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Research article

Impacts of climate change on human and plant nutrition and health

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Abstract: The impact of climate change on human and plant nutrition and health is felt worldwide. Rising atmospheric greenhouse gas concentrations, temperature extremes, changes in precipitation, increases in the frequency and density of weather events, and rising sea levels confer severe direct and indirect impacts on human health. The rapid flooding, intensive drought, unpredictable heat-waves including rapid wildfire outbreak has been on the increase exacerbating various chronic diseases and intensifying global cardiovascular heat-stress. Indirect health impacts of climate change may be long-term and might progressively lead to behavioural changes. The field survey was carried out in Calabar and Obubra, where anthropometric measurement of children under five (5) years were carried out. Soil-pant visual assessment for soil-plant nutrition and health was carried out in both Obubra and Calabar. Correlation statistics and analysis of variance (ANOVA) were used to analyze field data. Result of the field survey indicated that climate change can statistically ($P>0.05$) damage plant-human health and nutrition. Result analysis output indicated that there exist a relationship between human-soil health/nutrition and climate change. A climatic percentage analysis relationship indicated that human nutrition/health has a (% Relationship = 77.59), plant-soil health interaction (% Relationship = 63.34) which indicated that the climatic system has a strong influence on human-plant-soil survival and sustainability. Findings of the study revealed variation in climatic element of rainfall, temperature and relative humidity of Obubra and Calabar. The study encourages mineral fertilizer application including application of organic amendment, as a targeted strategy for soil improvement to reduce malnutrition. Further aggressive implementation of scientific and traditional strategy and approaches that will enable CO_2 and other greenhouse gas emission reduction have been advice for human-soil-crop health and nutrition sustainability.

Keywords: Man, Plant, Climate Change, Nutrition, Health, Human development.

INTRODUCTION

The impacts of climate change on human-plant health, nutrition, food security and soil sustainability has been on the negative for years now. Rising cases of human malnutrition, soil degradation including low crop yield has been attributed to the negative effect of the variation in the earth climatic system (FAO, 2006; WHO, 2016). Nutrition-related problems in plant, soil and humans has continued to affect adversely the wellbeing and economic development of most low- and middle-income countries, including Nigeria, acting as a barrier for the sustainability of the developmental strive of the nation. Research findings of Intergovernmental Panel on Climate Change (IPCC, 2007) has revealed that anthropogenic factors geared by human activities including fossil fuel and unsustainable land management have worsen the impact of climate change experienced globally. Projections for the 21st century shows that global warming will accelerate with predictions of the average increase in global temperature ranging from 1.8°C to 4°C (IPCC, 2007; Adiaha *et al.*, 2020). Apart from the increased average global temperature, climate change also influences stronger storm systems, increased frequency of heavy precipitation events and extended dry periods (NIMET, 2020). These changes also have implications for food production including human-plant nutrition and health, with grave consequences. CO_2 is crucial in the manufacture of plant food. Various projections on the increase of this potential greenhouse gas emission have been stressed. The future survivability of Humans-animal-environmental nexus is threatened with the current flux of CO2 among other greenhouse gases. The impact on the increasing levels of CO_2 in photosynthesis, biomass productivity and plant growth has been well documented in the work of Ainsworth & Long (2005).

Anthropometry, which is the use of body measurements to assess the nutritional status of individuals and groups (Gorsteina & Akrea, 1988), is a practical and accurate approach of evaluating the nutrition and health status of an individual. Anthropometry stands as one of the most practical method of nutritional assessment of individuals in a population, although biochemical techniques among others can also be assessed for this purpose. Nutritional assessment at the early years of life when growth rate is rapid in children gives the most reliable status of the nutritional status both immediate and cumulative of the individual in question, and the assessment of this growth parameters gives insight into nutritional status of both the individual and the entire population been targeted. Several studies including the research of

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(Gorsteina & Akrea, 1988) have presented a view that anthropometric data provides a useful guide for correlation of the health and nutritional condition of an individual or group with other sector, like the food production and agricultural sector. Building on this, the Caribbean Food and Nutrition Institute (2002), presented a view that anthropometric data can be correlated with data from the agricultural sector, where valid judgment can be made on the situation of the food, health, nutrition including the soil sector.

The occurrence of nutrient deficiencies or toxicities is a result of soil, crop, climate, and cultural factors. These factors interact to influence the availability of nutrients to crop plants (University of Missouri, 2002). The research of University of Missouri (2002) further indicated a view that soil nutrition and health can easily be assessed using visible indicators of planted crops in the area in question. Building upon this, FAO (2006) reported a view that the lacking nutrients in soils can be seen in visual observation of plants, and with a low status of soil nutrient indicated on plant appearance. Findings of the Caribbean Food and Nutrition Institute (2002) and FAO (2006) indicated that food production is greatly impaired when soils show low nutrient status in plant visible appearance. Low soil nutrient status geared by climatic impact has been reported by FAO (2000) to be one of the gearing factor of human-plant malnutrition and a drawback to food security. The objectives of the present study include:

1. Assess the nutrition and health of children in Obubra and Calabar, and correlate with it climatic behavior
2. Assess the nutrition and health of Maize (*Zea mays* L.) plant in Obubra and Calabar, and correlate with it climatic behavior
3. Assess the climatic status of Obubra and Calabar, with a view of advising stockholders on modalities for local mitigation and adaptation to climatic variation

MATERIAL AND METHOD

The study area

Obubra

Obubra lies between latitudes 5º 44' N to 6º 17' N and longitude 8º 11' E to 8º 33' E, covering an area of approximately 1122 km^2. Obubra is geographically located in the central part of Cross River State (Fig. 1). Obubra is a derived savanna, characterized with rain forest, tall tress and grassland. The area is characterized by rainy season which begins in April and ends in mid-October and the dry season which starts by mid-October up to April. Also, rainfall ranges from 120 to 220 mm annually (Egor *et al*., 2015). Annual precipitation in the area is usually over 2200 mm, while annual temperatures range between 23ºC and 32ºC (Akpan *et al*., 2013). The area has recorded a relative humidity of 88%. Obubra has low relief, undulating topography with surface water ponds and streams.

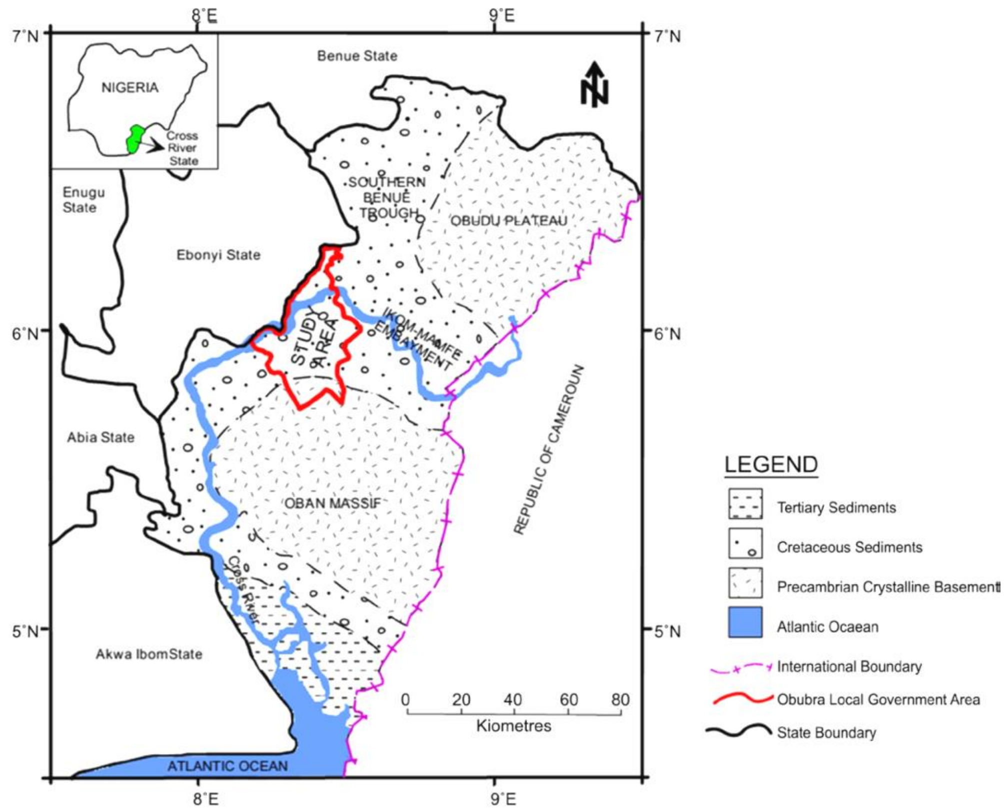

Figure 1. Location map of the study area within Cross River state. [modified after Kudamnya & Andongma (2017) and Kudamnya *et al*. (2019)]

Calabar

Calabar South Local Government Area of Cross River State is located on longitude 8º 19' and 8º 21' east of the Greenwich meridian and latitude 4º 54' and 4º 58' north of the equator. The region is bounded on the north by Calabar municipality and lies on a peninsula of the Calabar River in the west. The Great Kwa River is in the eastern flank of the region while the Cross River Estuary and the Atlantic Ocean are in the southern part of the region (Fig. 2). The area has a sub-equatorial type of climate. It experiences a moderately high temperature which ranges from 27ºC to 35ºC. The average annual rainfall is between 2000 to 3500 mm and relative humidity of 80 to 100 percent throughout the year (NIMET, 2015). The area lies in the low lying coastal lands and plains which form part of the larger coastal plains of south eastern Nigeria. The coastal plains are characterizes by level to gentle undulating topography. The elevation varies from zero to fifty metres (0-50 m) above sea level and increase northwards from the coast Okon (2010).

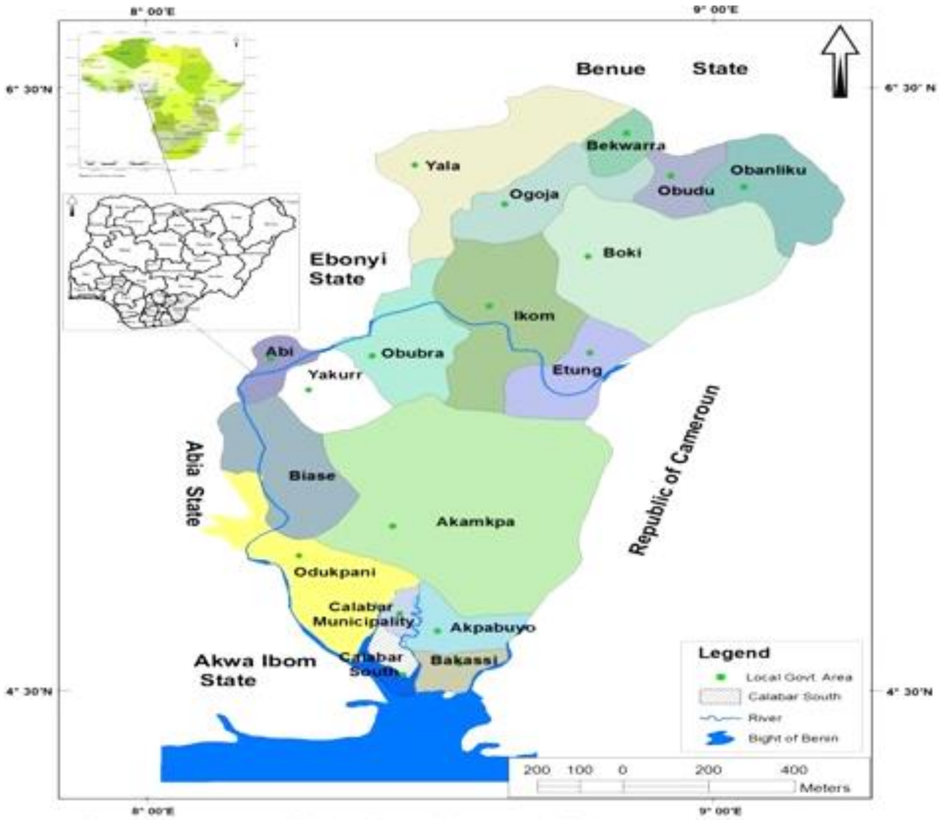

Figure 2. Base-map of Calabar South Local Government Area of Cross River State.

Sampling technique

The study adopted the stratified random sampling techniques, where four (4) communities in both Obubra and Calabar were randomly selected and stratified, using the institution situated in the two area as the common point. The areas were delineated using common characteristics. Bases map of the areas where developed following major ground trothing and field assessment studies.

Soil assessment through plant visual characteristics

Pant health and nutrition assessment

Four communities in both Obubra and Calabar were randomly selected using stratified random sampling technique, where traditional farmer field including students experimental control plots were used to assess soil-plant health and nutrition. Data collected were coded using a standardized procedure by FAO (2006) for rating non-numerical data.

Climate change science studies

The climatic element: temperature, relative humidity including the rainfall of Calabar and Obubra were studied. Data collection was done at the sedentary meteorological stations in the two localities. Climatic data was recorded for two years. Climatic data was subjected to both correlation and Analysis of Variance (ANOVA) analysis in-other to find the significance among means, interaction, and percentage impact

Human nutrition and health assessment

In-other to assess the health and nutritional status of the targeted stratified sample area, children under five (5) years where assessed. Data obtained for the anthropometric measurement include weight, height, body mass index (BMI) including head circumference. Field data was subjected to analysis of variance. The anthropometric data were further correlated with soil-plant and climatic data to find a relationship that exist, and the percentage influence of interaction.

Data analysis

Field data was subjected to Analysis of Variance (ANOVA) in other to present the variation among the related parameters. In other to find the interaction that exit between the parameters, the Pearson Product Correlation (PPMC) analysis was utilized, where the coefficient of determination (R) and correlation coefficient (r) was utilized to establish the relationship. Simple Linear Regression model: Y = a + b*X was utilized to present the relating influence among the various parameters. Duncan Multiple Range Test was used to find the differences that existed among means at 0.05% probability level. Durbin-Watson (DW) statistic was utilized to tests the residuals to determine if there is any significant among correlating parameters. A modelling and statistical tool: Statgraphic Centurion “version 18” was utilized to run data analysis and modelling.

RESULT AND DISCUSSION

Climatic drift and potential influence on human-soil-plant relationship

Table 1. Climatic Behavior Measurement of Calabar and Obubra.

Calabar municipality				Obubra		
Climatic Data of Calabar Local Government Area of Cross River State (2016-2017)				Climatic Data of Obubra Local Government Area of Cross River State (2016-2017)		
Months	Mean Rainfall (mm)	Mean Temperature (ºC)	Mean Relative Humidity (%)	Mean Rainfall (mm)	Mean Temperature (ºC)	Mean Relative Humidity (%)
April	100.2	28	80	163.2	34.5	81.1
May	401	27.6	84	263.1	31.3	83.1
June	678.7	25.8	92	537.1	30.1	87.7
July	386.6	22.5	93	637.5	32.3	90.8
August	422	25.5	93	389.8	29.2	85.3
September	476.8	26.4	92	421.5	28.1	87.2
October	208.4	26.5	88	301.2	30.4	75.5
November	392	27.4	86	187.1	29.5	84.1
December	0	27.2	65	15.3	29.5	65.7
January	0	28.3	68	13.4	21.3	58.3
X	306.57	26.52	84.10	292.92	29.62	79.88
STD	210.62	1.60	9.71	197.10	3.26	9.89
CV (%)	69	6	12	67	11	12
SE	66.60	0.50	3.07	62.33	1.03	3.13

The trend observed for the climatic condition in Obubra and Calabar (Table 1) indicated a drift in the effect of climate change on the study locations. Data analysis output indicated that the rainfall in the areas investigated in Calabar was seasonal, while presenting a coefficient of variation (CV% = 69) indicated a view that with the increasing variation and uncertainty in the climatic system, and with the continual global pill-up of CO_2 increase precipitation intensity is expected in the area. It was observed that the highest duration of rainfall was in June which recorded a rainfall intensity at (678.7 mm), this was followed by September which recorded a mean value of rainfall at (476.8 mm) indicating a view that rainfall in the area is seasonal, with an implication that there may be an increase with the current climatic variation in the climatic system. There was no rainfall in December 2016 and January of 2017, presenting a view that although this area witness relatively heavy period of rainfall, dry spells (period of no rainfall) is often witness, there exist the fear that with the continual increase in the earth warming due the rapid build-up of atmospheric CO2, then fear has been raise about the progressive increase in the period of dry spell in Obubra, this finding confirms the work of IPCC (2000), which stated rapid deterioration of the earth climatic system due to variation and rapid heating up of the earth by greenhouse gases. It was observed that the temperature of Calabar in January, 2017 recorded the highest temperature at (28.3^{o}C) which indicated a view that the intensity of heat in the area could approach normal to nearly higher values above room temperature with a climate change. The CV of the temperature of the area was observed to be (CV% = 6) which indicated a high variability for temperature increase. This view is in-line with the study of UNFCCC (2000) which stated rapid increase in environmental temperature been a factor triggering drought among other climatic driven change that causes severe suffering to humans and act as a degrading factor to environmental sustainability. The relative humidity of Calabar was observed to be at 93% for July and August 2016, respectively. The least relative humidity was observed at 65% which was observed for the December, 2016. The coefficient of variation (CV% = 12) was recorded for the humidity of Calabar, presenting a view that the area has close to normal amount of water vapour present in air. This finding is in-line with the assertion of NIMET (2017) which predicted normal and close to the abnormal relative humidity in coastal regions of Nigeria.

The rainfall of Obubra was observed to at a pick in July, 2016 to the volume of 637.5 mm, and also at a volume of 421.5 mm in the of September, 2016, while a low value of 15.3 mm was observed for December, 2016. The least volume of rainfall in this study was obtained in January, 2017, which produced a rainfall intensity that accounted for 13.4 mm of rainwater. A coefficient of Variation value at (CV% = 67) indicated the rainfall been high. A mean temperature of 34.5^{o}C was recorded for April, 2016 which was the highest amount of temperature flux observed for Obubra. This was followed by 31.3ºC which was observed for May, 2016. At September, 2016 a mean temperature value of 28.1ºC was obtained. The month of January, 2017 recorded the least flux in temperature, with a mean value recorded at 21.3ºC. A CV value (CV% = 11) was obtained, indicating that the mean temperature of the area was low. A mean relative humidity value of 90.8% was obtained for July, 2016, this was followed by 87.7% which was obtained for June, 2016. A value to the tune of 87.2% was obtained as the Relative humidity for the month of September, 2016. January, 2017 recorded the least Relative humidity flux for periods investigated for this study. A coefficient of Variation value (CV% = 12) was obtained for the behavior of Obubra's relative humidity in the months investigated, presenting an accurate observation frequency for the data recorded. Hence indicating that the relative humidity (amount of water vapour present in air) of the area is low. The view of this finding agrees with the work of Kudamnya & Andongma (2017) who reported variation in the climatic trend of Obubra Local Government Area of Cross River State.

Rainfall variation, interaction and influence

Mean rainfall variation in calabar vs. mean rainfall in Obubra

The output shows the results of fitting a linear model to describe the relationship between Mean Rainfall (mm) in CALABAR and Mean Rainfall (mm) in OBUBRA. The equation of the fitted model is Mean Rainfall (mm) in CALABAR = 52.8956 + 0.866019*Mean Rainfall (mm) in OBUBRA. Since the P-value in the ANOVA table is less than 0.05, there is a statistically significant relationship between Mean Rainfall (mm) in CALABAR and Mean Rainfall (mm) in OBUBRA at the 95.0% confidence level (Table 2, 3 and Fig. 3).

The R-Squared statistic indicates that the model as fitted explains 65.6774% of the variability in Mean Rainfall (mm) in CALABAR. The correlation coefficient equals 0.810416, indicating a moderately strong relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 137.956.

The mean absolute error (MAE) of 109.68 is the average value of the residuals. To test residuals and to determine if there exist significant among a data set in the manner of appearance the Durbin-Watson statistics is utilize. The rule guiding Durbin-Watson statistics holds that when P-value is greater than 0.05 then there is no existence of serial autocorrelation in the residuals at a 95.0% confidence level. The implication of the statistical output indicated a view that the rainfall in the two study areas has a strong relationship expressed in their correlation, this presented a view that the rains in the areas are seasonal, and with the continual increase in the earth climatic trend, this observed trend could be triggered towards the negative (increase rainfall, with flooding tendency) or less rainfall intensity that could exacerbate periods of drought. This finding is inline with the findings of the World Meteorological Organization (2000) that stated both increase and decrease in rainfall intensity due to the impact of climate change. Findings of IPCC (2000) further support this finding, where her report projected increase in rainfall and drought intensity in sub-Saharan Africa, among other vulnerable low-middle income countries of the world with low technology and manpower.

Table 2. Coefficients.

Parameter	Least Squares Estimate	Standard Error	T-Statistic	P-Value
Intercept	52.895600	78.146300	0.67688	0.5176
Slope	0.866019	0.221342	3.91258	0.0045

Note: Dependent variable: Mean Rainfall (mm) in OBUBRA; Independent variable: Mean Rainfall (mm) in CALABAR; Linear model: Y = a + b*X; Number of observations: 10.

Table 3. Analysis of variance.

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	291345.0	1	291345.0	15.31	0.0045
Residual	152255.0	8	19031.8		
Total (Corr.)	443599.0	9			

Note: Correlation Coefficient = 0.810416; R-squared = 65.6774 percent; R-squared (adjusted for d.f.) = 61.3871 percent; Standard Error of Est. = 137.956; Mean absolute error = 109.68; Durbin-Watson statistic = 2.7606 (P=0.8398); Lag 1 residual autocorrelation = -0.423.

Temperature variation, interaction and influence

The output shows the results of fitting a linear model to describe the relationship between temperature in CALABAR and OBUBRA. The equation of the fitted model is CALBAR= 22.244 + 0.926501*OBUBRA. Since the P-value in the ANOVA table is greater or equal to 0.05, there is not a statistically significant relationship between CALABAR and OBUBRA at the 95.0% confidence level. The R-Squared statistic indicates that the model as fitted explains 7.93142% of the variability in CALABAR. The correlation coefficient equals 0.281628, indicating a relatively weak relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 45.9731 (Table 4, 5 and Fig. 4).

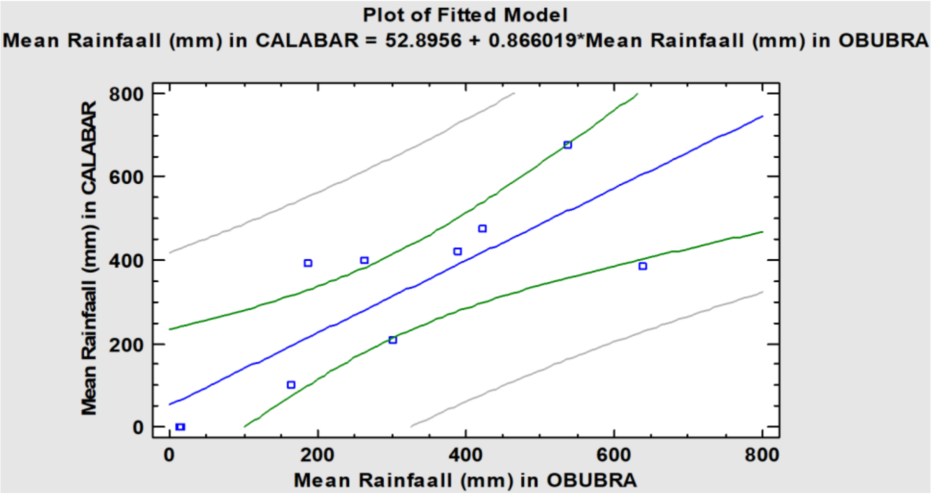

Figure 3. Rainfall Variation, Interaction and Influence in Calabar and Obubra.

The mean absolute error (MAE) of 27.897 is the average value of the residuals. It was observed that P-value is greater than 0.05 which indicated no indication of serial autocorrelation in the residuals at 95.0% confidence level. The implication of the statistical analysis indicated that the temperature of Calabar does not hold any influence on the temperature of Obubra, this view confirms the work of IPCC (2000) where her report indicated temperature variation, due to climate change in a different part of the earth.

Table 4. Coefficients.

Parameter	Least Squares Estimate	Standard Error	T-Statistic	P-Value
Intercept	22.244000	38.30470	0.580711	0.6202
Slope	0.926501	2.23209	0.415083	0.7184

Note: Dependent variable: OBUBRA; Independent variable: CALABAR; Linear model: Y = a + b*X; Number of observations: 4.

Table 5. Analysis of Variance.

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	364.148	1	364.148	0.17	0.7184
Residual	4227.060	2	2113.530		
Total (Corr.)	4591.210	3			

Note: Correlation Coefficient = 0.281628; R-squared = 7.93142 percent; R-squared (adjusted for d.f.) = -38.1029 percent; Standard Error of Est. = 45.9731; Mean absolute error = 27.897; Durbin-Watson statistic = 2.5041 (P=0.8721); Lag 1 residual autocorrelation = -0.36804.

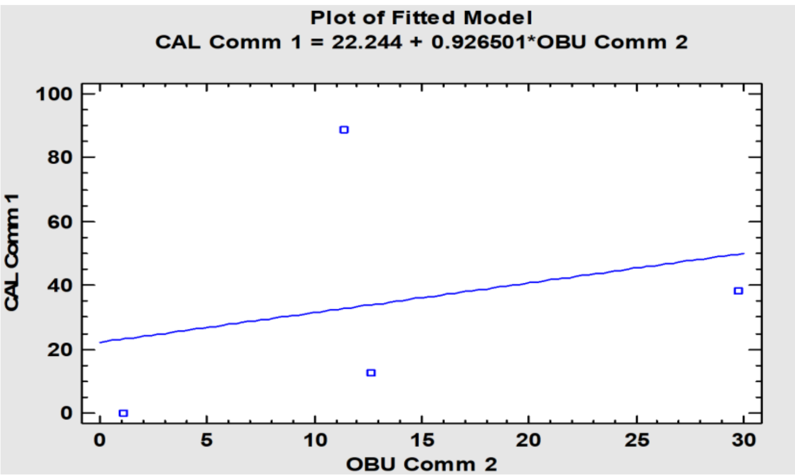

Figure 4. Temperature Variation, Interaction and Influence between Calabar and Obubra.

Relative humidity variation, interaction and influence

The output shows the results of fitting a linear model to describe the relationship between CALABAR and OBUBRA. The equation of the fitted model is CALABAR = 21.5629 + 1.06539*OBUBRA.

Since the P-value in the ANOVA table is greater or equal to 0.05, there is not a statistically significant relationship between CALBAR and OBUBRA at the 95.0% or higher confidence level. The R-Squared statistic indicates that the model as fitted explains 10.1457% of the variability in CALBAR. The correlation coefficient equals 0.318523, indicating a relatively weak relationship between the variables as presented in table 6, 7 and in figure 5.

The standard error of the estimate shows the standard deviation of the residuals to be 46.4057. The mean absolute error (MAE) of 28.1828 is the average value of the residuals. Analysis output presented in table 6, 7 and in figure 5 indicated that P-value is greater than 0.05, hence there is no serial autocorrelation in the residuals at 95.0% confidence level. Findings of this research agree with the work of WMO (2000) where her report indicated variation in the global amount of water vapour present in the air. The finding also confirms the work of NIMET (2016), where their finding indicated variation in Nigeria's water vapour present in the air.

Table 6. Coefficients.

Parameter	Least Squares Estimate	Standard Error	T-Statistic	P-Value
Intercept	21.56290	38.94210	0.553715	0.6354
Slope	1.06539	2.24193	0.475211	0.6815

Note: Dependent variable: OBUBRA; Independent variable: CALABAR; Linear model: Y = a + b*X.

Table 7. Analysis of variance.

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	486.312	1	486.312	0.23	0.6815
Residual	4306.980	2	2153.490		
Total (Corr.)	4793.290	3			

Note: Correlation Coefficient = 0.318523; R-squared = 10.1457 percent; R-squared (adjusted for d.f.) = -34.7815 percent; Standard Error of Est. = 46.4057; Mean absolute error = 28.1828; Durbin-Watson statistic = 2.53138 (P=0.8767); Lag 1 residual autocorrelation = -0.380355.

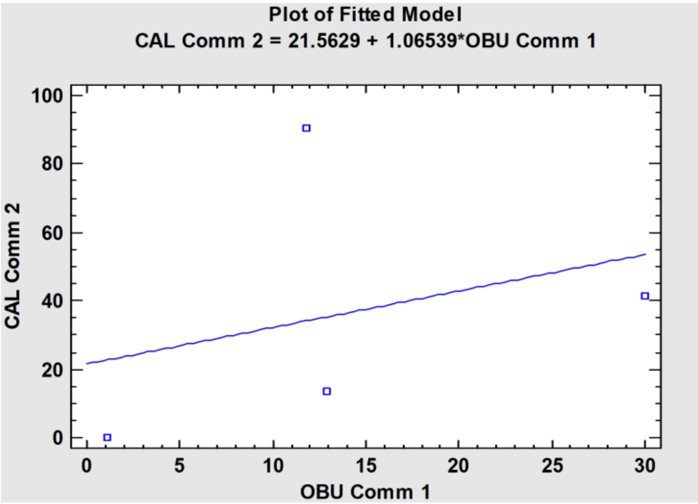

Figure 5. Relative Humidity Variation, Interaction and Influence between Calabar and Obubra.

Human nutrition and health interaction and influence

The nutrition and health of the targeted research participants measured indicated that the weight of children in University of Calabar smallholder farm (Table 8) is below the standardized weight prescribed by WHO (2016), presenting a value (12.8 kg for weight of the body) that indicated that the children where malnourished, presenting such children to be vulnerable to disease which may be triggered by the continual flux of atmospheric carbon. Assessment of the Basin Authority smallholder farm children nutritional status revealed that the mean weight of the research subjects was 13.4 kg indicating a low value when compared to the standardized value presented by WHO (2016) Table 8 indicating a view that the children in the area are malnourished. This same trend was observed for height (90.5 kg), head circumference (41.6 kg) and body mass index (BMI = 0.15). The same malnutrition case was observed in Ovonum and Ofudua communities of Obubra, where children under five (5) years were observed to weigh a mean value of (12.9 kg and 12.6 kg respectively) and BMI = 1.09 for Ovonum and BMI = 1.11 kg for Ofudua respectively, which indicated a view that these individuals are sick and nutritionally unbalanced. The outcome of this study presented in

Table, 8, 9 and 10 confirms the findings of WHO (2016) which indicated children under five (5) years been malnourished, sick and suffer from hinder hunger especially in low and middle-income countries.

Table 8. WHO standard for Anthropometric Parameters for children at 5 years.

Anthropometric Parameters	Standardized Value
Weight (kg)	18.3
Height (cm)	110.0
Head circumference (cm)	50.7

Note: Values falling below this standard poses problem to child health and nutritional development.
Source: World Health Organization (2016)

Table 9. Human Nutrition and health Anthropometric Measurement.

Anthropometric Parameters	Calabar		Obubra	
	CAL Comm 1 (Mean)	CAL Comm 2 (Mean)	OBU Comm 1 (Mean)	OBU Comm 2 (Mean)
weight (Kg)	12.80	13.40	12.90	12.60
Height (m)	88.60	90.50	11.80	11.40
Head circumference	38.30	41.60	30.00	29.80
Body Mass Index (BMI) (kg m^{-2})	0.14	0.15	1.09	1.11
X	34.96	36.41	13.95	13.73
STD	33.88	34.63	10.35	10.30
CV (%)	97.00	95.00	74.00	75.00
SE	16.94	17.32	5.18	5.15

Table 10. Communities where Human nutrition and health was Assessed.

S.N.	Calabar	Obubra
1	UNICAL small holder Farm	Ovonum
2	Basin Authority small holder Farm	Ofudua

Soil fertility and plant nutrition assessment through crop visualization

Result of visual analysis of soil-plant nutrition and health (Table 11) indicated that soils of the area has a low plant nutrient availability to support quality plant growth, development and yield. Data presented in table 11 indicated that the soils has low Nitrogen (N), Phosphorus (P) and Potassium (K), and this could be a threat to the sustainability of the soils, and may act as a serious hindrance to the improvement of the malnutrition status of the children assessed. Building upon this view, it could be stated that there exists a relationship between soil health, nutrition and human health and nutrition. The outcome of this finding as indicated in table 11 and 12, and in figure 6, agrees with the research of FAO (2006) which stated soil quality having a relationship with the health and nutritional quality of humans and livestock.

Table 11. Plant-Soil Nutrients Assessment.

Location	Com 1	Com 2	Com 3	Com 4
Nitrogen Deficiency Assessment				
Calabar	Yellowish-green leaves with spindly stalks	V-shaped yellowing, starting at the tip and progressing down the midrib towards the leaf base	Stunted growth of (*Zea mays* L.) was observed at this site)	Dominant lateral buds
Obubra	Necrosis (the dying of cell tissue) starting at the tip of the leaf	Dominant lateral bud formation, dwarf maize plant	Yellowish-green leaves with spindly stalks	Plants light green with necrotic spotting on leaves; scorched pale leaves
Phosphorous Deficiency Assessment				
Calabar	Purplish coloration in leaves, and stunted maize plant	Brown leaf-tips, with curl leaves	Dead leaf-tips. Maize plant looks purplish. Stunted plant	Purplish stalks. Small and curling leaves
Obubra	Curved ears and retarded maturity	Stunted plants, with dead leaf tips	Purplish coloration, with small curling leaves	Maize plant looks purplish and stunted
Potassium Deficiency Assessment				
Calabar	Chlorosis, with localized mottled areas in the leaves	Lodging (reduce stalk strength). Chlorosis along leaves margin	localized mottled areas in the leaves	Chlorosis along leaves margin
Obubra	Lodging of Maize plant	Chlorotic areas with leaf burn at margins	Chlorosis along leaves margin	Drying from leaf edges, with visible sign of necrosis

Note: For purpose of analysis of the non-numerical data obtained using crop visual observation for evaluation of soil-plant health and nutrition status, a code of 0.01 was used to depict low soil-plant nutrient status; Com 1= Community 1; Com 2= Community 2; Com 3= Community 3; Com 4= Community 4.

Table 12. Communities where soil-plant health/nutrient assessment was conducted.

S.N.	Calabar	Obubra
1	UNICAL small holder Farm	Ovonum
2	Basin Authority small holder Farm	Ofudua
3	New Airport small-holder farmer farms	Obubra main town
4	Ikot Effangha (8 miles, Calabar)	Ovat

Figure 6. **A**, N deficiency in corn (leaves are yellowish); **B**, P deficiency in corn (leaves are purplish and tips are brown and necrotic); **C**, K deficiency in corn (older leaves are chlorotic and leaf edges are burned, but the midrib remains green).

Influence of plant-soil health interaction on human nutrition and health interaction

Result of Analysis of Variance indicated that there is a significant difference that existed in the interaction of human nutrition and soil-plant nutrition. Data presented in table 13 indicated that human nutritional factor has a greater influence on the plant-soil system. Duncan Multiple Range Test (DMRT) mean separation indicated a value of (24.761) as the variance value, and thereby presenting a view that for human nutrition and health to be maintained, then the soil system (soil fertility and quality) must be at status that can produce the needed for the sustainability of human-livestock nutrition. The outcome of this finding as indicated in table 13 and 14 and in figure 7 agrees with the work of WHO (2006), which stated human-livestock nutrition and health been linked to soil heath and productivity.

Table 13. Influence of Plant-Soil Health interaction on Human Nutrition and Health interaction.

Factor		Mean
Human Nutrition/health Interaction		24.76194
Plant-Soil Health interaction		0.02
	DMRT ($p < 0.05$)	9.01

Table 14. Interaction of Plant-human health and nutrition.

Source of Variance	Degree of Freedom	Sum of Squares	Mean Sum of Square	F-Cal	F-Tab (0.05%)
Treatment	1	2,931.083	2,931.083	3.7475^{NS}	9.01
Block	3	853.378	284.459	0.3637^{NS}	
Error	3	2,346.455	782.152		
TOTAL	7	2,931.080			

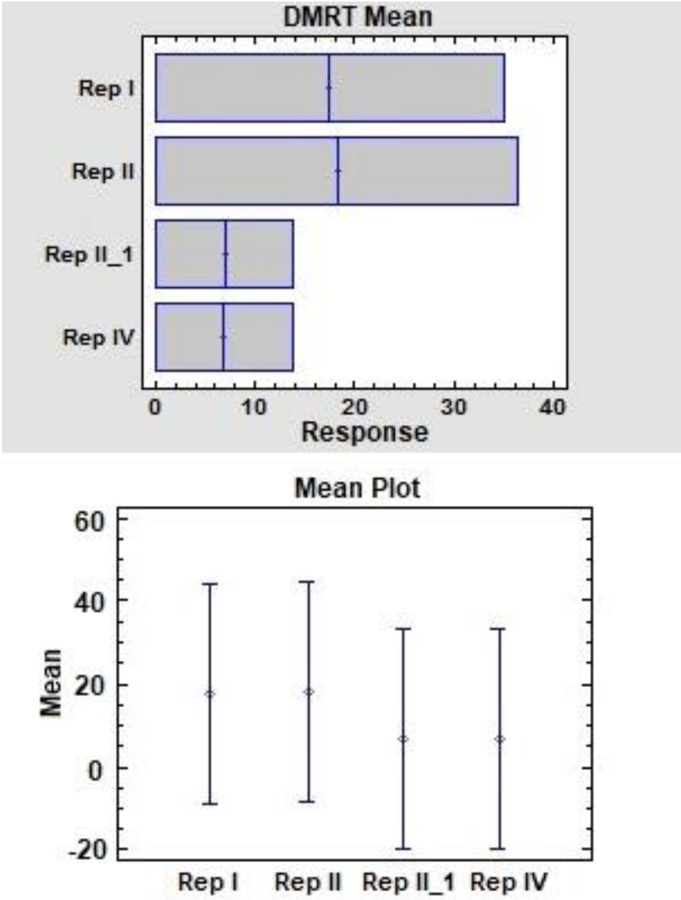

Figure 7. Mean Separation rating.

Relationship between plant-human health and nutrition and climatic behavior

Correlation between Plant-human health and nutrition and climatic behaviour indicated that Human Nutrition/health (Table 10) Interaction had the highest percentage of influence, with a (% Relationship = 77.59) indicating a view that humans depend heavily on the climate and soil for survival and for sustainability. A % Relationship value at (% Relationship = 63.34) was obtained for Plant-Soil Health interaction, presenting a view that plant nutrition, sustainability and health depends on the climatic system. Presenting a view that for the plant to be in good health, and produce the needed output to sustain humans on earth, then the climatic system need to be manipulated to support plant sustainability. The least level of % Relationship at a value of (54.37) as obtained for climatic interaction, which indicated that the climate does not depend heavily on either human or plant-soil system, but humans and soil-plants do. The outcome of this finding as indicated in table 15 and 16, and in figure 8 agrees with the work of WMO (2000) which stated the earth climatic system been a great influence on human, plant and soil sustainability. The resulting outcome of this study further agrees with the work of NIMET (2016) which stated the climatic system as one of the most important factors controlling human, soil including plant sustainability. Further, the work agrees with the assertion of IPCC (2000) which stated the earth climatic system been a potential influence on human existence on earth, adding that with a constant variation in the climatic system due to climate change humans, soil, plant including other sectors of the economy will suffer the great impact.

Table 15. Climatic, Soil-pant and Human-health/nutritional field measurements.

	CAL Comm 1	CAL Comm 2	OBU Comm 1	OBU Comm 2
Mean Anthropometric measurement	34.961	36.412	13.948	13.726
	Rainfall (mm)	**Temp (^{o}C)**	**RH (%)**	**Elevation (m)**
Mean Climatic Behavior at CAL	306.57	26.52	84.1	37
Mean Climatic Behavior at OBU	292.92	29.62	79.88	43
Plant-Soil Nutrients Deficiency symptoms Status	**low**	**low**	**low**	**low**
CAL	0.01	0.01	0.01	0.01
OBU	0.01	0.01	0.01	0.01

Table 16. Relationship of Plant-human health/nutrition and climatic behavior.

Relating Factors	Strength of Relationship				Model	R^2	% Relationship	r
Human Nutrition/health Interaction	34.961	36.412	13.948	13.726	-8.6168+46.304	0.7759	77.59	0.88
Plant-Soil Health interaction	0.020	0.020	0.020	0.020	0.02+14.201	0.6334	63.34	0.80
Climatic Interactions	599.490	56.140	163.980	80.000	-145.06+587.56	0.5437	54.37	0.74

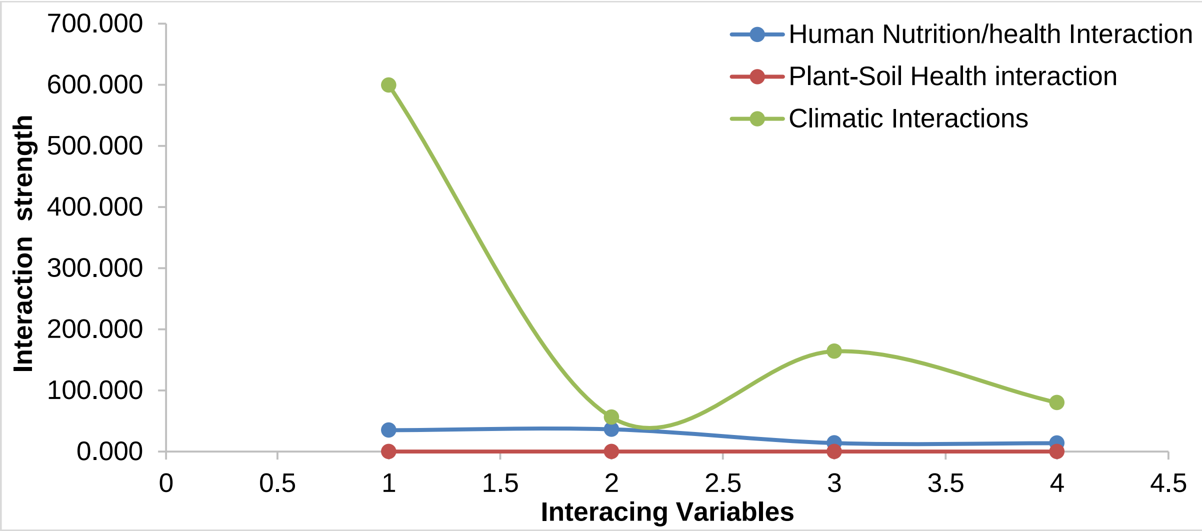

Figure 8. Relationship of Plant-human health/nutrition and climatic behavior.

CONCLUSION

Climatic element of rainfall, temperature including relative humidity has been found to have an influence on human-plant nutrition and health. A strong correlation has been found to exist between soil-plant health and fertility. It has been found that human nutrition and health including plant nutrition and health depends greatly on the climatic system, with a view that an increase in the hazard of climate change, human-plant health and nutrition could be greatly affected, thereby hindering human sustainability. Outcome of this research has revealed that there exist level of malnutrition in Obubra and Calabuar which could be exacerbated by the impact of climate change on soil-plant system, which has a strong statistical influence on human nutrition and health. The study therefore encourages targeted adaptation and mitigation strategies including soil fertility maintenance through application of mineral fertilizers and organic amendments among other agronomic practices, as key to soil survival and sustainability. While also encouraging technical and traditional modalities for the reduction of CO_2 and other Greenhouse gas emission.

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