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ASSOCIATING FARMERS' PERCEPTION OF CLIMATE CHANGE AND VARIABILITY WITH HISTORICAL CLIMATE DATA

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Abstract: The farmers' perceptions of climate change (CC) and variability in Okpuje were assessed and compared with historical climate data. They perceive an occurrence of change that affects their farm activities, but lack the scientific understanding of this change. While some do not know what causes the change, others attribute it to God's vengeance. The perceptions of rising temperature and delay in the onset of the rainy season are corroborated by the analysis of the climate data. The temperature is significantly rising and it increased at the rate of 0.14°C per decade between 1960 and 2019. The rainfall decreased at the rate of 8.5 mm per decade. The rainy season tends toward late-onset and early cessation dates. However, the perception of increasing rainfall in the area was not upheld by the trend analysis of the rainfall data. The difference might be due to high variability in rainfall in space and time. The high rainfall recorded lately might have posed difficulty for the human memory as closer events are remembered easier than distant events and hence can be unravelled via a scientific approach. Nevertheless, since perception shapes adaptation, the people's indigenous perceptions and experiences should form part of intervention measures and policies for CC adaptation to command greater participation and wider acceptance. Thus, farmers' perceptions provide vital information but would be more reliable if integrated with scientific data analysis for policy and decision-makers in CC science, implying that none of them should be relegated but integrated.

Key words: climate change and variability, rainfall, temperature, perception, Nigeria.

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Introduction

Climate change is a global menace that affects all sectors of the economy and particularly food security (Clarke et al., 2012; Ayanlade et al., 2017). The global temperature is rising, coupled with changing rainfall patterns. The global mean temperature rose by 0.8°C in the past century and is likely to increase by 1.5 to 4.8°C in the next century if nothing is done to reduce emission levels (IPCC, 2014; Hansen et al., 2006; Shankar, 2018). The temperature rise has already triggered some extreme events like heatwaves and droughts. The rainfall patterns are also changing, however, this change has many uncertainties, unlike the temperature change (Byakatonda et al., 2019). Certain regions will experience an increase in rainfall, while in others, it may decrease or become more erratic. Also, the impacts of climate change are uneven in a way that the developing countries are more vulnerable than the developed world. Sub-Saharan Africa is also likely to experience higher impacts of climate change (Sylla et al., 2016) in terms of extreme warming with little increase in precipitation in some parts (Abegaz and Wims, 2015).

Hence, Sub-Saharan Africa is regarded as one of the most vulnerable regions to climate change (Ayanlade et al., 2017). This obtains from the fact that its high dependence on rain-fed agriculture is worsened by a high level of poverty. Furthermore, the poor rural farmers of the region are more vulnerable to climate change and variability owing to high dependence on rain-fed agriculture and poor technological and infrastructural development (Lipper et al., 2014; Adimassu and Kessler, 2016). The increasing occurrence of extreme events could modify the climatic patterns, thereby affecting bio-resources and food production, which would lead to food insecurity (Shankar, 2018). The extent to which the impacts of climate change are felt is principally dependent on the extent of the adaptive capacity of the people or location (Gbetibuo, 2009). Hence, poor rural farmers whose livelihoods depend on the exploitation of natural resources are likely to be more vulnerable (Gbetibuo, 2009).

Climate change in terms of rainfall and temperature changes has impacted crop production in many countries, especially wheat and maize yields (Porter et al., 2014). Most of the major crops in the study area are vulnerable to climate change, such as cocoyam, yam, groundnut, beans, maize, cowpea, and paw-paw. Rising heat and dryness significantly reduce yields of maize, soybeans, wheat, and yam, but the effects on rice and cassava are not significant (Jarvis et al., 2012; Porter et al., 2014; Del Rio and Brent, 2014; Matiu et al., 2017). Mannack (2009) has shown that a shortfall of 4 million metric tonnes of maize occurs due to drought damages to maize in southern Africa. Kaye and Quemada (2017) have hinted that climate change increases the incidences of erosion and leaching, which affect soil fertility. Hence, climate change negatively affects agricultural productivity (Nelson et al., 2014; Morton, 2017). For instance, cocoyam in southern Nigeria has been affected severely by climate change (Tunde, 2011; Ukonze, 2012; Ifeanyi-obi et al., 2016, 2017; Ifeanyi-obi and Togun, 2017). A temperature increase of a degree Celsius in Nigeria could lead to a reduction in crop yield (Olakojo and Onanuga, 2020). Irregular and unpredictable rainfall and sunshine hours lead to a 2.4% decline in the productivity of yam, maize, melon, and sorghum (Idowu et al., 2011). The challenges of climate change are worsened by low adaptation strategies due to low income (Enete et al., 2011), which reduces the coping strategy and leads to food insecurity.

In Nigeria, the problem of food insecurity is aggravated due to several other factors, such as neglect of agriculture for the oil-driven economy, conflicts, and climate disasters like flooding and droughts (Fasoyiro and Taiwo, 2012). There have been increasing impacts of climate change on agricultural production via the high frequency of drought events and flooding (Laux et al., 2010; Watkiss et al., 2012; Makame and Shackleton, 2019). Though climate projection has been able to provide information on the impact of climate change on global and regional levels, local-level studies with the rural farmers cannot be overlooked as they will provide first-hand information based on their experiences with the climate effects on their livelihoods. The perceptions of climate change and variability are informed by personal experiences and knowledge of the stimulus (Brown and Besner, 2004 cited by Makame and Shackleton, 2019). However, the ability to relate the experiences, including their scientific basis, is enhanced by educational status. Such knowledge of how the locals perceive climate change is known to be critical to examining their vulnerability, responses, and initiating adequate adaptation strategies (Adelekan and Gbadegesin, 2005; Gbetibuo, 2009).

Perception in this content entails the approaches through which the people understand their environment and so can utilise the environmental resources and acquire the capability to adapt to the stimuli that may arise from their interactions. Perceptions also relate to aspects of the environment or climate which form part of the individual's everyday experiences, prompting them to adjust to certain climate variability that affects their livelihood (Cuni-Sanchez et al., 2019; Makame and Shackleton, 2019). Such experiences make a farmer, for instance, opt for early maturing crops if the rains become more erratic or the growing season becomes shorter. Such actions might have been done without any scientific analysis of climate data or recommendations from scientists (Teka and Vogt, 2010). However, extreme events such as heatwaves, droughts, and floods may push the perception beyond the 'perceptual threshold of human experience' (Whyte, 1985; Makame and Shacklton, 2019). Normal climates might be perceived and interpreted differently among individuals based on key livelihood experiences, culture, memory, and resilience (Adger et al., 2009), which also vary with the exposure, education, and income levels.

Several studies explore the correlation of rural farmers' perceptions of climate change and climate variability with climate data. Such studies include Makame and Shackleton (2019) in Zanzibar, where they find that the perceptions of the local communities are influenced by the relations between the elements and the people's livelihood activities and their recall of past climate. Also, Rapholo and Makia (2020), working in South Africa, find that the perception of 64% of the farmers was consistent with results from meteorological data. Amadou et al. (2015) got similar results in the Upper East region of Ghana. Cherinet and Mekonnen (2019), in Ethiopia, have found that the perception of the people is in agreement with meteorological data showing that temperature is rising, but rainfall is decreasing as the onset date is later than before. The study of Etana et al. (2020), in central Ethiopia, finds that the perception of the farmers on temperature increase fairly aligns with the climate data but disagrees with the rainfall. Also, in Ghana, the result from climate data showing a rising trend in rainfall, temperature, and wind speed is corroborated by the people's perception. The findings of the study conducted by Limantol et al. (2016) over the Vea catchment in Ghana have revealed the climatic data is in agreement with the people's perception that temperature is rising but is incongruent with their perception of decreasing rainfall amount, duration, and intensity. In Burkina Fasso, Sanfo et al. (2014) find that the climate data is in agreement with people's perceptions, except for the perception of rising solar radiation.

In Nigeria, several studies have been done on farmers' perceptions of climate change and variability. However, only a few attempted to compare the farmers' perceptions with the results of climate data analysis. Similar or related studies that compared rural farmers' perceptions with results from meteorological data in Nigeria include Ayanlade et al. (2017), where the perception of the majority of the respondents is in line with the results from climatic data in Southwestern Nigeria. Falaki et al. (2013), in north-central Nigeria, find the farmers' perception to agree with climate data in north-central Nigeria. Based on the authors' search, there has been none so far conducting a similar study in the southeastern part of Nigeria. Yet, it is a region that is losing its forest resources widely due to rapid urbanization. Though there is no need to validate farmers' perceptions with climate data, their congruence boosts the level of confidence in the findings (Makame and Shackleton, 2019). Therefore, the study will achieve the goal by finding the perception of the farmers, investigating the trends in rainfall and temperature data, predicting the onset dates of the rainy season, and comparing the findings from the two dimensions.

Material and Methods

Study area

The study was done in Okpuje, a fast-growing rural farming community in the Nsukka local government area of Enugu State, Nigeria. Its location is in the northwestern part of Nsukka (Ijere, 1976; Nwamarah et al., 2015). Its geographical location is between 6.76^{O}N and 6.95^{O}N and longitude 7.20^{O}E – 7.33^{O}E (Figure 1). The area covers a landmass of about 65km^2 (Nwamarah et al., 2015). It has 12 villages that comprise Amafor, Ama-ozzi, Echara, Ejuona,Ibeku, Mkwurushi, Okpuje-ani, Okpuje-eti, Ewo-noya, Iga, Uhu-Asama, and Umuhu. Okpuje shares a border with Okutu to the north, Ibagwa-ani and Ibagwa-agu to the east, Anuka to the west, south with Edem and to the southwest with Uzouwani LGA.

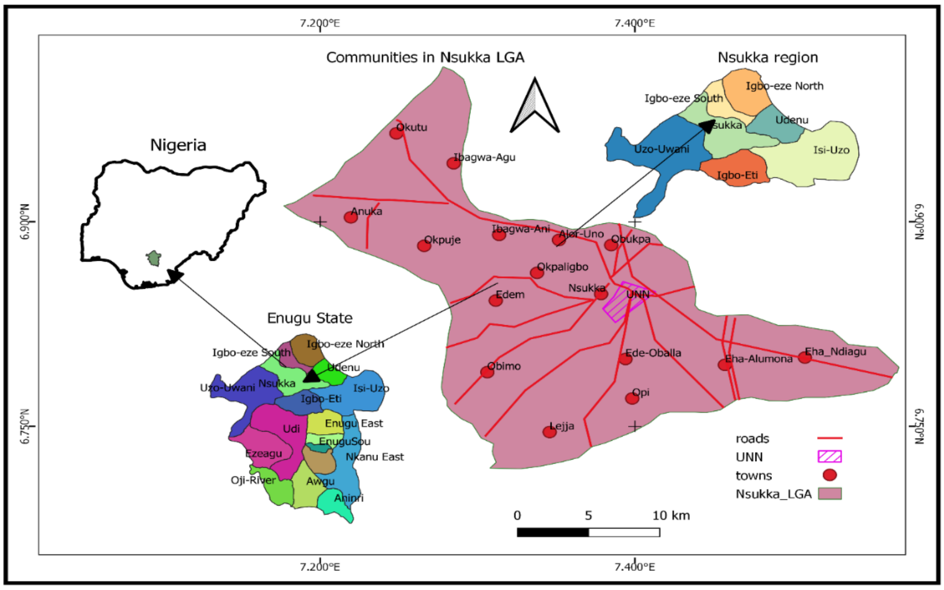

Figure 1. The study area (Okpuje).

Okpuje had a population of 8021 persons in 1991 (NPC, 1991), which was projected to be 18351 persons in 2019. Its mean annual rainfall and temperature are 1720 mm and 26.5°C, respectively (Sunday and Oghenenyoreme, 2014). The rainy season extends from April to October, and a dry season from November to March (Nwamarah et al., 2015) (Figure 2).

Data

The study population

The study population was drawn from households within Okpuje. These households make up the sampling frame for the survey study, while village leaders comprise the key informants. Households here comprise all people who live together and share a common food source, eat together and have a sense of belonging together as one social unit (NPC, 2006). The household's heads are males or females who are farmers and have attained the age of 45 and above. The age bracket was chosen as they were considered to be able to describe the changes and variability in climate of the area in the past and present based on their experiences over time. The aged will likely give more reliable information than the youths who may not have been born at the time or period under investigation. Besides, the younger ones might not have had the experiences and might not be cognizant of the happenings in their surroundings like the elderly. Moreover, it has been shown that elderly people have more experiences and always have a higher probability among all age brackets of giving reliable information on the variability of the climate of their area (Amadou et al., 2015; Cherinet and Mekonnen, 2019; Etana et al., 2020).

The community's population comprises 9078 males and 9273 females (NPC, 1991) of 110 clans and 12 villages.

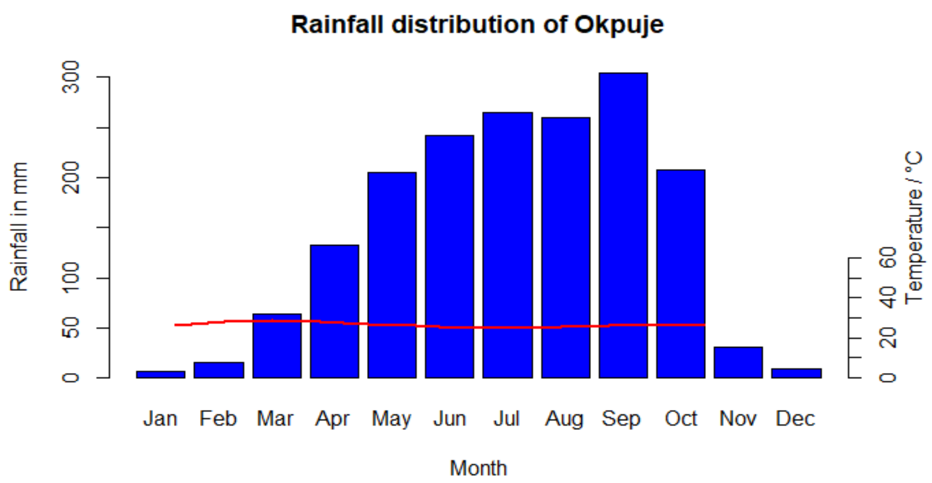

Figure 2. The mean monthly rainfall sum and temperature in the Okpuje area.

Study design

The study comprised both primary and secondary data. The primary data were a cross-sectional study using a mixed (quantitative and qualitative) method. A semi-structured questionnaire was used for the quantitative study, while interviews involving key informants and focus group discussions were used for the qualitative study. Historical climate data were the secondary data.

Sample size and sampling technique

Determining the sample size using households could not be done as there was no information on the number of households in the villages. However, the number of clans that are known was used to determine the number of respondents for the study. Thus, 344 eligible households were selected from the 86 clans randomly chosen out of the 110 clans though some clans were deliberately dropped for security reasons. The selected households were included in the study based on a number of criteria that included: farming being their only source of income; having an adult female or male farmer of 45 years and above, and having resided in the community for over 30 years. The households comprised 47.9% of males (163) and 52.1% of females (177). Two groups of focus group discussions (FGDs) comprising eight persons each and twelve key informant interviews were conducted. The FGDs were included in order to gain an in-depth understanding of the farmers' perception of climate change in the area. It helped to strengthen, corroborate, or permit cross-comparisons of the data (Kitzinger, 1994). Copies of the questionnaire were distributed to get information on their perception of climate change, particularly changes in temperature, rainfall distribution, its onset, and dry spells. The questionnaire comprised close-ended questions from which the respondents chose the one that suits their situation with a few open-ended questions. Additionally, several other questions were posed to the respondents on the cause of the change. Also, follow-up discussions were instigated with the respondents to get more information on the variability of weather and climate.

Historical climate data

Rainfall and temperature data were retrieved from the Climate Prediction Centre Merged Analysis of Precipitation (CMAP) for the Nsukka area. The CMAP has a spatial resolution of 2.5 by 2.5 and has a global coverage (Xie and Arkin, 1997; Xie et al., 2007). The temporal resolution of the data is daily and the period accessed covers sixty years from 1960 to 2019. It is freely accessed and downloaded from https://psl.noaa.gov/data/gridded/data.cmap.html. The data were divided into two periods, from 1960 to 1989 and from 1990 to 2019. This was done to learn the magnitude of change between the two periods as it is postulated that significant global warming started after the 1980s (Hansen et al., 2006; Swanson et al., 2009). This is necessary to identify change, especially as rainfall and temperature are key measures of changing climate (Hansen et al., 1996, 2006). The rainfall and temperature data were then used to do trend analysis and estimate the onset and cessation dates of the rainy season (see section 2.3).

Data Analysis

Primary data

The quantitative data were entered into the Statistical Package for Social Sciences (SPSS) version 25 for analysis. The perception of climate variability and change were subjected to simple analyses like frequencies, mean, and percentages.

Historical climate data

The rainfall and temperature data were analysed with the Mann-Kendall trend test (equations 1–3) (Mann, 1945; Kendall, 1975) using the 'trend' package (Pohlert et al., 2016) in the R software, which is freely available at https://cran.r-project.org/. A positive (negative) value denotes a rising (decreasing) trend. The standard Z statistic is calculated and used to test for significance (equation 3). It tests the null hypothesis that if Z is greater than alpha (0.05), then the null hypothesis is rejected, meaning there is a significant trend. If the trend is positive, then it denotes an increasing trend, but if the reverse holds, then the trend is decreasing (Ceribasi et al., 2013; Ceribasi et al., 2014; Ahmad et al., 2015; Alemu and Dioha, 2020; Hu et al., 2020). The computational techniques for the Mann-Kendall test take account of time series of unknown data points (n) where Ti and Tj are subsets of the data where i = 1, 2 …, n-1, and j = i+1, i+2…n (Motiee and McBean, 2009). Each data Ti becomes a reference point and compares with all the data points Tj as shown in equations 1 and 2.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign\left(T_j - T_i\right) \quad 1$$

$$sign\ (T) = \begin{cases} 1\ if & T > 0 \\ 0\ if & T = 0 \\ -1\ if & T < 0 \end{cases} \quad 2$$

where T_j and T_i are values per annum in years j and i, j > 1 (Motiee and McBean, 2009).

Thus for S > 0, the later observations in the series tend to be larger than the earlier observations, and if S < 0, then the reverse holds.

Hence, the variance of S is given by the relationship in equation (3) for n ≥ 10.

$$\text{var}(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_t f_t(f_t - 1)(2f_t + 5)\right] \quad 3$$

where $_t$ varies over a set of tied ranks, f_t is the frequency of occurrence of $_t$.

Therefore, the Mann-Kendall test calculates the Z-statistic using equation 4.

$$Z = \begin{cases} (S - 1/\sigma) & S > 0 \\ 0 & S = 0 \\ (S + 1/\sigma) & S < 0 \end{cases} \quad 4$$

The Kendall correlation coefficient (tau) is given by the relationship in equation (5).

$$\tau = \frac{S}{[n(n - 1/2)]} \quad 5$$

The rainfall data were also used to determine the dates of the onset and retreat of the rainy season using Anyadike's method (equation 6).

$$ORD = \frac{DM(0.083Tr - Ac)}{RM} \dots\dots\dots\dots\dots\dots\dots\dots \quad 6$$

where ORD is the date of the onset/retreat of the rainy season, DM is the number of days in the month that contain the rain amount greater than or equal to (Tr * 0.083), and Ac is the rains accumulated in the months preceding the month that has the value of (Tr * 0.083), Tr is the total annual rainfall, and RM is the total amount of rain in the very month that has (Tr x 0.083) (Anyadike, 1993). The formula is applied in reverse order by accumulating rainfall total backward from the end of the year to obtain the real date of retreat (Anyadike, 1993; Ezeh et al., 2021).

Results and Discussion

The rainfall and temperature distribution of the area

The area has a high annual rainfall of 1733.1 mm and a mean annual temperature of about 26.4°C. The lowest annual rainfall of 1292 mm was recorded in 1983, while the highest recorded was 1958.6 mm in 1995. The wettest month is September, followed by July (Figure 2). The driest months are from December to February. The lowest mean annual temperature was recorded in 1975 and 1976 (25.6°C), but the highest was in 2016 (27.1°C). The hottest months are March (28.6°C), February (28.2°C), and April (28°C).

Rainfall: perceived and inferred from climate data

More than half of the respondents claim to be aware of climate change while 24% say that they do not know about climate change. They assert that they have heard of climate change, however, over 58% of the respondents lack a scientific understanding of what climate change is. Most of the farmers have no idea of the causes of climate change, as claimed by 81% of the respondents, while 16% attribute it to cosmological powers or the 'Gods'.

On the perceived changes in rainfall over time, 95% of the respondents say that they have observed changes in the rainfall of the area. Of these, over 59% show they have observed increasing rainfall and polluted rain, 54%, and 52% have observed a delayed onset of the rainy season and erratic or irregular rainfall, respectively (Table 1). Similar responses were obtained from the Focus Group Discussions (FGDs).

Table 1. The observed change in the annual rainfall of the area as perceived by the respondents.

Variables	Frequency	Percentages
Changes observed in rainfall		
Yes	328	96.2
No	13	3.8
The observed changes		
Increasing rainfall	194	59.10
Reducing rainfall	27	8.20
Delayed rainfall	176	53.70
Too early rainfall	9	2.70
No change	15	4.60
Do not know	2	0.60
Acid rainfall	194	59.10
Irregular rainfall	172	52.40
Turbulent rainfall	40	12.20

The variabilities in rainfall are depicted in the plot of their deviations in Figure 3. It reveals the inter-annual variability such that the decades 2000–2019 were the driest as most of the years had rainfall below the mean. Only 5 years had annual rainfall above the mean, unlike the preceding decades. The trend analysis of the rainfall indicates a negative trend (Figure 4).

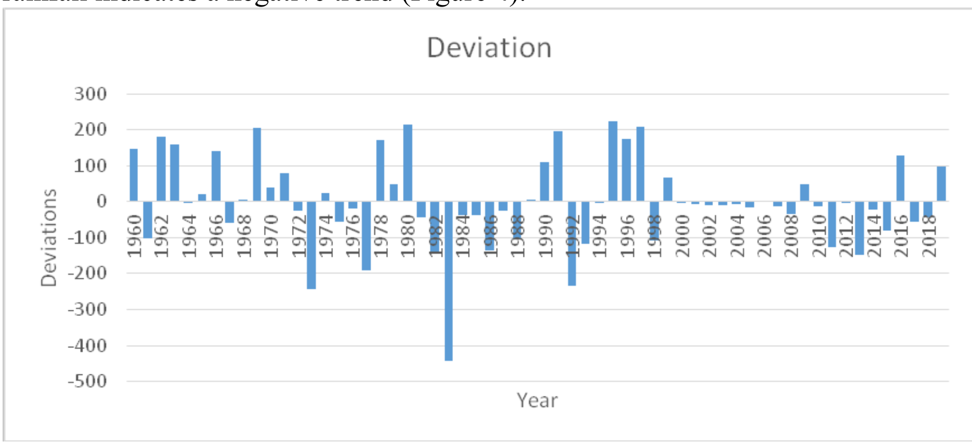

Figure 3. Deviations in the annual rainfall over the years.

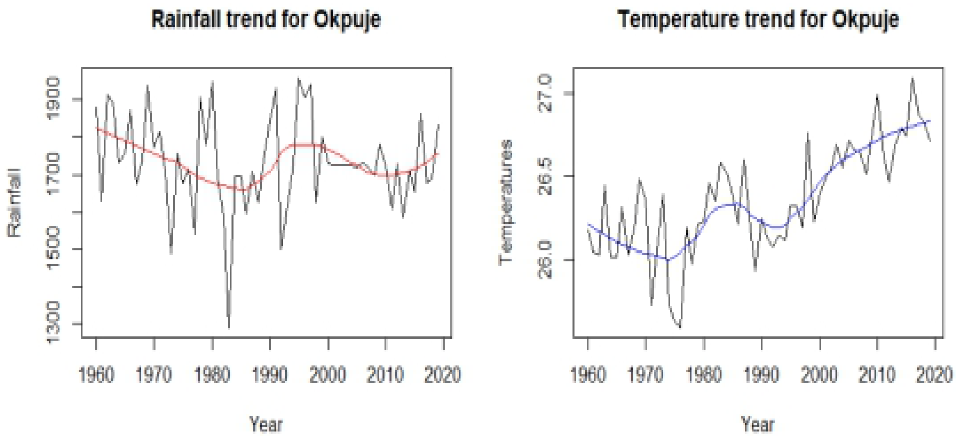

Figure 4. Annual rainfall and mean annual temperature trends of Okpuje from 1960 to 2019.

However, when broken into two periods of pre-change (1960–1989) and change periods (1990–2019), the magnitude of change reduced in the change period from 5.85 mm to 2.43 mm per annum (Tables 2 and 3). The pre-change period is significant, while the change period is not significant. This shows that rainfall decreased over the years, though, with some sort of rain recovery in the later years.

Table 2. The trend analysis of the annual rainfall and mean annual temperature from 1960 to 2019.

	Tau	Z	Sen's slope	P-value
Rain	-0.11	-1.21	-0.85	0.23
Temp	0.54	6.11	0.014	0.014

*Tau defines the strength of the monotonic relationship; Z-statistic is the standard normal deviate that determines when the null hypothesis is to be rejected or not.

Table 3a. The trend analysis for the annual rainfall and mean annual temperature in Okpuje from 1960 to 1989.

	Tau	Z	Sen's slope	P-value
Rain	-0.26	-2.00	-5.85	0.046
Temp	0.18	1.41	0.008	0.15

Table 3b. The trend analysis for the annual rainfall and mean annual temperature in Okpuje from 1990 to 2019.

	Tau	Z	Sen's slope	P-value
Rain	-0.24	-1.82	-2.43	0.069
Temp	0.64	4.94	0.03	0.00000

*Tau defines the strength of the monotonic relationship; Z-statistic is the standard normal deviate that determines when the null hypothesis is to be rejected.

Temperature: perceived and inferred from climate data

Over 94% of the respondents observed changes in temperature over time in the area, while a little over 5% did not observe a temperature change. Similarly, about 99.7% of these observed rising temperatures (Table 4). Narratives from the FGDs also support the rising temperature in the area.

Table 4. The observed change in the mean annual temperature of the area as perceived by the respondents.

Changes observed in temperature		
Yes	321	94.4
No	19	5.6
The observed changes		
Increasing temperature	311	99.7
Decreasing temperature	1	0.3

The results of temperature analysis show that the temperature of the area is rising. For instance, the plot of the deviations shows that the temperature rose, with the past two decades being the hottest over the study period (Figure 5).

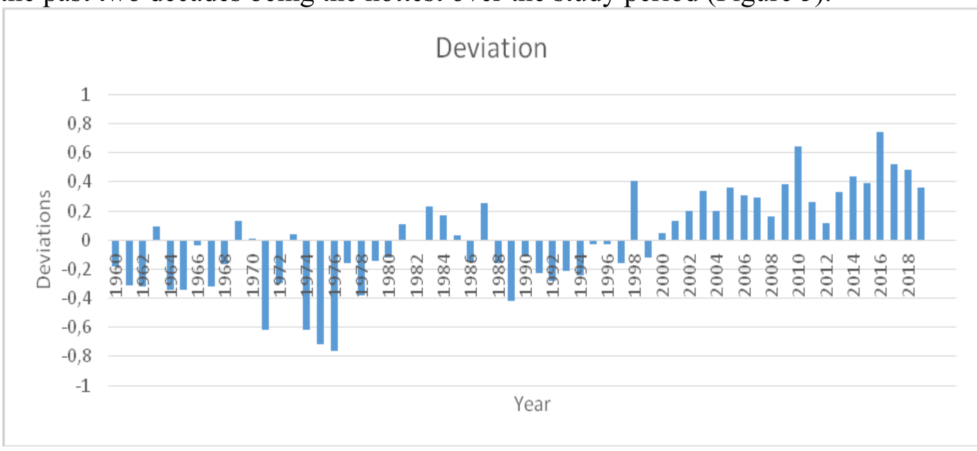

Figure 5. Deviations in the mean annual temperature over the years.

The decades 2000 to 2019 had their temperatures above the mean, while from 1960 to 1969, their temperatures were below the mean except for 2 years (Figure 5).

The trend analysis of the temperature data reveals a significantly increasing trend (Figure 4). When divided into two periods of pre-change and change periods, the magnitude of the trend rose from 0.008 to 0.03. While the pre-change period is not significant, the change period is highly significant (Tables 2 and 3).

To understand the pattern of change in the onset of the rainy season, the results of the onset/cessation dates of the rainy season were subjected to trend analysis which shows that the onset of the rainy season tends towards the late onset of the rainy season while the cessation comes earlier than before (Figure 6).

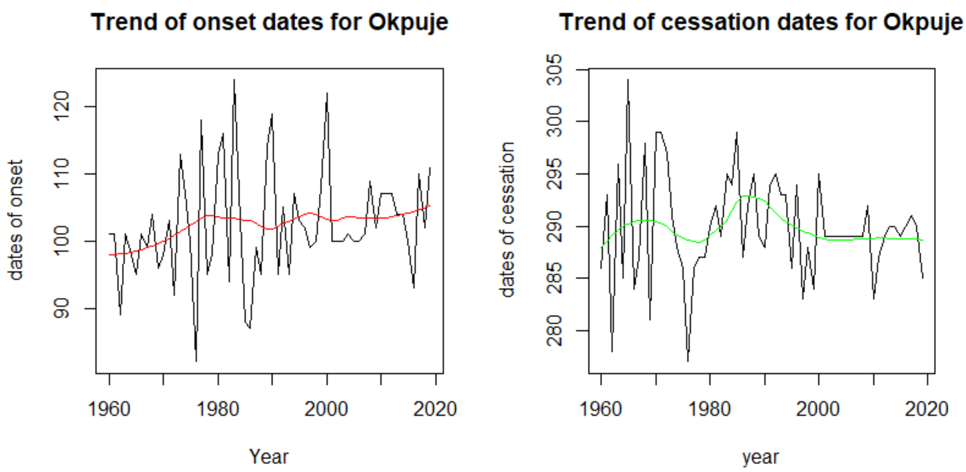

Figure 6. The trend analysis of the onset and cessation dates of the rainy season.

Namely, it has an increasing trend for the onset dates but a decreasing trend for the cessation dates. The mean onset date of the rainy season is April 12, while that of cessation is October 17.

The farmers are aware of the change happening to their environment, but none of them could mention the causes of climate change. A few, however, attributed it to the wrath of the 'Gods'. This is similar to findings elsewhere, for instance, Ogalleh et al. (2012) in Kenya, Makame and Shackleton (2019) in Zanzibar, among others. This shows they have limited scientific knowledge of climate change though they are aware of something drastic happening to their agricultural planning and productivity, such as increasing storms, rising temperature, delay in the onset of the rainy season, and irregular or erratic rainfall that affect their crops and other economic trees. This indicates a low to medium knowledge of climate change, which agrees with the UNDP (2010) report that there is a low level of climate change awareness in Nigeria. This has a negative implication on their adaptation and mitigation strategies because what you do not adequately understand or lack sound knowledge of, you may not find a solution to it (or you cannot find the most accurate solution to it). The literature shows a strong correlation between farmers' awareness and perception of climate change and their adaptation to its impacts (Adger et al., 2009; Debela et al., 2015). Farmers' sound knowledge of climate change and their responses to climatic threats will shape their adaptation alternatives and outcomes (Pauw, 2013; Debela et al., 2015). Similarly, Olorunfemi (2010) adds that inadequate awareness and knowledge are a major setback to reducing the impacts of climate change in Nigeria.

The perception of the farmers is that there are notable changes in rainfall intensity, delay in the onset of the rainy season, and erratic rainfall. The views were corroborated by FGDs and narratives from some respondents stating that:

"Rain falls and ceases making the already planted crops die-off". "Excess heavy rainfall kills all crops". "Even intense sunshine without rainfall makes crops die-off" (respondent 1).

"Intensive sunshine affects all food crops by drying them up and rain affects any type of beans by washing them away" (respondent 2).

"There was excess rainfall last year which led to the destruction of some crops such as black beans and tomatoes" (respondent 3).

These views conform with Ali and Erenstein (2017) that the pattern, timing and intensity of rainfall have been altered by climate change. Onyeneke et al. (2018) add that the changing climate conditions in the southeast, which are expressed in changes in rainfall pattern, are worrisome. Related studies have also highlighted the delay in the onset of the rainy season in the southeast (Chukwuone, 2015; Nnadi et al., 2019). Their perceived increase in rainfall contradicts earlier studies across Nigeria (Ndambiri et al., 2012, Nnadi et al., 2019) but concurs with Chukwuone (2015), who finds excess rain in Enugu State. The erratic nature of rainfall in the area is corroborated by FGDs and a key informant who adds that there is no consistency in rainfall pattern in the community: "Rainfall varies yearly and it is not all years we experience heavy and much rainfall".

The perception of temperature in the area is that it is increasing. The FGD and key informant interview support this view. This is in agreement with several studies (Olayemi, 2012; Nnadi et al., 2019) that the temperature has been increasing over the years.

The comparison of observed climate change based on people's perception and climate data

The findings indicate that there is climate change in the study area based on the respondents' perceptions. They believe that there is an increase in rainfall, the delayed onset of the rainy season and irregular rainfall patterns (Table 1). Also, they noticed that there was an increasing temperature in the study area far higher than what was obtained in the past decades.

The analysis of the climate data also indicates that there is a changing climate in the area. However, the people's perception of an increase in rainfall is countered by the results of trend analysis as the rainfall of the area has been decreasing over the years, unlike what was obtained between 1960 and 1989. The reason for the disparity might be due to the rainfall recovery in the area in 2016 and 2019. Both years have one of the highest mean annual rainfall in the last decade (Figure 3). It might be due to human weakness in keeping track records over a long period as the memory will more quickly cognize the most recent event than the distant past. Also, rainfall is highly variable and poses difficulties for human memory to recall the vagaries of its occurrences. The variable nature of rainfall also poses a challenge to scientists modelling its future scenarios or projections. Related studies elsewhere in Sub-Saharan Africa have shown a disparity between the perception of rainfall and climate data analysis (Limantol et al., 2016; Etana et al., 2020). However, to buttress this further, the period was divided into two. The trend analysis of rainfall for the first two decades shows about a 58.5-mm decrease in rainfall, while the last two decades reveal about a 24.3-mm decrease in rainfall per decade. This shows that though rainfall has been decreasing, the rate of decrease has slowed in recent years, which concurs with the postulation of rain recovery recently (Sanogo et al., 2015). On the other hand, the temperature steadily increased from the first two decades to the last two decades in the study period, where it rose from 0.08°C to 0.3°C per decade. This is close to the global average, as shown by Hansen et al. (2006).

The perception of the delayed onset of the rainy season is corroborated by the findings of the climate data analysis. It shows that the area has a delay in the onset of the rainy season and the early cessation of the rainy season. Related studies in Nigeria have shown that there is a delay in the onset of the rainy season (Chukwuone, 2015; Nnadi et al., 2019). This corroborates Dunning et al. (2018) that West Africa is experiencing a delay in the onset of the rainy season. Such delays in the onset dates accompanied by early cessation dates affect food security as the possibility of crop failure increases with such variability (Odekunle et al., 2005; Usman and AbdulKadir, 2013). This might result in wilting of plants and likely their death due to insufficient moisture to attain maturity. This portends danger for rain-fed agriculture in the area as it will affect yield (Usman and AbdulKadir, 2013; Shukla et al., 2021). Additionally, the increasing temperature identified by the respondents is validated by the trend analysis of the temperature data and shows that temperature has been rising in the last two decades. The last decade was the hottest across the study period. This is in line with the findings of several studies (Olayemi, 2012; Ndambiri et al., 2012; Chukwuone, 2015; Nnadi et al., 2019). It concurs with the global temperature increase of 0.014°C per year

(Table 2) (Spinage, 2012; Makame and Shackleton, 2019). This is similar to a study by Collins (2011) that there is a 1.5°C increase in African temperature per century.

The climate change and variability in the area are so noticeable that they affect the agribusiness of the area as perceived by the people. This is corroborated by the study by Uguru et al. (2011) that the climate is changing in the area. The most worrisome is the rising temperature, which is highly significant and in line with IPCC's report (IPCC, 2013). Another one is the erratic nature of the rainfall. These are very critical to agricultural production, as there is a maximum tolerable limit of temperature for any crops beyond which they will die. Also, without sufficient moisture available as when due, the crops will wilt and die. This is in line with FAO's (2019) which opines that climate change and variability are the main causes of stress on food production and availability. Hence, the changing climate is a challenge to ensuring food security in the study area and to the achievement of zero hunger of the 2030 agenda for Sustainable Development Goals (SDG).

Conclusion

The analysis of rural farmers' perception of climate change and its relationship with historical climate data was carried out. It shows that the farmers' perception correlates with the results from the analysis of climate data, except for increasing rainfall. This might be due to the ability of human memory to easily recall the most recent event, in which case, there seems to be somehow rain recovery as it rained heavily in 2019. The perception of increasing temperature is upheld by the trend analysis, which showed a significantly increasing trend in the temperature with an average increase of 0.14°C per decade. There is a decrease in annual rainfall of about 8.5 mm per decade in the area. The temperature increase is statistically significant, but the decrease in annual rainfall is not significant. The Tau values of 0.64 for temperature and -0.24 for rainfall indicate that the temperature has a very strong positive relationship with time, unlike rainfall with a moderate negative relation. It shows that there is a higher likelihood for the temperature to rise in the area than the rainfall, which decreases at a lower magnitude. The perception of the farmers that there is a delay in the onset of the rainy season is also corroborated by the trend analysis of the onset dates. This shows that people's perceptions can give reliable information based on their experiences with events happening in their surrounding environment. Such experiences shape their reactions and adaptation strategies, which manifests in their planning for farming activities that affect their food security status.

Hence, the farmers' perceptions and views should be integrated into climate change planning, mitigation, and adaptation policies. Additionally, national policies should also include measures to embark on an aggressive and massive rural awareness campaign to sensitise the farmers on sound climate change information. The few who responded to the question on the cause of climate change attributed it to the Gods, while others did not answer. Such a knowledge gap will affect how they tackle the menace or their adaptation strategies, as they may likely do nothing since it is God's doing, which nobody can oppose. Knowledge of risk and its causes is key to initiating the right responses and adaptation measures. Therefore, since perception shapes adaptation, the people's indigenous perceptions and experiences should form part of intervention measures and policies for climate change adaptation in the future to command greater participation and wider acceptance. However, studies on perception should always be integrated with quantitative climate data analysis to give more reliable information for decision-making.

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POVEZIVANJE PERCEPCIJE POLJOPRIVREDNIKA O KLIMATSKIM PROMENAMA I VARIJABILNOSTI SA ISTORIJSKIM PODACIMA O KLIMI

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R e z i m e

Percepcija poljoprivrednika o klimatskim promenama i varijabilnosti u Okpujeu procenjena je i upoređena sa istorijskim podacima o klimi. Poljoprivrednici uočavaju pojavu promene koja utiče na njihove poljoprivredne aktivnosti, ali im nedostaje naučno razumevanje ove promene. Dok neki ne znaju šta uzrokuje promenu, drugi je pripisuju Božjoj osveti. Percepcije o porastu temperature i odlaganju početka kišne sezone potkrepljene su analizom klimatskih podataka. Temperatura značajno raste i povećavana je za 0,14°C po dekadi između 1960. i 2019. godine. Padavine su se smanjile za 8,5 mm po dekadi. Uočena je tendencija da kišna sezona kasno počinje i rano se završava. Međutim, percepcija povećanih padavina u tom području nije potvrđena analizom trenda zasnovane na podacima o padavinama. Razlika može biti posledica velike varijabilnosti padavina u prostoru i vremenu. Visoke padavine zabeležene u poslednje vreme mogle su predstavljati poteškoće za ljudsko pamćenje jer se bliži događaji pamte lakše nego daleki događaji i stoga se mogu rastumačiti naučnim pristupom. Ipak, s obzirom na to da percepcija oblikuje adaptaciju, iskonske percepcije i iskustva ljudi treba da budu deo interventnih mera i politika za adaptaciju na klimatske promene, kako bi se postiglo veće učešće i šire prihvatanje. Stoga, percepcija poljoprivrednika pruža vitalne informacije, ali bi bila pouzdanija, ako bi se integrisala sa analizom naučnih podataka za donosioce politika i odluka u nauci o klimatskim promenama, što podrazumeva da nijedna od njih ne bi trebalo da bude odbačena, već integrisana.

Ključne reči: klimatske promene i varijabilnost, padavine, temperatura, percepcija, Nigerija.

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