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Research Article
Response of Cassava and Maize Yield to Varying Spatial Scales of Rainfall and Temperature Scenarios in Port Harcourt

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Abstract
Background and Objective: Climate change is a serious threat to crop productivity in regions that are already food insecure. There is broad interest in the impacts of some climate parameters on agriculture in Sub-Saharan Africa and on the most effective efforts to assist adaptation to these changes, yet the scientific basis for evaluating production risks and prioritizing some specific climate variables have been quite limited. This study assessed the impacts of temperature and rainfall on the yield of two major crops (cassava and maize) in Port Harcourt for the period of 2005-2009 spanning 5 years. **Materials and Methods:** Temperature and rainfall used for the study were sourced from the archive of the Nigerian Meteorological Agency, Lagos and crop yield data of cassava and maize sourced from the agricultural development programme Port Harcourt using statistical correlation analysis. **Results:** The study revealed that the temperature has a negative relationship with the yield of both cassava and maize, therefore, indicating that as temperature decreases, the yield of both cassava and maize increases, which means that the minimum temperature plays a significant role in the growth of cassava and maize in Port Harcourt. While rainfall has a moderate influence on the yield of both crops, indicating that high rainfall amount may have a negative impact on the crop yields. **Conclusion:** The response of crop yields to maximum high temperature might have an adverse effect on agricultural production in the study area, which is not good as it may lead to the shortage of food, hunger and food insecurity in the study area. The study provides insight into the significant impacts of the temperature and rainfall on cassava and maize yield in the study area.

Key words: Temperature, climate change, crops yield, agricultural products

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Global food security weakened by climate and environmental change is one of the most critical difficulties in the 21st century to supply adequate food for the increasing population while sustaining the already stressed environment has become more undermining to the continuous development globally. The mean global temperatures have been increasing in line with precipitation increases since 1850, mainly due to the accumulation of greenhouse gases in the atmosphere[1]. Extreme climate conditions, for example, high wind, torrential rainfall, heat and cold can bring about far-reaching situations such as typhoons, surge, droughts, avalanche, dry spells and ocean level ascent. Pest and diseases are also embroiled in climate change. Significant climate conditions such as temperature, precipitation, sunshine and wind can influence and quicken their distribution and their increase[2].

Intergovernmental Panel on climate change[3] suggests that crop production around the globe, especially in the Sahel region, is expected to be badly affected by the climate change i.e. rise in temperature, droughts and erratic rainfall. Global warming and consequently the unexpected weather variability can be harmful to agriculture sector through its negative impact on plant growth and development[4].

Nigerian agriculture depends profoundly on climate since rainfall, radiation, temperature and relative humidity is the principal drivers of crop yield and growth[5,6]. Produce of farm products generally need a specific measure of precipitation during growth stages for best yield and when this ends up plainly extreme it prompts poor harvest if by any stretch of the thought. Additionally, when this is added to high temperature the condition of the soil will exhibit conducive to micro-organism which disintegrates biomass into organic or natural matters. This event will result into soil unproductiveness that may prompt extremely poor yield. This sets changing climate as an essential element in agricultural production for food security for both locals and universally. Climate change influences the natural ecosystem and soil, which altogether impacts farming generally sustenance production[4]. It was predicted that Nigeria and other West Africa nations are expected to have agricultural declines of up to 4% of GDP due to climate change[7,8]. This is in accordance with the discoveries of Ofuoku[9], who stated "that rural farmers are getting to be plainly poorer on the grounds that their farming system is described by low and declining productivity because of the impact of climate change". Farming products are essential in ensuring food assurance. The increment in farming strength enhances rural benefits and lower food costs, making it more available and beneficial to the poor. Although, the effect of environmental change may incite low farming effectiveness in achieving rural families' food stability and this approach is needed in the study area due to the food scarcity where rural farmlands are rendered ineffective and crops have been wrecked as a result of flooding and other environmental related components combined with the current oil spillage in the area. If food demands increase and farming product diminishes persist in the area, therefore, the study area will undoubtedly be food insecurity problem in the area, if outstanding actions are not taking to uncover the threat of changing climate that causes flooding and other related hazards which pose a significant danger to food creation. Many rural households in the area are vulnerable to persistent food curtailments, inconsistent supply, poor quality and fluctuating food costs[10]. Notwithstanding most households in the study area live in the rural areas and mostly involved in agriculture for the production of food for individuals and state at large. Developing agreement in the scientific literature revealed that, in the nearest future or decades higher temperatures and changing precipitation levels caused by climate change will be unfavorable to crop growth in many regions and countries[7,8,11,12]. In other to know the extent at which climate change affects agricultural production, this study examined the impacts of temperature and rainfall on cassava and maize farming in Port Harcourt, Rivers state of Nigeria.

MATERIALS AND METHODS

The study area for this work is Port Harcourt, Rivers state of Nigeria and it falls between the latitude 4°49' 27"N and 7°2' 1"E and longitude 4.82417°N and 7.03361°E, the total area covered by Port Harcourt is approximately 369 km^2 (142 sq mi) metropolis, 360 km^2 (140 sq mi) land, 9 km^2 (3 sq mi) water. Port Harcourt is the capital of Rivers state and the largest city of Rivers state, Nigeria. It lies along the Bonny river and is located in the Niger delta. As of 2016, the Port Harcourt urban area has an estimated population of about 1,865,000 inhabitants, up from 1,382,592 as of 2006 (Fig. 1).

The data used for this study is mainly secondary data which are the monthly temperature (minimum and maximum) and rainfall between 2005 and 2009 for Port Harcourt obtained from the operational headquarters of the Nigerian Meteorological Agency Oshodi, Lagos State. The cassava and maize yield data between 2005 and 2009 was obtained from the Agricultural Development Programme (ADP), Port Harcourt Rivers state. The mean daily observation for each month and each year for the period 2005-2009 for both the temperature (minimum and maximum) and rainfall were statistically analyzed to obtain the monthly values for rainfall and temperature for the station under study. This period was considered in the study due to the Nigerian Meteorological Agency report on the impact of climate variability on agricultural products between 2001 and 2012[9,13], this was done with the available information on cassava and maize yield in the area.

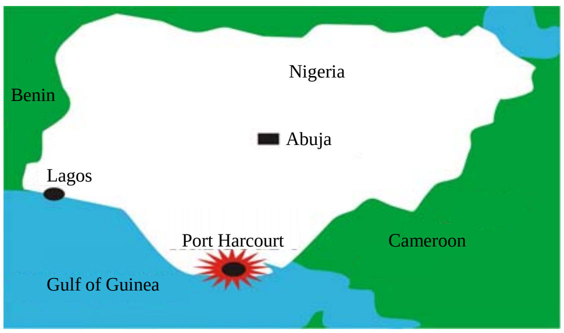


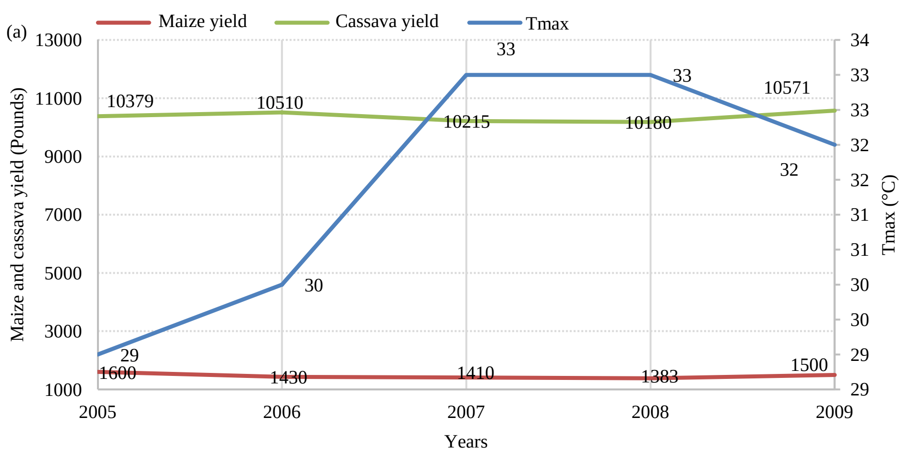
Fig. 1: Map of the study area

Statistical analysis: The method used in this study includes the trend analysis and correlation analysis between rainfall, temperature and the crop yield data and other statistical analysis like mean standard deviation.

RESULTS AND DISCUSSION

Maximum temperature appeared to vary independently with little or no positive response on maize and cassava compared with minimum temperature where it seems the crop yields are influenced by this phenomenon. Conversely, the production of all the food crops seemed to be more reliant on the minimum temperature and lesser on the amount of precipitation (Fig. 2a-b, 3).

The regression analysis of crop yields and weather variables present in Table 1. The result revealed that R^2 and adjusted R^2 between minimum temperature and crops yield indicates that the model explains the significant relationship between both variables compared to other weather variables (rainfall amount and maximum



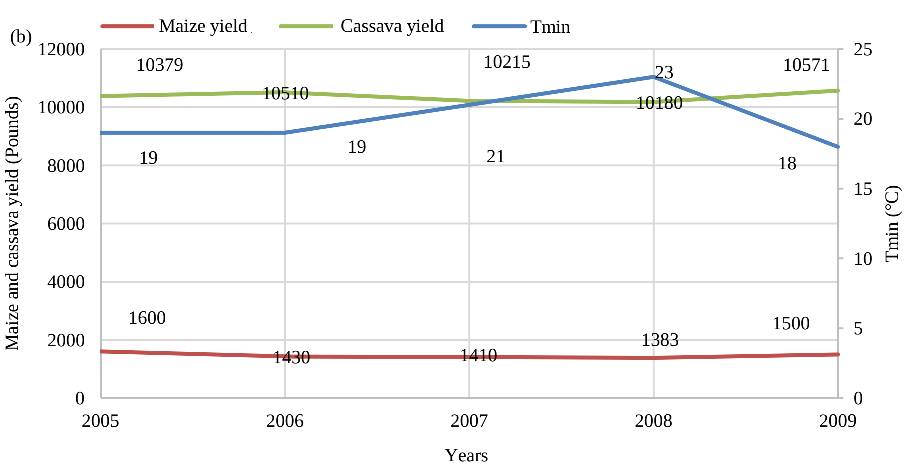


Fig. 2(a-b): Annual variability in (a) Maximum and (b) Minimum temperature, maize and cassava yield between 2005 and 2009

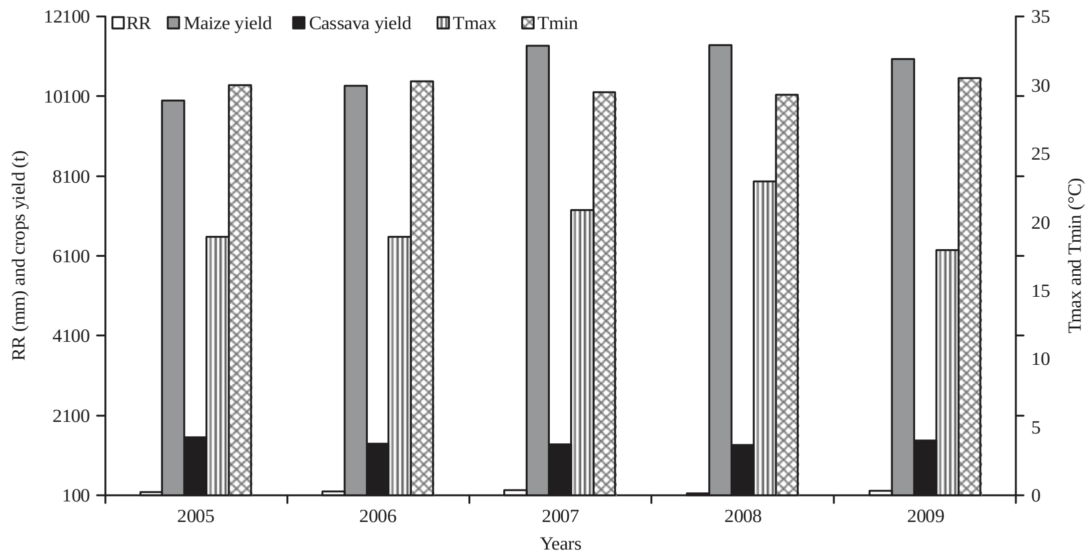


Fig. 3: Crops yield and climate variables

Table 1: Regression analysis of crop yields and climatic parameters

Variables	R^2	Adjusted R^2	F factor	Significant F	p-value	Standard error
RR and maize yield	0.0965	-0.2047	0.3204	0.3109	0.02914	0.1924
RR and cassava yield	0.0549	-0.2602	0.1742	0.2045	0.02045	0.0990
Tmax and maize yield	0.55758444	0.410112591	3.780955	0.147067	0.01471	0.0079
Tmax and cassava yield	0.26546286	0.020617146	1.084205	0.3742941	0.03743	0.0052
Tmin and maize yield	0.755739781	0.74319708	2.512069	0.711154	0.07112	0.0098
Tmin and cassava yield	0.846583	0.795444	16.55458	0.626784	0.162678	0.0026

temperature). In general, the higher the R^2 and the adjusted R^2 the perfect the association of the variables. As Table 1 also shown, the p-value revealed the significant relationship between the two variables as p-values higher than alpha level (0.05) between minimum temperatures compared to the other one where they have less than alpha level. If the p-value is less than alpha value, the analysis is not statistically significant[14].

Figure 2 and 4 show the inter-annual average climatic variables and crop yields in the study area from 2005-2009. The estimated mean of the temperature and rainfall variables indicate that the amount of rainfall amount varied appreciably from year to year. The trend of the rainfall over the area shows that year 2007 recorded higher annual rainfall compared with the earlier years indicating that the study area has experienced variability in the rainfall trend between 2005 and 2009. Figure 2a, b and 4 depict the relationships between crop yields and the climatic variables in the study area.

During the study period, the year 2009 had the lowest minimum temperature of 18°C and highest minimum temperature in the year 2008 with 23°C (Fig. 2b). The results revealed that crops yield increase with the decreasing trend in minimum temperature which implies that the lower the temperature the more the increase in crop yields. These trends are indications that the minimum temperature is one of the most climatic variables that support the cassava and maize yield in the study area as indicated in Fig. 2b. Table 2 presents the correlation matrix between the variables used in this study. A correlation matrix is a table showing correlation coefficients between variables, where variables are correlated to each other values in the table. The result shows that minimum temperatures and crops yield have a strong positive correlation while other variables have a weak negative correlation. The outcome of this analysis connotes the strength of minimum temperature on crop yields in the area and other factors might contribute to its impacts such as fertilizer application, soil types, geographic location[5,6,15].

The annual trends variations in climatic variables and crop yield (Fig. 2-4) are indications that the minimum temperature amount was the most meteorological variable in the study area that influences the crops yield of both cassava and maize during the study period. The present investigation concurs with the perceptions made by Oluwasegun and Olaniran[16]. The inter-annual variability of rainfall was evident and this may often result in impacting the rate of crop yields in the area, especially during the torrential rain, with wrecking impacts on

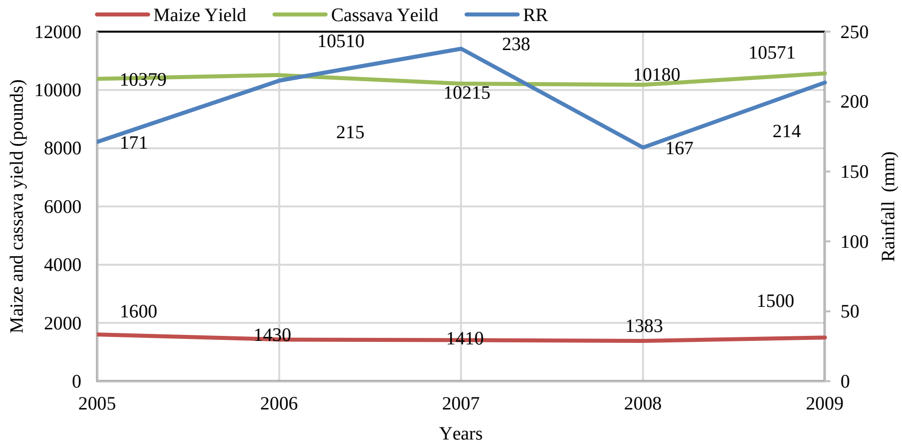


Fig. 4: Annual variability in rainfall, maize and cassava yield between 2005 and 2009

Table 2: Correlation matrix table for climatic variables and crops yield between 2005 and 2009

	Tmax	Tmin	RR	Maize yield	Cassava yield
Tmax	1	1	1	1	1
Tmin	0.619292	1			
RR	0.288941	-0.30373	1		
Maize yield	-0.74672	-0.67509	-0.31063	1	
Cassava yield	-0.51523	0.9201	0.234281	0.454040706	1

food creation and related catastrophes and human sufferings[17]. The efficiency of agricultural production in the region is profoundly unfit due to climate variability[18,19]. This study demonstrated that crop yields and precipitation amount varied essentially from year to year and there was a notable relationship between crop yields and minimum temperature and partially with rainfall amount (Fig. 2b, 4).

The result depicts that the production trend for cassava and maize were very similar but differ in quantity, implying that similar factors affected their production. The yields of maize and cassava were between 10180 and 10571 t and between 1383 and 1600 t for cassava and maize, respectively over the same period. Climatic elements between 2005 and 2009 might have accounted for the crop yields of the two crops. The yields for the crops (maize and cassava) do not follow the same trend throughout the period of study, but cassava and maize have their peaks in the year 2009 with 10571 t and 2005 with 1600 t, respectively which corroborated with the years that recorded lowest minimum temperature, this supports that minimum temperature have much impact on cassava and maize yield[13,20].

CONCLUSION

The impact of rainfall and temperature on cassava and maize yields in the study area have been studied using climatic data and crops yield from Nigerian Meteorological Agency and the Agricultural Development Programme (ADP), Port Harcourt Rivers state respectively between 2005 and 2009. The results gave the baseline levels of impact of these parameters on maize and cassava yields using correlation analysis. The correlation between crop yields and climatic components have been assessed and it was observed that the minimum temperature have a significant impact on the two crop yields compared to the rainfall amount and maximum temperature. Moreover, distant from climatic variables, crop yield may also rely upon mixes of various connecting factors which are of both environmental and non-climatic elements. Despite the fact that the crop yields could be climate reliant, other variables such as farm administration systems, seed type, soil fertility, pests and quality and planting period may contribute fundamentally to varieties in crop yield.

A reasonable connection between crop yield and climate parameters, especially the temporal change in precipitation amount and temperature has been verified. Subsequently, for future study, specific technologies and administration styles may need to be developed to ensure the sustainability of agricultural products.

SIGNIFICANT STATEMENTS

This study discovers the possible significant effect of temperature and rainfall on crop yields and this result can be of great benefit to the agriculture sector. While the minimum temperature in the study area has a substantial impact on cassava and maize yields and this might be beneficial to farmers in the area. This study adds to existing knowledge and will also help the researcher to uncover the yield response to these climatic variables that many studies were not able to explore. Thus, a new approach to these phenomena and possibly other factors, may be arrived at.

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