorded in 1997 may be as a result of the increase in rainfall and minimum temperature.

Table 4 and Figure 5 show the descriptive analysis of tomatoes products yield data in Ondo State from 1997 to 2014. Out of the four selected crops, tomatoes has a total sum of production of 111.467 mt and a mean value of 5.87 mt .This shows that within the years under study, tomatoes had the lowest yield value. Year 2014 also recorded the highest tomatoes yield of 3.89 mt/ha compared with the previous year which recorded a yield of 3.74 mt/ha. The table shows that in 2014 mean annual rainfall increased from 1880.20 to 2002.41 mm, relative humidity reduced from 78.30 to 77.40%, minimum temperature reduced from 20.40 to 20.40°C and maximum temperature increased from 30.64 to 30.64°C.

Table 4. Trend line showing the trend in tomatoes from 1996 - 2014 in Ondo state, Nigeria

Year	Rainfall (mm)	Relative humidity (%)	Minimum temperature (°C)	Maximum temperature (°C)	Tomatoes output (mt)	Tomatoes yield (mt/ha)
1996	1838.63	76.46	19.63	33.75	3.02	1.60
1997	2011.14	73.43	20.14	29.08	3.32	1.75
1998	1818.26	81.68	18.58	31.2	7.2	2.13
1999	1740.71	77.87	18.37	32.1	4.06	1.72
2000	1932.63	77.06	20.17	31.7	4.92	1.95
2001	1433.38	78.07	18.18	24.85	4.7	1.86
2002	1495.86	76.49	20.28	31.7	5.89	2.07
2003	1496.86	73.57	20.28	31.89	6.06	2.11
2004	1384.34	76.51	20.26	31.34	6.87	2.29
2005	1640.2	77.29	21.66	31.55	9.04	2.01
2006	1835.66	77.7	19.36	31.46	10.94	2.42
2007	1974.11	75.51	20.36	31.89	8.76	2.22
2008	1738.46	70.13	20.79	31.75	4.12	3.67
2009	1566.65	76.36	21.11	30.8	3.46	3.61
2010	222.59	77.2	20.8	32.5	2.99	3.4
2011	2397.42	76.2	20.4	30.1	8.55	3.88
2012	1729.6	77.7	20.12	30.7	5.77	3.6
2013	1880.2	78.3	20.4	30.5	7.16	3.47
2014	2002.41	77.4	20.1	30.64	6.47	3.89

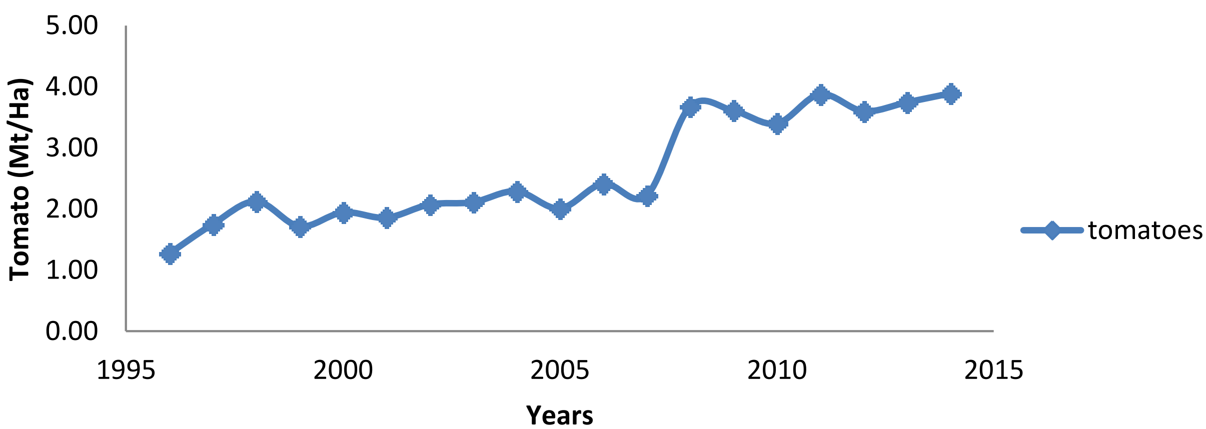

Figure 5. Trend line showing the trend in tomatoes from 1996 to 2014 in Ondo State, Nigeria.

The increase in tomatoes yield recorded in year 2014 may be as a result of the increase in rainfall and maximum temperature from the previous year 2013. Year 1996 recorded the lowest tomatoes yield of 1.27 mt/ha, the next year recorded an increase in yield from the 1.27 to 1.75 mt/ha, also annual mean rainfall increase from 1834.63 to 2011.14 mm, relative humidity reduced from 76.46 to 73.43%, minimum temperature increased from 19.63 to 20.14°C and maximum temperature reduced from 32.75 to 29.08°C. The increase in yield recorded in 1997 may be as a result of the increase in rainfall and minimum temperature.

Regression results on the effect of climate variability on crop yield

Table 5 shows the regression result for the effect of annual mean rainfall, temperature and relative humidity on the yield of cassava in the study area. After some econometric considerations, the result from the linear function was chosen as the lead equation. The result from the regression analysis showed that the regression coefficient of determination R^2 was 0.207, it can be noted that about 20.7% of variation in cassava could be explained by means of rainfall, relative humidity and

Table 5. Regression result on the effect of rainfall, temperature, relative humidity on cassava yield.

Variable	Linear	Semi-log	Double-log
Constant	4.098(27.889)	2.253(1.409)	-0.665(5.477)
Mean rainfall	0.004(0.002)	0.000(0.000)	0.351(.212)
Mean temperature	0.299(0.566)	0.015(0.029)	0.357(.694)
Mean relative humidity	0.010(0.267)	0.000(0.014)	-0.031(1.024)
R^2	0.207	0.197	0.190
Adjusted R^2	0.049	0.037	0.028
F-value	1.307	1.230	1.170

Figure in parenthesis indicates 'T- value'.

Table 6. Regression result on the effect of rainfall, temperature, relative humidity on yam yield.

Variable	Linear	Semi-log	Double-log
Constant	2.536 (21.986)	1.906(1.370)	-0.850(5.317)
Mean rainfall	0.003 (.002)	0.000(.000)	0.282(.205)
Mean temperature	0.365 (.446)	0.026(.028)	0.615(.674)
Mean relative humidity	-0.012 (.211)	-0.001(.013)	-0.116(.994)
R2	0.186	0.193	0.188
Adjusted R^2	0.023	0.031	0.025
F-value	1.144	1.195	1.154

Figure in parenthesis indicates 'T- value'.

mean temperature. The remaining 79.3% were largely due to other variables outside the regression model that also have effect on cassava yield. The regression result also reveals that for every unit increment in rainfall there is a 0.04% positive effect on the yield of cassava also for every unit increment in temperature there is a 29.9% positive effect in the yield of cassava, and lastly for every unit increment in relative humidity there is a 1% positive effect on the yield of cassava during the study period. The implication of these findings is that the volume of rainfall, mean temperature and relative humidity may not necessarily determine the output of cassava in the study area.The important determinant is the spread of the rainfall within the year. According to Ojo (2000), one-month drought when maize is tasseling can result in serious reduction in the output of maize, and thus the same principles apply to the other climatic variables.

Table 6 shows the regression result for the effect of annual mean rainfall, temperature and relative humidity on yam yield in the study area. After some econometric considerations, the result from the linear function was chosen as the lead equation. The result from the regression analysis showed that the regression coefficient of determination R^2 was 0.186, it can be noted that about 18.60% of variation in yam could be explained by means of rainfall, relative humidity and temperature, the remaining 81.40% were largely due to other variables outside the regression model that also affects the yield of yam in the study area. The regression result also reveal that for every unit increment in rainfall there is a 0.03% positive effect on the yield of yam, also for every unit increment in temperature there is a 36.50% positive effect in the yield of yam, and for every unit increment in the relative humidity there is a 1.20% positive effect on the yield of yam during the study period in Ondo State.

Table 7 shows the regression result for the effect of mean annual rainfall, temperature and relative humidity on the yield of pepper in the study area. After some econometric considerations, the result from the linear function form was chosen as the lead equation. The result from the regression analysis showed that the regression coefficient of determination R^2 was 0.268; it can be noted that about 26.80% of variation in pepper could be explained by means of rainfall, relative humidity and temperature. The remaining 73.20% were largely due to other variables outside the regression model that also has effect on the pepper yield in the study area. The regression result also reveal that for every unit increment in rainfall there is a 0.01% positive effect on the yield of pepper, also for every unit increment in temperature there is a 1.70% positive effect in the yield of pepper, and for every unit increment in the relative humidity there is a 2.0% positive effect on the yield of pepper during the study period in Ondo State.

Table 8 shows the regression result for the effect of annual mean rainfall, temperature and relative humidity

Table 7. Regression result on the effect of rainfall, temperature, relative humidity on pepper yield.

Variable	Linear	Semi-log	Double-log
Constant	-1.823(4.010)	-2.092(3.018)	-11.524(11.773)
Mean rainfall	0.001(.000)	0.000(.000)	0.761(.455)
Mean temperature	0.017(.081)	0.017(.061)	0.394(1.492)
Meanrelative humidity	0.020(.038)	0.015(.029)	1.121(2.201)
R2	0.268	0.201	0.187
Adjusted R2	0.121	0.041	0.025
F-value	1.829	1.257	1.153

Figure in parenthesis indicates 'T- value'.

Table 8. Regression result on the effect of rainfall, temperature, relative humidity on tomatoes yield.

Variable	Linear	Semi-log	Double-log
Constant	1.428(9.699)	.255(3.817)	-2.714(14.844)
Mean rainfall	0.001(.001)	0.000(.000)	0.687(.574)
Mean temperature	0.065(.197)	.029(.078)	0.699(1.881)
Mean relative humidity	-0.034(.093)	-0.011(.037)	-0.873(2.775)
R2	0.155	0.125	0.116
Adjusted R2	-0.014	-0.049	-0.060
F-value	.917	0.717	0.658

Figure in parenthesis indicates 'T- value'.

on the yield of tomatoes in the study area. After some econometric considerations, the result from the linear function form was chosen as the lead equation. The result from the regression analysis showed that the regression coefficient of determination R^2 was 0.155. It can be noted that about 15.50% of variation in tomatoes could be explained by means of rainfall, relative humidity and temperature. The remaining 84.50% were largely due to other variables outside the regression model that has effect on the yield of tomato in the study area. The regression result also reveal that for every unit increment in rainfall there is a 0.01% positive effect on the yield of tomato, also for every unit increment in temperature there is a 6.50% positive effect in the yield of tomato, and for every unit increment in the relative humidity there is a 3.40% positive effect on the yield of tomato during the study period in Ondo State.

Conclusion

In conclusion, this project analyzed the effect of current climate trend on yield of four different crops in Ondo State. The study showed that there were variations in the climatic parameters (rainfall, temperature and relative humidity) over the nineteen years' period of study (1996-2014). There were also variations in the output and yield of the crops under study (cassava, yam, pepper, tomatoes) during the same period, with cassava having the highest output mean value of 2039.23 mt, and tomatoes having the lowest output mean value of 2039.23 mt. From the result of the analysis, it was concluded that climate variability had a 20.7% effect on the yield of cassava, 18.6% effect on the yield of yam, 26.8% effect on the yield of pepper and 15.5% effect on the yield of tomatoes in Ondo State during the nineteen years of study. However, the empirical evidence established strong credibility that, overall, climate variability and change adversely impacted yield and cropping area of major these fruit and tuber crops in Ondo State. The project research also shows that some other factors affects the output and yield of crops in Ondo State Nigeria, non-climatic factors, such as farm management practices, soil fertility, pests, seed type and quality and planting period may contribute significantly to variations in crop yield. Inappropriate management practices such as soil compaction during the site clearing and preparation, topsoil and litter repositioning, burning of debris, harvesting methods and management of harvest residues (Chen et al., 2004; Onyekwelu et al., 2006) have been reported to influence crop yield. As a result of these, the concerned authority should take proper plan to combat against climate change impacts on agriculture in the country for ensuring food security for the ever increasing population through implementing sustainable agricultural development. In summary, data on crops yield and climate might not depict the true scenario for the different agro-ecological zones of any country about climate change impacts on crops yield (Amin et al., 2015). Therefore, region-specific research should be conducted to highlight regional differences and to guide intensive measures on the perspective of climate change and cultivation of major food crops in agro-ecological zone of Nigeria.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

AbdulAziz T (2002). "Corruption" Sustainable Food Security for All by 2020, IFPRI, pp. 172-175.

Adefolalu DO (1986). Rainfall trends in Nigeria. Theoretical and Applied Climatology 37(4):205-219.

Amin MR, Zhang J, Yang M (2015). Effects of climate change on the yield and cropping area of major food crops: A case of Bangladesh. Sustainability 7:898-915.

Asiwaju-Bello YA (1999). Electrical resistivity mapping of structures of controlling a spring system. A case study of Federal University of Technology, Akure, Nigeria. Futa Jeet 1:7-16.

Butterworth MH, Semenov MA, Barnes A, Moran D, West JS, Fitt BDL (2010). North-south divide; contrasting impacts of climate change on crop yields in Scotland and England. Journal of the Royal Society Interface 7:123–130.

Chen CR, Xu ZH, Mathers NJ (2004). Soil Carbon pools in adjacent Natural and Plantation Forests of Subtropical Australia. Soil Science Society of America Journal 68:282-291.

Community Food Security Coalition's North American Urban Agriculture Committee (CFSCNAAC) (2003). Urban Agriculture and Community Food Security in the Limited States. Farming from the City Centre to the Urban Fringe.

Fasinmirin JT (2009). Development and calibration of a digital recording system for automation of runoff measurement. Journal of Applied Irrigation Science 44(2):177-185.

Fasinmirin JT, Konyeha S (2009). Evaluation of some hydraulic characteristics of furrow irrigation system in a cassava Manihot esculenta crantz field. Zeitschrift für Bewässerungswirtschaft 44(1): 71-84.

Intergovernmental Panel on Climate Change (IPCC) (2014). Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects. Cambridge University Press.

Misselhorn AA (2005). What drives food insecurity in Southern Africa? A meta-analysis of household economy studies. Journal on global environmental change 15: 33-43.

Mthulisi ED (2013). Food security in South Africa: A comprehensive review of the past two decades. Master's dissertation submitted in fulfillment of the requirements for the degree of Master of Science in Nutrition and Rural Development.

Odiana S, Ibrahim A (2015). An Assessment of the evidence of Climate change in Bauchi, Nigeria. Journal of Applied Sciences and Environmental Management 19(3):375-381.

Ojo SO (2000). Factor productivity in maize production in Ondo State, Nigeria. Applied Tropical Agriculture 15(1):57-63.

Olaniran OJ (1991a). Rainfall anomaly patterns in dry and wet years over Nigeria. Journal on international climatology 11:177-204.

Olaniran OJ (1991b). Evidence of climatic change in Nigeria based on annual series of rainfall of different daily amounts, 1919-1985. Journal on climate change 19:319-341.

Omotosho, JB, Abiodun BJ (2007). A numerical study of moisture buildup and rainfall over West Africa. Journal on meteorology application 14:209-225.

Onyekwelu JC, Reinhard M, Bernd S (2006). Productivity, site evaluation and state of nutrition of gmelinaarborea plantations in Oluwa and Omo forest reserves, Nigeria. Journal on ecology 229:214-227.

Osang JE, Egor AO, Equetan UI, Emeruwa C, Agbor ME (2015). Inter-Annual variability of rainfall in some states of southern Nigeria. International Journal of Scientific and Technology Research 4(10):134-154.

Peng S, Huang J, Sheehy JE, Laza RC, Visperas RM, Zhong X (2004). Rice yields decline with higher night temperature from global warming. Proceedings of the national academy of science 101(27):9971-9975.

Salami AT, Matthew OJ (2009). Challenges of Effective Climate Change Adaptation and Mitigation in Nigeria: The Role of Education. A paper presented at 5th World Environmental Education Congress May 10 - 14, at Montreal, Canada.

Semenov MA (2009). Impacts of climate change on wheat in England and Wales. Journal of the Royal Society Interface 6:343-350.

Tadross MA, Hewitson BC, Usman MT (2005). The interannual variability of the onset of the maize growing season over South Africa and Zimbabwe. Journal of Climate 18(16):3356-3372.

Wiebe K (2003). Land Quality, Agricultural Productivity, and Food Security at Local, Regional, and Global Scales. Paper presented at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July 27–30, 2003 Economic Research Service, USDA.

Ziervogel G, Cartwright A, Tas A, Adejuwon J, Zermoglio F, Shale M, Snith B (2008). Climate change and adaptation in african agriculture. Prepared for rockefeller foundation by Stockholm environment pp. 36-32.