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Research Article

Climate Change Effects? Compelling Evidence from Data, Farmers and Artisans' Perception in Warri, Delta State, Nigeria

Ozabor Famous*[a], Wodu Douye[a], Pere-ere[a], Okoh Ikechukwu Emmanuel[c]

[a] *Department of Geography and Environmental Management, University of Portharcourt, Choba, Rivers State, Nigeria.*

[b] *Department of Geography College of Education, Agbor, Delta State, Nigeria.*

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Abstract

This study assessed climate change in Warri, by looking at the evidence from archival records and the perception of the locals regarding same topic. The dangers of 'not knowing' about the phenomenon of climate change motivated this study. Also, the impacts of climate change have become rampant in the area. The inquiry was pursued using ex-post facto and survey research designs were used for the study and the Nigerian Meteorological Agency was consulted for rainfall and temperature data, while questionnaire was used to solicit information from respondents. Analyses were carried out using linear regressions. Established in the study is that, there is climate change in the area and its manifestations are in flooding, increased frequency of rainfall, poor crop yield etc. On the premise of findings, the study recommended proper climate education, harnessing ICT for mitigating climate change impacts and more inquiry into climate change milieu in the area by looking at the seasonality, onset and cessation of rains and other climate parameters.

Keywords: Climate, Change, Adaptation, Mitigation, Warri.

1. Introduction

There is still no consensus that climate has changed (Arbuckle et al., 2015; Bamberg et al., 2015; Beilin et al, 2012; Di Falco et al., 2011). However, evidence of the impacts of climate change continues to generate concerns, since it affects agriculture and man's activities (Falaki et al., 2013; Sarzynski, 2015). These evidence presents in flooding, temperature rise, changes in rainfall characteristics, droughts and water shortages (Adger et al., 2003; Asante and Amuakwa-Mensah, 2015; Intergovernmental Panel on Climate Change (IPCC), 2007; Adu et al., 2017). Odada et al., (2008); and Alhassan et al., (2019) revealed that climate change and variability are a serious challenge to future developments, categorically in tropical Africa. In this region of the earth around 85% of farmers are smallholders who earn a living through rain-fed agriculture (IPCC, 2014; Morton, 2007; Harvey et al., 2014). It is therefore logical that changes in climate, would not only affect the farmers, but will impact food security (Spence et al., 2011; Alhassan et al.,

*Corresponding author: Email: famphidoz@gmail.com, (O. Famous).
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2019; Sousa-Silva, 2018).

Following from the assertion above there is need therefore to continually, investigate the climate conditions of a place to ascertain the current and future climate conditions. This is because, having clear information about the climate will result in change of strategies and implementation of agricultural plans and same for other climate dependent sectors (Arbuckle et al., 2015). It is against this backdrop that this study is birthed to unravel the climate conditions for the past and present in Warri, Delta State Nigeria.

In Warri the presence of the oil firms and allied companies are documented to be causing serious environmental pollution (Ozabor, 2014) and consequently leading to serious alteration of atmospheric gases (Efe, 2010). According to IPCC (2014), these processes would lead to warming and climate change. Furthermore, the presence of the oil industry and other industries in the area have led to wide scale development, without planning, or environmental protection (Alhassan et al., 2019). The import is a serious manifestation of climate change in the environment of Warri. It is documented (Nwagbara et al., 2017) that farmers in this area have little to show for their labour as crops have poor yields and farms submerged in flood water. On the other hand, artisans have to look for alternative sources of income in the rainy period (Habib et al, 2012). However, what is not known is the root cause of these anomalies in the area. Some farmers and artisans have blamed poor governance and environmental management (Efe, 2008), while others have accused their gods of punishing them for sins committed (Efe, 2006). But very few are aware that the human activities of the past could possibly be affecting the climate of the area, hence the changes they are witnessing. There have been studies on climate change in the area (Efe, 2006, 2008, 2010, Odjugo, 2010), but some looked at establishing climate change, while others looked at climate change using ex-post facto method. This study used empirical data and went further to assess the perception of the locals and therefrom ascertaining the impacts of climate change on the locals. Therefore, the main aim of this paper is to establish if the climate change exists based on data and perception, and then identify the impacts of these changes in climate on farmers and artisans.

2. Materials and methods

This study was carried out in Warri. Warri is located in the south-south geopolitical zone of Nigeria and domicile in Delta State, which is one of the 9 states of the Niger Delta region (Efe, 2007). It is located on latitudes 5.5544 °N and longitudes 5.7932 °E. The area is bounded to the north by Sapele, to the west by Warri south-west, to the east by Ughelli north and to the south the area is bordered by Burutu and Bomadi respectively. The area is home to several oil installations with several mining activities going on, thereby lending credence to the climate change milieu.

The oil extraction activities going on in the area notwithstanding, the tropical type of climate prevails over the area. This climate used to encourage agriculture and other economic activities, especially those that depend on climate. Albeit, the continued anthropogenic activities that characterize the area, is purported to cause changes in the atmospheric composition of gases (Gandure et al., 2012; Gbetibouo, 2018; Niles et al., 2013) and consequently leading to climate change (Below et al., 2012). The aforementioned accounted partly, for the selection of the area (Warri) as study area.

This study adopted the ex-post facto and survey research designs. The area has only one weather station that is accredited by Nigerian Meteorological Agency (NIMET), which has been collecting data on rainfall and temperature since the year 1901. This station is also managed by NIMET, which is the agency saddled with the responsibility of climate data collection and usage in Nigeria. Therefore, data for rainfall and temperature were collected from same weather station and for a period of 117 years (1902-2017). The justification for the selected period include; the period is all the station had in public domain as at the time of this data acquisition and the researcher needed to show the climate behavior over 4 climatic normal which is sufficient for establishing climate change (Ayoade, 2004). For periods where data was not recorded (especially the civil war period) the interpolation or extrapolation methods as suggested by Efe (2010), Ozabor (2018), was used. Data analyses for archival weather data was carried out using simple linear regression in excel environment. Presentation and description of data was done using statistical diagram, tables and descriptive statistics. For the purpose of deconvoluting the data, the averages of the monthly data was computed first and then transferred for analysis. On the other hand, the perception of respondents was sorted using a well-structured questionnaire. The questionnaire was the quasi structured questionnaire and was developed to elicit information regarding people's perception of climate change in the area. This is a new approach to climate change inquiry in the area. Since most people are still bereft of climate change information. The purview of the survey included the perception of the people regarding temperature changes, rainfall changes, what is the manifestation of climate change, impacts on their daily activities and adaptive measures to the observed changes in climate of the area. The target population for the study were farmers and artisans. The purposive sampling technique was used to select 200 respondents. The test retest method was used to validate the

questionnaire, and the Pearson's product moment correlation coefficient was used for computation and an r value of 0.94 was realized for both attempts. Data from the questionnaire survey were presented in tables.

Figure 1: Delta State Showing Warri. Modified after ministry of lands and surveys and urban development, Asaba (2017).

3. Results

As it was expected in the south-south part of Nigeria, the temperature of the area ranged between 25.5 °C and 29.5 °C, while the rainfall ranged between 20 mm and 300 mm (Efe, 2010). The area experienced rainfall all year round as such does not experience distinctly dry months as has been pointed out in previous studies (Efe, 2010; Ozabor, 2014) even though older studies maintain that there exist two distinct seasons (Iloje, 1981). The patterns of rainfall and temperature across the months showed that the air masses that flow through the area have serious effects on climate in the area. Therefore, in figure 2, temperature starts to rise in January when there is drier condition (which results from the influence of the tropical continental air mass (cT) coming into the area from the Sahara Desert) and is lowest when the tropical maritime air mass (mT), which enters the area from the Atlantic, has the most influence. As such the wettest months are characterized with very low temperature amounts which ranged between 25.5 °C and 26 °C respectively. However, the double maxima characteristics for rainfall, as averaged by earlier studies are corroborated in this study, with August being the month in which the hiatus occurs.

The annual distribution of rainfall and temperature in the area in figure 3 showed that both rainfall and temperature is on the increase judging from the equations of the trend lines for both temperature (Y=0.0036x+27.8 °C) and rainfall (Y=0.0385x+2062.6 mm). However, the increase in temperature is more lucid as compared with rainfall which is almost flat in trended. This is misleading as a cursory look at the monthly data in Table 1 and Table 2 suggest that the monthly characteristics of both rainfall and temperature have been dissimilar over the years. Table 1 presented the descriptives of the rainfall data in the area. The table shows that the months with the highest amount of rainfall in the area June, July August and Septeember, with July (315.98 mm) being the month with the highest amount of rainfall. However, the standard diviation recorded in the month of August (123.02) showed that variability in rainfall in more associated with this period of the year in the area. The reason for this is that, the occurrence of the hiatus in that period of the year (Efe,

2010). On the other hand, the months with the lowest amount of rainfall were December (32.2 mm) and January (24.6 mm) and these months also possessed the lowest standard deviations of 26.9 and 19.2 respectively. This signifies that, there is less rainfall variability in this period. Temperature is the opposite of of rainfalll in the area (Table1). Where as it is more erratice and intense in the months of December (Std ± 0.54) and January (std ± 0.52). Higher temperatures were however recorded in the months of February (28.7 °C), March (28.8 °C) and April (28.1 °C), while the lowest temperature was recorded in the month of August (25.3 °C).

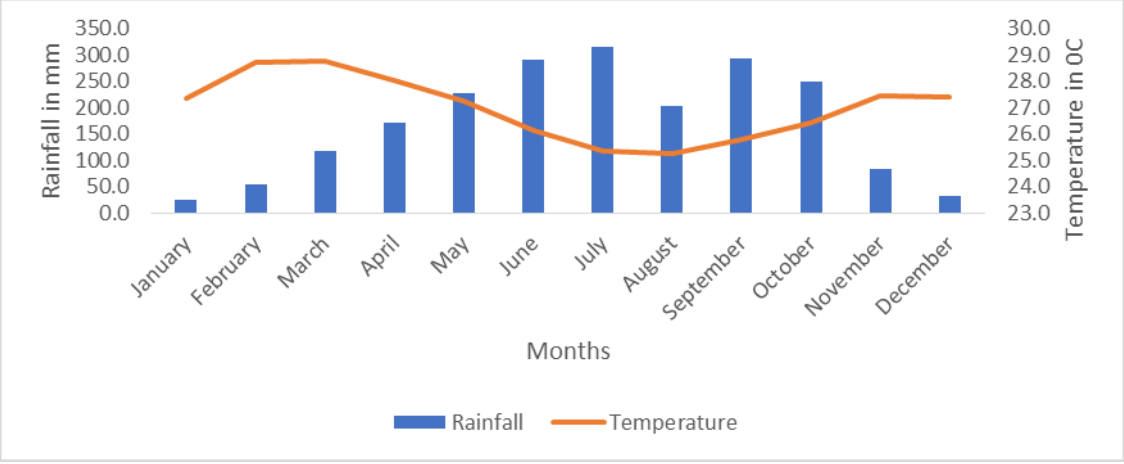

Figure 2: Monthly rainfall and temperature in Warri.

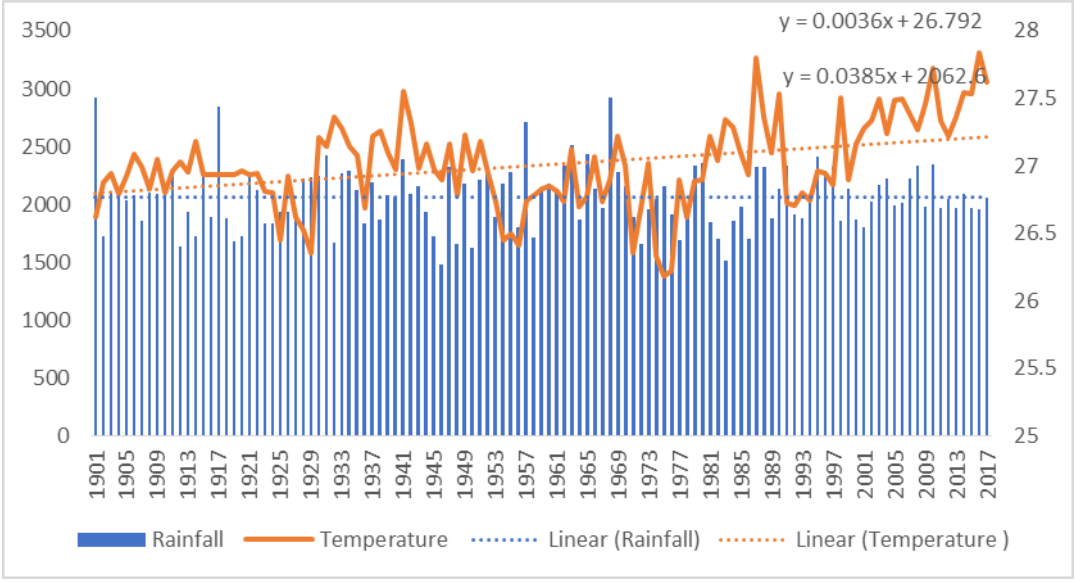

Figure 3: Annual rainfall and temperature in Warri.

The decadal outlook of the rainfall and temperature for warri is presented into 12 epoch in Table 2. The mean decadal rainfall for the area appeared to have been highest in the decade 1961-1970 (2275.9 mm) and the departure from the baseline period was 166.7 mm. The decade with the lowest rainfall amount in the series is 1941-1950 (1956.3 mm) and the departure from the baseline period was -

152.9 mm less of the base line period. Overall, the rainfall of the area has been consistently decreasing from the decade 1971-1980 to 2011-2017. It can also be seen in Table 2 that from the decade 1971-1980 to 2011-2017, temperature has also been on the increase, looking at the baseline period. In the decade of 2011-2017, the departure was 0.6 °C. These variabilities in climate were regressed over time in Table 3 and table 4 and were found to have changed with time and were significant at $p<0.05$ for temperature but not significant for rainfall at $p>0.05$. There are however, intricate information about the rainfall and temperature of this area, that has not been unraveled in this current attemp, since the foci of this paper was to sustanciate the evidence of climate change in the area and then compare that with the opinion of inhabitants.

Table 1: descriptive statistics of monthly rainfall and temperature in Warri.

Months	N	Rainfall		Temperature	
		Mean	Std. Deviation	Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
Jan	117	24.6145	19.15441	27.3632	.51455
Feb	117	54.9744	34.06116	28.7436	.48803
Mar	117	116.979	44.83586	28.7650	.50520
Apr	117	170.600	41.85002	28.0590	.48158
May	117	228.213	45.68736	27.2855	.38130
Jun	117	290.349	50.31166	26.1573	.41154
Jul	117	315.985	110.01182	25.3590	.39766
Aug	117	203.382	123.02800	25.2709	.39306
Sept	117	294.020	82.14157	25.7880	.33967
Oct	117	250.565	63.48818	26.4410	.39700
Nov	117	82.905	35.64135	27.4453	.47769
Dec	117	32.2453	26.98652	27.3863	.53818

Table 2: Mean decadal rainfall and temperature and their departures from baseline period in Warri.

Period	Rainfall (mm)	Temperature (°C)	Detected change	
			Rainfall (mm)	Temperature (°C)
1901-1910	2109.2	26.9		
1911-1920	1986.7	27.0	122.5	0.1
1921-1930	2056.9	26.8	52.3	-0.1
1931-1940	2081.2	27.1	28	0.2
1941-1950	1956.3	27.1	152.9	0.2
1951-1960	2143.9	26.7	-34.7	-0.2
1961-1970	2275.9	26.9	-166.7	0
1971-1980	1998.0	26.6	-111.2	-0.3
1981-1990	1923.6	27.3	-185.6	0.4
1991-2000	2110.8	26.9	1.6	0
2001-2010	2110.3	27.4	1.1	0.5
2011-2017	2008.4	27.5	-100.8	0.6
Mean	2063.4	27		

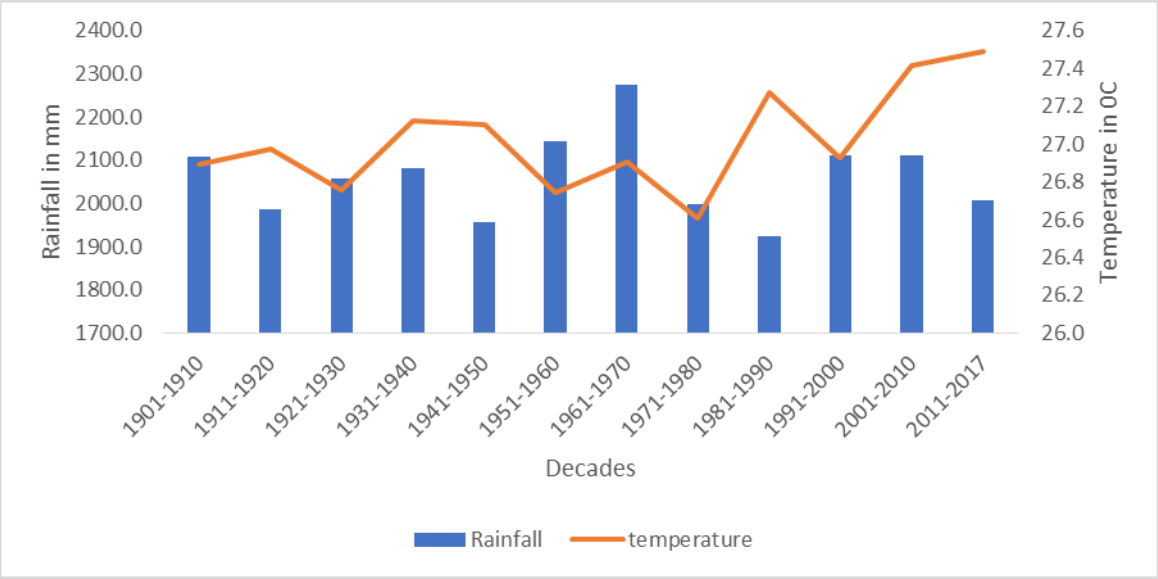

Figure 4: Decadal patterns of rainfall and temperature in Warri.

Table 3: Regression output for rainfall 1901-2017.

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	198.1391	198.1391	0.002745	.95831
Residual	115	8302280	72193.74		
Total	116	8302478			

Table 4: Regression output for temperature 1901-2017.

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	18802.121	18802.121	18.859	.000
Residual	115	114655.879	997.008		
Total	116	133458.000			

Evidently, in Table 5, the greater proportion respondents (87%) averred that they agreed with the opinion that rainfall is increasing in the area, although data showed that it was not significant statistically. This lends impetus to suggesting that, there is need for further studies on the seasonality of rainfall in the area. Therefore, the annual values may not have changed, but the monthly amounts, seasonal amounts and the onset and retreats may have all changed. Albeit, respondents (74%), opined that temperature was increasing and more intense in nature. This was also confirmed in the data, which showed that the past four decades have witnessed continuous increase in temperature without abating. The regressions model (table 4) showed that this assertion was significant statistically at $p<0.05$. The manifestations of climate change in the area were enumerated in Table 6. However, more prominent effects of climate change in the opinion of respondents are flooding (14%), increased frequency of rain fall (13%), hindered hiatus (17%), reduced crop yield (14%) and delayed rainfall cessation (12%), while the less prominent was decreased temperature (1%). Meanwhile, the impacts of

the manifestation of climate change in the area are presented in table 7. Respondents averred that their farm lands are flooded (11%) due to increase frequency of rainfall in the area (11%). Similarly, tuber crops have also been impacted (17%), since the farm lands are flooded. On the other hand, seeds planted due to misjudged onset of rainfall in the area decay (17%). As such there are cases of forced migration in the area (10%).

Table 5: Perception of changes in rainfall and temperature

Rainfall is increasing	**Frequencies**	**Percentage response (%)**
Strongly agree	121	60.5
Agree	53	26.5
Disagree	21	10.5
Strongly disagree	05	2.5
Total	**200**	**100**
Temperature increasing and more intense	**Frequencies**	**Percentage response (%)**
Strongly agree	67	33.5
Agree	81	40.5
Disagree	42	21
Strongly disagree	10	5
Total	**200**	**100**

Table 6: Manifestation(s) of the changes in climate.

Manifestations	**Frequencies**	**Percentage response (%)**
Flooding	28	14
Increased frequency of rainfall	26	13
Decreased frequency of rainfall	2	1
Hindered hiatus	34	17
Prolonged hiatus	12	6
Reduced crop yield	27	14
Delayed rainfall onset	13	7
Early onset of rainfall	17	9
Delayed rainfall cessation	24	12
Increased temperature	16	8
Decreased temperature	1	1
Total	200	100

Table 7: Impacts of climate change on activities of respondents.

Impacts	**Frequencies**	**Percentage response (%)**
Flooded farm lands	22	11
Increased frequency of rainfall	21	11
Decreased frequency of rainfall	01	1
Decay of tuber crops	34	17
Seed decay	27	14
Stunted growth in plants	13	7
Leaf scorch	17	9
Disruption of workshops and work place	08	4
Increase in transport costs	11	6
Road traffic congestion	12	6
Destruction of life and properties	15	8
Increasing cases of intra and inter migration	19	10
Total	200	100

Table 8: Adaptive measures to the observed changes in the climate.

Options	Frequencies	Percentage response (%)
Construction of local bridges	23	12
Hiding from the rain and being weather smart	51	26
Changing the crop species	35	18
Delayed planting	25	13
Using ridges as alternative farm practice	10	5
Avoid going out on a rainy day	8	4
Application of internet for communication	48	24
Total	200	100

Table 8 revealed the adaptive measure adopted by the respondents in the area. Evidently the presence of government is lacking in the fight against the whims of climate change in the area, looking at the adaptive measures averred by the respondents. This finding has been corroborated in a study on climate change adaptation, although in another region of same country (Adogi, 2020). Thus it is co mmon place to see the following adaptive measures in the area: Hiding from rain (26%) change of crop species (18%) and application of internent and morbile phones for co mmunications (24%) dominated the respondents adaptive measures, while avioding to go out on a rainny day (4%) was the least among the measures pointed out as adaptive measures to climate change in the area.

4. Conclusion and recommendations

This study assessed climate change by looking at evidence from archival records and perception in Warri, Delta State, Nigeria. The drive of the work was to enumerate the perceived impacts of climate change on the people in Warri. Evidence from data showed that there is climate change in Warri. Changes in temperature were statistically significant and corroborated by respondents, but that of rainfall was not statistically significant. However, the responses from the respondents suggested that there is change in the pattern of rainfall in the area, revealing that there is need to inquire further to ascertain where the variability and possibly change as opined by the respondents is emanating from. This is a limitation of the current inquiry. Albeit, the implication of the changes in climate characteristics include flooded farm lands, decay of tuber crops and even death. Therefore, these problems cited by the respondent's calls for immediate actions as suggested below:

a) Proper climate education is needed for the inhabitants on the study area. Particularly the farmers and artisans which formed the population for the current study. This initiative can be anchored by the government, nongovernmental organizations (NGOs), or both as a partnership.
b) The place of information communication technology in combating or mitigating climate change impacts have not been properly harnessed in this area. It's the opinion of the researchers of this study that it be popularized by government.
c) More inquiry is needed into the climate change milieu in the area. This is to be done by looking at the seasonality, onset and cessation of rains and other parameters in the area.

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