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Time Series (Trend) Analysis of Some Climate Variables and Forest Resources Availability in the Central Agro-Ecological Zone of Cross River State, Nigeria

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ABSTRACT

This research did time series/ trend analysis of rainfall, temperature and relative humidity over a period of thirty-five years to identify changes and investigated how these changes influence forest resources availability in the Agro-ecological Zone of Cross River State, Nigeria. Quantitative and qualitative research methods were adopted. Climate data from 1988 to 2023 were sourced from the Nigerian meteorological Center Jos, Abuja and Calabar. Respondent's opinion on socio-demographic variables and forest resources availability were elicited using structured questionnaire. Data generated were analyzed using simple descriptive statistics, while for the influence

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of climate change variables on forest resources availability was analyzed using one way analysis of variance (ANOVA). Climate change variables were analyzed using Autoregressive Integrated Moving Average (ARIMA software) to regress and do the time series trend analysis. The result of the analysis shows that between 1988 and 2023, rainfall experienced some changes in 1988 with 1768.1mm3 to 2023 with 2221.3mm3 producing a variance of + 453.2 mm3. Between 1988 and 2023, there were some changes in temperature; by 1988, maximum temperature was 32.1 0c and by 2023 maximum temperature became 35.4 0c showing a difference of +3.3 0c. Minimum temperature was 22.6 0c by 1988, by 2023 minimum temperature was 24.90c, producing a difference of +2.3 0c. The relative humidity of the study area was 83% by 1988 and by 2023, it was 79% with a variance of -2%. The ANOVA result shows significant changes in climate variables with very significant influence on forest resources availability. It was concluded that between 1988 and 2023, there are significant changes in the three climate variables analyzed; these changes also have significant impacts on forest resources availability in the study area. It was recommended among others that alternative livelihood sources should be provided, while reducing pressure on the exploitation of forest resources for livelihood sustenance.

Keywords: time series analysis, climate variables, forest resources availability, agroecological zones, anthropogenic activities, minimum and maximum temperatures, rainfall and relative humidity

INTRODUCTION

Human population impacts on the environment have become very worrisome and disturbing. Globally, humans are faced with a plethora of environmental issues-pollution, poverty, food insecurity, war, epidemics, climate change, biodiversity depletion and extinction, crimes and terrorism. Most scientists opined that these are orchestrated by human livelihood activities through their insatiable quest for production and consumption of goods and services using scarce natural resources; others suggest human greed and capitalism where nuclear industries produced more than 80% of global greenhouse gases responsible for the current climate change with its attendant problems.

Environmental resources are the greatest pillars of human development; more than 85% of all the resources come from the natural resources base of every nation. Man's dependence on environmental resources have created a triple tragedy of the commons: the current generations are faced with resources scarcity and environmental degradation, the future generation will be faced with more scarcity of environmental resources and also a huge environmental problems to contend with, (Pingali, et al. 2019; Cammarano, et al. 2020; Herrig & Lindsey, 2020). The triple tragedies of the commons faced globally have brought about changes in the atmospheric condition of the world environment. The changes and variability associated with these climatic factors and the pattern of extreme high or low temperature and precipitation are very important for agriculture as well as forest resources abundance and availability, as well as the economic development of the society, especially in the central Agro-ecological Zone of Cross River State and Nigeria at large (Eneji, et al. 2022).

It is important to state that, rainfall, temperature and humidity in Nigeria and West Africa in general are influenced by the dynamics of continental and maritime air mass which meet along a slanting surface called inter-tropical discontinuity (Ojekunle, 2014; Merino, 2019). Climate change manifest in different forms like melting of ice, increase in temperature, changes in precipitation and sea level rise, the intensification of natural hazards like wild bush fires, rainstorm, floods, droughts and landslide among others (IPCC, 2012). Global warming orchestrates greater scarcity and variability of renewable resources in many parts of the world. Outside agriculture, which is the economic mainstay of most communities, dependence on forest resources is almost equaled agriculture for food, fiber, raw materials, employment generation and other forest and non-timber forest products whose abundance are dependent on climate factors. Adeleke, et al., (2018) examined the variability of rainfall and temperature based on spatio-statistical data retrieved from Nigeria Meteorological Agency (NIMET). The findings concluded that the area was experiencing significant increase in temperature with mean temperature (28^{0c}) and mean sunshine (4.7) hours. Temperature anomaly ranged between -2.31C and 1.73C. The correlation coefficient revealed average temperature (0.867) which was significantly related to minimum temperature, sunshine hours (-0.389) and average temperature (-0.749) was significantly related to maximum temperature.

While in terms of rainfall, there was a significant decrease in the amount and intensity of rainfall by -320 mm^3. There was a noticeable reduction of rainfall trend from 9 months to 5.5 months and the rainfall duration was also shortened from about 6 hours on peak days to about 2-4 hours (Ogbuabor & Egwuchukwu, 2017; Akande et al 2017; Herrig & Lindsey, 2020; Kadiyalaa, et al., 2021).

Climate change affects all countries globally, developing countries are the most vulnerable as they have inadequate resources to adapt. Nigeria in particular as the horn of Africa in general has for the past decade experienced unprecedented food and resources shortages due to climate change (Eneji, et al. 2022; Tofu &

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Mengistu, 2023). Severe climate scenarios are expected to occur frequently in the future, the amount of arid and semi-arid land in sub-Saharan Africa is expected to increase by 15 to 28% by the 2030s (Warburton, 2020). In Nigeria, the national economy is dependent on sectors that are vulnerable to climate factors- agriculture, fisheries, forestry and tourism. Dry spells and droughts will be inconsistent and torrential down pours heavier, all phenomena that increase the risk of soil erosion and vegetation damage through runoff will increase the endangerment of most indigenous species, especially those that are already vulnerable to harsh environmental conditions (Eneji, et al 2021).

IPCC, 2021-2023 working group II reports on climate change assessed the impacts of climate change, from a wide horizon of scope ranging from the global to regional and sub-regional perspective, taking into cognizance of the different dimensions of the ecosystems and biodiversity, of humans and their diverse societies, cultures and settlements. The report also took cognizance of their vulnerabilities and the capacities and limits of these natural and human systems to adapt to climate change and thereby reduce climate-associated risks together with options for creating a sustainable future for all through an equitable and integrated approach to mitigation and adaptation efforts at all scales (IPCC, 2023).

Although agriculture has frequently been challenged by climate factors, however the impacts on forest resources are even worse (NIMET, 2013), the sector remains the backbone of the Nigeria economy. It directly supports about 85% of the population for employment and livelihood. It contributes about 50% of the country's Gross Domestic Product (GDP) and generates about 90% of the export earnings (Blaauw, et al. 2018; Eneji, et al. 2021). Rising temperature, changes in rainfall, frequent and severe floods/ droughts have significant concern especially to those highly dependents on natural resources, like forest resources exploitation and agricultural resources for their livelihood.

Rainfall is a natural phenomenon whose prediction is challenging and demanding as the world continues to witness an ever-changing climatic condition. Its forecast plays an important role in forest resources management and therefore it is of particular relevance to the agricultural sector, which contributes significantly to the economy of any nation. Addisu, et al., (2015) observed that rainfall in Nigeria increases from coastal region, with annual rainfall greater than 3500 mm^3, to the Sahel region in the north-western and north eastern parts with less than 600mm^3 (Olujumokem, et al., 2016). The inter-annual rainfall variability, particularly in central Agro-ecological Zone often results in climate hazards especially flood and erosion with their devastating effects on forest resources.

The distribution of temperature generally reflects the distribution of rainfall. Temperature has strong effects on rainfall as increase in temperature leads to increase in evaporation and moisture in the atmosphere, improving greatly the volume, lushness and greenery of the forest cover and species abundance in the forest floor (Ibrahim, 2018 in Gebeyehu & Hirpo, 2019). Wolff, et al. (2021) in Eneji, et al. (2022) used a kilometer resolution data to ascertain the influence of forest cover on temperature conditions in Berau regency, Indonesia, between 2002 and 2018. Spatially explicit data was used with satellite climate model and population to estimate the effects of global warming, between 2002 and 2018. After applying 1.0^{0}c, 1.5^{0}c and 2.0^{0}c of global warm to 2018 temperatures on all-cause mortality and unsafe work conditions, the results analyzed shows that between 2002 and 2018, a deforestation rate of about 4375km^2 in Berau was observed, corresponding to approximately 17% of the entire regency. It found that deforestation increased average daily maximum temperature by 0.95^{0}c (95%).

The study found that heat index became a variable across space and time than captured by the data from the study. The Ikm^2 resolution MODIS observation was found to dampen the temperature extremes experienced on the ground. It was believed that the specific constant humidity which was assumed to be found across Berau was the most simplified of the water vapor variability occurring within locations and across time and space. It was concluded that the forest plays a very significant role in the cooling effects of the ecosystem, especially as it provides environmental services which no one is capable of providing, (Martínez-Camilo 2018; Mudelsee, 2019; Halder, et al. 2020; Ye, et al. 2020; Demirhan, et al. 2020; Asanok, et al. 2020). This implies that where forest cover is allowed to exists, there is moderate to low temperatures, while where deforestation has taken place with bare land, temperature increases to a high extent. The transpiration capacity of plants and trees are also reduced because this process takes place through plant stomata (Srivastava & Panda, 2020; Demirhan, 2020; Ayeni & Oloukoi, 2022).

Fekadu, et al. (2020) cited in Eneji, et al. (2022) carried out a GIS-based assessment of climate change impacts on forest habitable *Aframomum corrorima* (Braun) in Southwest Ethiopia coffee forest. Local bioclimatic and meteorological data sourced from the WorldClim database were used to do a mapping of the past, present and future distribution of the crop in the Coffee Forest System of Southwest Ethiopia. 96 key informants were interviewed and completed questionnaire to compliment the distribution modeling. Result shows that temperature and precipitations were the most important environmental variable, due to deforestation, temperature increased by 1.3 ^{0}c in the past (1988-2018), it was also predicted to increase by further 1.4 ^{0}c before 2050. Precipitation decreased by an average of 10.1 mm^3 from the past, while it is also predicted that there will be a further decrease by 12.5 mm^3 before 2050. The model developed indicated that the area suitable for corrorima in 1988 was 20,638.2 ha and was reduced by half to become 10,545.3 ha in 2018, and predicted to shrink to 3225.5 ha by 2050.

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Diress and Bedada, (2021) assessed precipitation and temperature trend analysis with Mann Kendall test in Addis Ababa methodological station, Ethiopia, the authors observed that climate change impact on annual and monthly air precipitation, with temperature receiving a great deal of attention. The study focused on detecting trend in annual precipitation and temperature in Ethiopia methodological station, data was analyzed using SPSS in combination with excel spreadsheet, with Mann-Kendall test and Sen's slope method to detect trend and the magnitude of change.

The result of data analysis shows mean minimum temperature ranges between 8.45°c and 12.5°C, whereas, the mean maximum temperature varies between 21.1°c and 25.5°c. It shows a monthly coefficient of variation (cv%) for both maximum and minimum temperature ranging from (5.4% in April) to (14.08% in December). The Mann Kendal test and Sen's slope estimate the annual maximum temperature to be statistically significant, increasing trend but no significant positive or negative trend was detected in annual precipitation. Due to global warming, changes in rainfall will influence changes in forest cover due to global warming which will also influence the hydrological cycle and stream flow pattern and demand, especially for agricultural and natural resources use (Gehman, et al. 2018; Getachew, 2018).

Humidity is essential for life; it is often expressed as relative humidity, which is the ratio of the current absolute humidity relative to the maximum humidity at a specific temperature, indicating the amount of water vapor in the air at that temperature. As a key environmental factor, it plays very significant role in air quality, which determines the forest extent (Thammanu, et al. 2021). Humidity is one of the climatic factors, sometimes after rain, the air feels moist. Generally, humidity levels will be higher in the warmer region than in the cooler areas making forest exploitation activities more difficult to work in. The time of the year and weather pattern significantly contributes to higher humidity, during thunderstorms, rainfall increase and forest species abundance is usually high during these periods.

Castaño-Vázquez, et al. (2022) examined how humidity in a cavity-nesting bird influences ectoparasites' abundance, the authors observed that the effects of climate change on host parasites interaction have been poorly studied in arid and semi-arid habitats (Sheikh, et al. 2015; Schoofa & Robesonb,2016). They conducted experiment with the purpose of manipulating temperature increase inside European rollers *Coracias garrulus* nest boxes located in a semi-arid habitat on different nesting sites types to examine the effects on different ectoparasites abundances and nestling growth. It was observed that in heated nests, the average nesting temperatures were slightly higher than in control nests, despite this result, differences were not statistically significant. Relative humidity was significantly lower at nights in heated nests compared to the control nests (Diem, et al., 2018; Howitt, et al. 2012; Asanok, et al. 2017). The authors concluded that a slight increase in temperature reduces relative humidity at night inside nest cavities of rollers, this increase in temperature and reduction in relative humidity positively and significantly affect some ectoparasites like sand flies and mites inside nests. The location of next boxes is also an essential factor to predict ectoparasite abundance inside nests.

Therefore, authors like Gehman et al. (2018); Castaño-Vázquez et al. (2018); Kent, et al. (2017) opined that relative humidity is a factor in species abundance not just in ecoparasite abundance but in other wildlife species diversities. This is measured by the percentage volume of wetness, dampness or moisture in any environment. Scholars like Castaño-Vázquez et al. (2021); Veiga and Valera, (2020b) and Warburton (2020) in their respective studies hold that relative humidity act as a stop gap to rainfall, these authors posited that in the dry seasons where rainfalls are not available, atmospheric moisture like humidity, dew and hale falls back as substitute for rain. These help in providing the water plants need, these authors further posited that once this occurs, plants get some substantial amount of moisture for their survival.

Brooks and Kyker-Snowman, (2008) studied forest floor temperature and relative humidity following timber harvesting in Southern New England, USA. The authors posited that salamanders as forest amphibians prefer forest with shaded, cool and moist forest floors. These researchers believe that forest harvesting opens the forest canopy and exposes the forest floor to direct sunlight, increasing forest floor temperatures and reduce soil moisture. It is also established that changes in microclimates can potentially degrade the harvested stand for amphibian habitat or affect other biotic resources or ecological processes at the forest floor and in the understory, (Gehman, et al. 2018; Veiga & Valera, 2020b). Another study by Chen, et al. (2022) on the negative impacts of excessive moisture contributing to the seasonal dynamics of photosynthesis in the Amazon moist forests, observed that photosynthesis in the Amazonian rainforest is essential to carbon and water cycle on a global scale. Its seasonal dynamics remain less understood. The authors used clear sky satellite products combined with in-situ ground observations to investigate the seasonal dynamics of photosynthesis as well as the contribution of moisture to these dynamics (Wolff, et al. 2021 in Castaño-Vázquez, et al. 2022). Studies have shown that the extent of relative humidity affects how plants open their stomata on the undersides of their leaves. The process where plants breathe or transpire is through the stomata. When the weather is warm, plants may close its stomata to reduce water losses. The cooling mechanism of plants is done by the stomata (Gebeyehu & Hirpo, 2019; Chen, et al. 2022).

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It is evident that each time plant transpires, the humidity around forest saturates the leaves with water vapor. When relative humidity levels in forest are too high, there is hardly air circulation, so plants cannot evaporate water through the transpiration process. They cannot draw plant nutrients from the soil. If air circulation is impaired for a long time and water cannot evaporate, plants eventually would rot. In forest areas surrounded by warm temperatures and low relative humidity, transpiration rates in plants increases, thereby increasing the need for a grower to fertilize his crops (Rosenzweig & Hillel, 2015; Cammarano, et al. 2020).

Gebeyehu and Hirpo, (2019) reviewed the effects of climate change on forest ecosystem with strong effects on the forest ecosystems species distribution, structure, abundance and continuity of the forests. Climate change especially rainfall, temperature and relative humidity strongly affects the forest ecosystem by altering the growth, composition, mortality and reproduction of trees, shrubs, other plants, animals and other life forms within the forest ecosystem. Increasing temperatures change the timing of life cycle events (phenology) leading to bud burst, leafing and flowering in trees. Some authors found relationships between climate factors and forest ecosystem, where they posited that changes in climatic factors leads to the alteration and shifting of forest ecosystems both indirectly and directly, (Kadiyala, et al. 2015; Robinson, et al. 2015a & 2015b; Islam, et al. 2016).

Thammanu, et al. (2021) examined the influence of environmental factors on species composition and distribution in a community forest in Northern Thailand, a stratified systematic sampling of the forest's total area of 3925ha and 25.116 ha survey plots were established in three different stands of the deciduous forest to estimate and characterize the difference in biological diversity among the stands. The Canonical Correspondence analysis (CCA) was used to assess the differences in biodiversity of stands and environmental factors. The analysis shows a high biodiversity of trees in the forest as 197 species, 144 genera and 62 plants families were identified. The CCA coordination identified the environmental factors which were most important in species differences to include elevation, distance to streams, temperature, soil moisture, humidity, rainfall, organic matter and distance to communities. These factors significantly influenced the diversity and distribution of tree species ($p < 0.05$) in the community forest. Similar results were found by Martínez-Camilo, et al. (2018), Diem, et al. (2018) and Eghdami, et al. (2019).

The pattern of rainfall, temperature and humidity in the Central Agro-ecological Zone of Cross River State, Nigeria has been a source of concern to the inhabitants, especially as it affects their forest resources and those relying on it for livelihood. Climate variability plays a significant role in agricultural production and environmental sustainability (IPCC, 2012; Kyei-Mensah, 2019; Adejuwon & Ogundiminegha, 2019 in Eneji, et al. 2022b). There are some important climate elements that appear to have some level of influence on environmental resource abundance and availability like solar radiation, topography, temperature, rainfall, precipitation, sunshine, relative humidity among others (Eneji, et al. 2022a). The relationship between climate variables and forest resources availability has attracted multiple interests from scholars (World Meteorological Organization (WMO), 2017; Elisha, et al. 2017; Akande, et al, 2017; Eneji, et al. 2022b).

It is expected that variability in climate and weather events may affect forest resources availability and livelihood, this scenario especially in the Central Agro-ecological Zone happens where farmers and forest user groups depends largely on agriculture and forest resources, which is climate sensitive for their living, making them vulnerable to negative climate change effects. The gap identified in this study is that of all the few studies addressing this topic, not even a single study has been carried out in this region to ascertain how climate variables influence forest resources availability and abundance in this area. Hence, this would provide empirical data using time series analysis to fill this identified gap in the central agroecological zone of Cross River State, Nigeria

Research Questions

i. What is the trend of rainfall from 1988-2023 in the Central Agro-ecological Zone of Cross River State?
ii. What is the temperature trend from 1988-2023 in the Central Agro-ecological Zone of Cross River State?
iii. What is the trend of relative humidity from 1988-2023 in Central Agro-ecological Zone?
iv. How do temperature, rainfall and relative humidity influence environmental resources availability and abundance in Central Agro-ecological Zone?

Hypothesis

Rainfall, temperature and relative humidity do not significantly influence environmental resources availability and abundance in the Central Agro-ecological Zone of Cross River State.

MATERIALS AND METHODS

This study adopted the survey research design with mixed methods -quantitative and qualitative approaches. Qualitative data was generated from the Nigerian Meteorological Center Abuja, Calabar and Ikom stations and National Center for Remote Sensing and Geo-informatics Jos for 35 years period (1988-2023). Calabar and Ikom weather stations collect climate data from the respective areas and send all to Jos and Abuja for analysis and storage of data as a national repository. The quantitative data sourced from respondents with structured questionnaire. Time series analysis is a statistical estimation of climate events over a period of time to examine relative variations in the trend of certain climate variables and the effects such variation could have on certain characteristics of the environment. Most often this act of learning is called time estimation which is an aspect of applied statistics (Asanok, et al. 2017; Saltelli & Stark, 2018; Mudelsee, 2019; Asanok, et al. 2020). Most authors have used either process-based biophysical models or economic and statistical models to investigate the impacts of climate variables on different crop productions in different part of the world (Kadiyala et al. 2015; Cammarano et al. 2020). Crop simulation and other autoregressive models have been widely used to examine the impacts of abiotic stresses such as long-term changes in surface temperatures, carbon dioxide (CO_2) emissions and rainfall on various crops (Battaglia & Protopapas, 2012; Efron & Hastie, 2016; Blaauw, et al. 2018; Halder et al. 2020; Ye, et al. 2020; Demirhan, 2020; Kadiyalaa, et al. 2021).

Study Area

The study is located in the Central Agro-ecological Zone of Cross River State, Nigeria. The zone is made up of six local government areas: Boki, Ikom, Etung, Obubra, Abi and Yakurr local government areas. Using a handheld Germin-18 Global Positioning System (GPS), the geographic coordinates of the area lies between Latitude 5^0 9' 06" and $6^0$12'N of the Equator and Longitude 8 ^{0} 05' 80" and $9^0$11'60" E of the Accra meridian. It has an estimated combine population of about one million, one hundred and forty-eight thousand, nine hundred and ninety-nine persons (1,148,999) (Google 2023 Population projection) and a land mass of about 8116 Km^2.

The zone is located within the tropical rainforest, with abundant forest species and other natural resources between Boki and Yakurr Local Government Areas. This is also where the Okwangwo division of the Cross River National Park is located, the World Wildlife Fund for Nature (WWF) and the International Union for the Conservation of Nature (IUCN) declared this section of the national park as the world biodiversity hotspot since 1991, where a lot of endemic species are found. There are other wildlife protected habitats like the Afi Mountain Wildlife Sanctuary, the Mbe Mountain and Buantsebe gorilla forest.

Hydro-geomorphic survey shows that the zone is generally low-lying with about 80% of the entire area being at less than 350 m above sea level; substantial part of the area lies within the Benue valley trough (Fadama 11, 2008). The zone has an undulating topography drained by the famous Cross River. The soil formations are characterized by medium to coarse grained feispathic sand stone, sandy clay shells, calcareous sandstone and shelly limestone. The areas within the Cross River valley flood plains are majorly made up of alluvial sandy soil, clay and humus soil, which is why agriculture and plantation agriculture especially is encouraged here. These soil characteristics coupled with the abundant sunshine, relative humidity, temperature and rainfall are the reason for the high tropical rainforest located within the zone. This zone alone accounts for about 75% of the remaining tropical rainforest in Nigeria (Eneji, et al. 2022).

The study Area experiences distinct dry and wet seasons with rainfall, temperature and humidity varying with each season. The wet season occurs between April to October with an estimated mean annual rainfall of 2500 mm^3 to 3500 mm^3 and rain distribution of 6-7 months. Mean annual temperature goes between 24^0c to 35^0c. The dry season which is the harmattan period is between November to March and is characterized by dry, dusty and hazy north-east trade winds that blow over the area from the Sahara desert which reduces the visibility to less than l000m. Due to livelihoods activities and improvement in living conditions, the zone has been transformed from natural vegetation as a result of agriculture, logging for timber and fuel wood, cultivation and grazing of animals, residential area development and the harvesting of non-timber forest products. Other causes are the conversion of forest land to plantation agriculture like for cocoa, oil palms, plantain, banana and moringa plantation (Eneji, et al. 2022b). Majority of the people are farmers who grow cash and stapple food crops, hunters, traders, timber dealers, and palm wine tappers, a handful of the population are civil/public servants and students. Gender disaggregated data shows that about 57% of the population are women, 43% are men, while about 72% of the population are engaged in forest related occupation (activities)(Eneji, et al. 2022a).

Areas like Boki, Ikom and Etung LGAs engaged in the exploitation of NTFPs (Non-Timber Forest Products). The marshy and water-logged areas along river valleys and streams also support market gardening and fishing (Fadama II, 2008, Eneji, *et al.* 2013). Using the multistage approach, three LGAs were selected, followed by the selection of 40% wards from the three LGAs selected (11 wards). This was followed by the selection of 10% of the communities listed in each Ward. After the selection of communities, 3% sample was selected from the total number of people on the community register. Total samples of three hundred and fifteen (315) respondents were selected for the administration of the instrument.

Two sets of data were collected for the study, firstly, primary data using structured questionnaire titled: Climate Variability and Forest Resources Abundance and Availability in the Central Agro-ecological Zone Questionnaire (CVAFRAAQ) with three response options of high (3), medium (2) and low (1), with a reverse coding for negative

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questions. The secondary data included climate data for temperature, rainfall, and relative humidity from the weather stations for a period of 35 years (1988-2023).

Hardware and Software: High-speed memory digital electronic Hewlet Packard (HP) laptop computer and Auto-Regressive Integrated Moving Average (ARIMA) software was used for the time series analysis for 35 years.

RESULTS AND DISCUSSION

Respondents' Personal Socio-Demographic Characteristics

The simple percentage analysis revealed that 84 respondents (26.7%) of the respondents are farmers, 58 (18.45) respondents said they are businessmen, 21 respondents said they are artisans (6.7%). Fifty-six (56,17.7%) ticked that they deal on timber and non-timber forest products, 44 respondents (14.0%) are public/ civil servants, 45 respondents (14.3%) are students, while 7 respondents (2.2%) said they are engaged in other occupations where they make their living. It therefore means that more men are engaged in forest resources exploitations than their female counterparts.

Based on the ages of the respondents, 102 respondents (32.3%) are between the ages of 35 -45 years, 87 respondents (27.6%) are between 46-55 years, 68 respondents (21.6%) are between the ages of 56-65 years. 45 respondents indicated that they are between the age bracket of 66-75 years, while 13 respondents, (4.2%) are above 76 years of age, while 189 respondents (60%) were males, 126 respondents (40%) were females. Educational status shows that 21 respondents (6.7%) never attended any formal school, 32 (10.2%) attended elementary school, 88 respondents (27.2%) attended secondary education, 78 respondents (24.8%) attended tertiary institutions with NCE, ND, RN/RM/R.PSY. 58 (18.4%) respondents acquired either a university degree or HND equivalent from the polytechnic or other institutions of higher learning. Another 23 respondents (7.3%) said they possess master's degree, 15 respondents (4.8%) said they have a PhD degree.

Rainfall Data Trend between 1988 and 1998

The result shown on figure 1 depicts rainfall data by 1988 with a mean annual rainfall amount of 1768.1mm^3, in 1989, mean annual rainfall was 2021.9mm^3, in 1990 the rainfall was 2248.0mm^3. In 1991 and 1992, it was 2447.0mm^3 and 2039.7mm^3 respectively. By 1993 and 1994, it was 2102.6mm^3 and 2305.7mm^3 respectively. By 1995 and 1996, rainfall was 2325.8 and 2239.9mm^3 respectively. While by 1997 it was 2517.9mm^3 and 2369.0mm^3 for 1998 respectively. The variation between 1988 and 1998 was 600.9 mm^3. This shows that the annual amount of rainfall has increased over the years from 1768.1 to 2369.0mm^3.

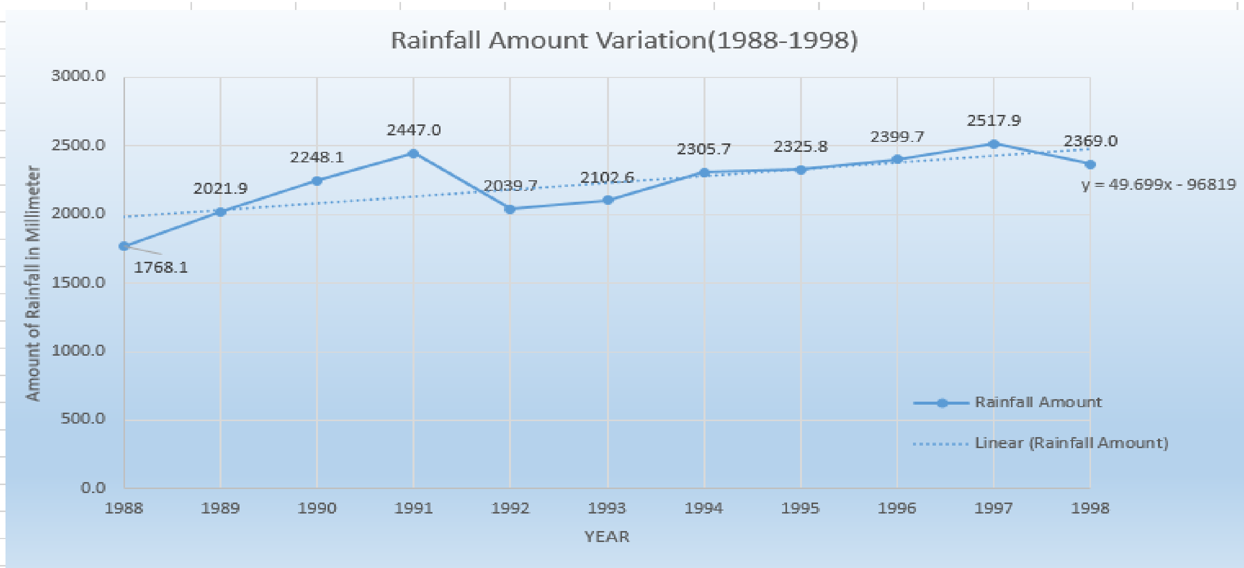

Figure 1: Mean annual rainfall data between 1988 and 1998 in Central Agro-ecological zone

Temperature Variations between 1988 and 1998

Temperature data from figure 2 and figure 3 indicates that there are two data sets from 1988 to 1998 for the study area. These are the maximum and minimum mean annual temperatures.

Mean Annual Maximum Temperatures between 1988 and 1998

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Looking at the data for the mean annual maximum temperature as shown on figures 2 and 3 by 1988, the maximum mean annual temperature was 32.1 ^{0}c, while in 1989, the temperature data was 32.2 ^{0}c. By 1990, mean temperature was 32.4 ^{0}c and 32.1 ^{0}c for 1991. 1992 and 1993 had an annual mean temperature of 31.9 ^{0}c and 31.9 ^{0}c respectively. By 1994 and 1995, the mean maximum temperatures were 31.8^{0}c and 32.4^{0}c respectively. While 1996 and 1997 temperatures were 32.3 ^{0}c and 32.4 ^{0}c respectively. It was also revealed that the annual maximum temperature for the studied zone between 1988 to1998 was 32.7 ^{0}c and increase of 0.5 ^{0}c.

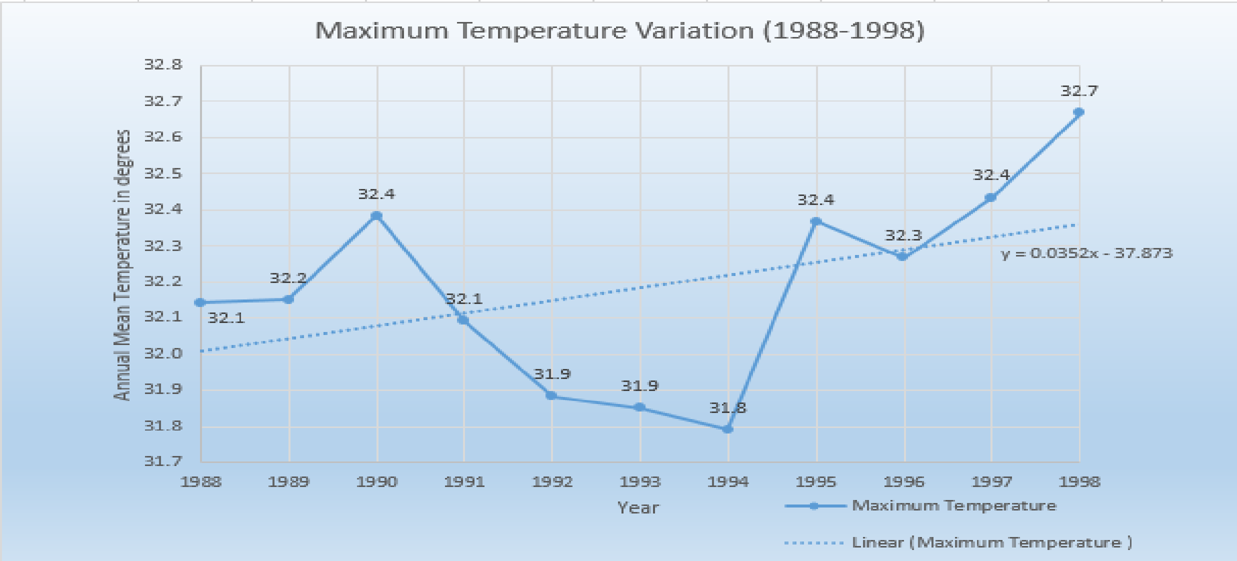

Figure 2: Mean annual maximum temperature between 1988 and 1998 of Central Agro-ecological zone

Mean Annual Minimum Temepratures between 1988 to 1998

Figure 3 shows the mean annual minimum temperature of the study area, by 1988 was 22.6 ^{0}c, by 1989, 1990 and 1991, the area had a mean annual minimum temperature of 21.5 ^{0}c, 22.5 ^{0}c and 22.4 ^{0}c respectively. By 1992 and 1993, minimum temperatures were 21.7 0^c and 22.2 ^{0}c, while by 1994 and 1995; it was 21,7^{0}c and 22.0 ^{0}c respectively. It also shows that by 1996, minimum temperature was 22.3 0^c and by 1997, the mean annual temperature was 21.5 ^{0}c and 22.6 ^{0}c for 1998 respectively. The result revealed that there were no serious variation in minimum temperatures between 1988 and 1998.

Looking at the relative difference in mean annual temperatures between the maximum and the minimum, results on figure 2 and 3 further revealed that in 1988, the maximum temperature was 32.1 ^{0}c, while the minimum annual temperature for 1988 was 22.6 ^{0}c, the variation in the annual mean maximum and the mean annual minimum is 9.5 ^{0}c, furthermore, the mean difference in 1989 shows that maximum temperature was 32.2 ^{0}c and minimum temperature was 21.5 ^{0}c a variation of 10.7 ^{0}c occurred.

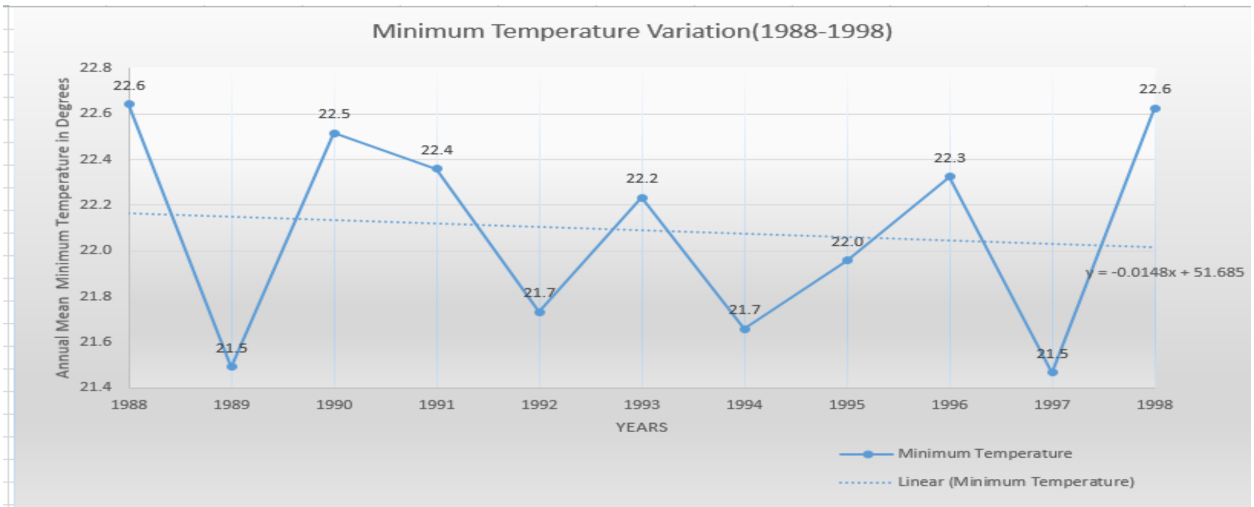

Figure 3: Mean annual minimum temperature between 1988 and 1998 of Central Agro-ecological zone

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Mean Annual Relative Humidity Changes between 1988 and 1998

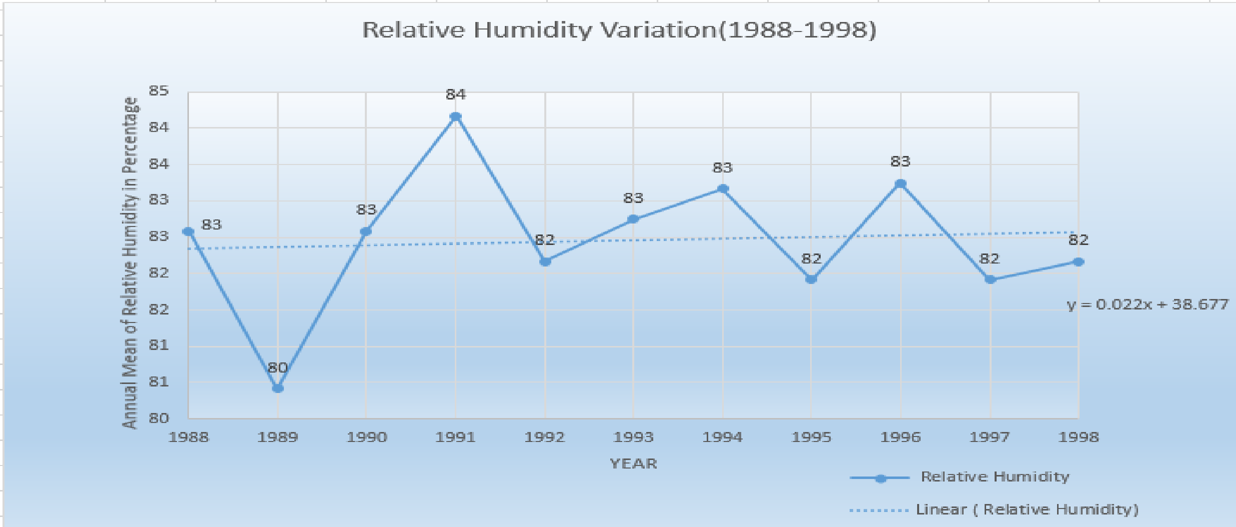

Figure 4: Mean annual relative humidity data between 1988 and 1998 of Central Agro-ecological zone

Figure 4 shows relative humidity of the study area by 1988 was 83%, while by 1989, the relative humidity was 80%, by 1990, it was 83% and by 1991, 1992, and 1993, the relative humidity was 84%, 82% and 83% respectively. It was also found that by 1994 and 1995, it was 83% and 82%, while by 1996, 1997 and 1998; the relative humidity was 83%, 82% and 82% respectively. The mean variations between 1988 and 1998 were -1% indicating that the relative humidity of the study area dropped from 83% in 1988 to 82% in 1998. This implies that there are variations in form of reduction in the percentage of mean annual relative humidity of the study area between 1988 and 1998 by -1%.

Rainfall Trend between 1998 and 2008

Table 1 shows rainfall trend, by 1998, the mean annual rainfall was 2369.0 mm^3, by 1999, it was 2319.0 mm^3, while in 2000, it was 2378.9 mm^3. By 2001 and 2002, the mean annual rainfall was 1971.9 mm^3 and 2225.6mm^3 respectively. By 2004 and 2005, the mean annual rainfall was 2178.9 mm^3 and 1986.8mm^3. By 2006 it was 2168.0 mm^3, 2007 and 2008, the mean annual rainfall were 2406.3 mm^3 and 2057.6 mm^3 respectively. By 2000, the rainfall was 2378.9 mm^3, with the lowest peak in 2001, being 1971.9 mm^3. Further analysis of the variations in rainfall between 1998 and 2008 shows that by 1998 rainfall was 2369.0, by 2008 it was 2057.6 mm^3, the variance is -311.4 mm^3, showing a reduction in rainfall.

Table 1: Selected climate element variations from 1998-2008 in Central Agro-ecological zone

	Years	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Change
Rainfall in mm^3	Max	2369.0	2319.0	2378.9	1971.9	2225.6	2178.9	1986.8	2168.3	2243.7	2406.5	2057.6	-311.4
Temp in ^{0}c	Max	31.9	32.1	32.9	31.9	31.8	32.3	32.1	32.5	33.1	32.5	32.8	+0.9
	Min	22.6	22.1	21.6	22.3	22.9	23.2	23.1	23.1	23.0	22.8	22.9	+0.3
	Diff	9.3	10.0	11.3	9.6	8.9	9.1	9.0	9.4	10.1	9.7	9.9	+0.6
Rel Humidity %	Max	82	84	81	82	82	82	81	82	82	82	81	-1

Temperature Trend between 1998 and 2008

Temperature results on Table 1 also show the maximum and minimum annual mean temperatures of the study area between 1998 and 2008.

Mean Annual Maximum Temperature Trend 1998-2008

Table 1 shows the mean annual maximum temperature, by 1998 temperature was 31.9^{0}c, by 1999 and 2000, and temperatures were 2.1^{0}c and 32.9^{0}c respectively. By 2001, 2002, and 2003, the mean annual maximum temperatures were 31.9 ^{0}c, 31.8 ^{0}c and 32.3 ^{0}c, respectively. While by 2004 it was 32.1 ^{0}c, 2005 was 32.5 ^{0}c, by 2006, maximum temperature was 33.1 0^c. Table 1 shows that mean annual maximum temperatures for 2007 and 2008, were 32.5^{0}c and 32.8^{0}c respectively. Variations in the mean annual maximum temperature ranges between 1998 and

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2008, were 31.9^{0}c and 32.8 ^{0}c with a variance of 0.9 ^{0}c. The implication of this result is that between 1998 and 2008, there was an increase in the mean annual maximum temperature from 31.9 ^{0}c to 32.8 ^{0}c by 0.9 ^{0}c.

Mean Minimum Temperature Trend between 1998 and 2008

Table 1 show that by 1998, the mean annual minimum temperature was 22.6 ^{0}c, while by 1999, was 22.1^{0}c and in 2000, it was 21.6^{0}c. Between 2001, 2002 and 2003, the mean annual minimum temperatures were 22.3^{0}c, 22.9^{0}c and 23.2^{0}c respectively. By 2004, 2005 and 2006, the mean annual minimum temperatures were 23.1^{0}c, 23.1^{0}c and 23.0^{0}c. By 2007 and 2008, the mean minimum temperatures were 22.8^{0}c and 22.9^{0}c respectively.

From the result on Table 1, it was revealed that between 1998 and 2008, there were some variations in minimum annual temperature trend of the study area. The variation between 1998 and 2008 (22.6^{0}c and 22.9^{0}c), has a variance of $+0.3^{0}$c increase in the ambient temperature of the study area. Taking a holistic look at the temperature variations between the minimum and the maximum, the difference is +0.6 ^{0}c implying increase in temperatures in the study area.

Relative Humidity Trend between 1998 and 2008

Table 1 shows the relative humidity trend between 1998 and 2008. By 1998, the annual mean relative humidity is 82%, for 1999 it was 84%, while in 2000; it was 81% and 82% in 2001. By 2002 and 2003, the relative humidity was 82% and 82% respectively, while by 2004 and 2005, the annual mean relative humidity of the area was 81% and 82% respectively. By 2006 and 2007, it was 82% and 82% respectively, while for 2008 it was 81%. Some variations occurred in the relative humidity of -1% within the study area during the periods under study.

Rainfall Trend between 2008 and 2018

Table 2 shows mean annual rainfall trend for 2008 with 2057.6 mm^3, in 2009, the mean rainfall was 2570.3 mm^3, while in 2010; the mean was 2263.2 mm^3. In 2011, 2012, 2013, the mean annual rainfalls were 2237.6 mm^3 and 2438.0 mm^3. In 2013, it was 2325.6 mm^3, while 2014 and 2015 was 2301.2 mm^3 and 2204.2 mm^3 respectively. 2016 has 2524.5 mm^3 and 1965.3 mm^3 in 2017, by 2018, rainfall was 2849.3 mm^3. Table 3 further revealed that by 2008, it was 2057.6 mm^3, for 2018, rainfall was 2849.3 mm^3, there is a variation between 2008 (2057.6 $mm^{3)}$ and 2018 having 2849.3mm3 and a variation of +791.7 mm^3, implying that there was an increase of 791.7 mm^3 in the study area. There was a gradual increase in the annual rainfall from 2008 to 2012 (2057.6-2438.0mm^3), and from 2013, (2325.6 mm^3) to 2015 (2204.2 mm^3), another gradual decline in the rainfall. Table 3 further revealed that from 2016, the rainfall again rose to 2524.5 and fell by 2017 to 1965.3 and rose again to 2849.3 mm^3 in 2018.

Table 2: Selected climate element variations from 2008-2018 in Central Agro-ecological Zone

	Years	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Change
Rainfall in mm^3	Max	2057.6	2570.3	2263.2	2237.6	2438.0	2325.6	2301.2	2204.2	2524.5	1965.3	2849.3	+791.7
Temp in ^{0}c	Max	31.9	32.1	32.9	31.9	31.8	32.3	32.1	32.5	33.1	32.5	32.8	0.9
	Min	22.9	22.5	22.9	22.0	22.3	22.4	22.6	22.9	22.9	23.0	22.7	-0.2
	Diff	9	9.6	10	9.9	9.5	9.9	9.5	9.6	10.2	9.5	10.1	1.1
Relative Humidity %	Max	81	82	81	82	80	79	81	80	83	82	82	1

Mean Maximum Temperature Trend between 2008 and 2018

Results on Table 3 shows that by 2008, the mean maximum temperature was 31.9^{0}c, while by 2009, mean temperature was 32.1^{0}c, by 2010 mean temperature was $32,9^{0}$c and for 2011 it was 31.9^{0}c. Again, by 2012, the mean temperature was 31.8^{0}c and for 2013, the temperature was 32.3^{0}c. The result of the trend analysis further revealed that by 2014, the mean annual maximum temperature was 32.1^{0}c, while for 2015, it was 32.5^{0}c. For 2016 and 2017, the annual mean maximum temperatures were 33.1^{0}c and 31.5 ^{0}c respectively. There are variations in the maximum temperatures between 2008 and 2018, (31.9^{0}c and 32.8^{0}c) with a variance of 0.9^{0}c.

Mean Annual Minimum Temperatures from 2008 to 2018

The trend analysis on Table 2, revealed that the minimum temperature for 2008 was 22.9 0^{c}, 2009 and 2010 were 22.5^{0}c and 22.9^{0}c respectively. By 2011, 2012 and 2013, the annual minimum mean temperatures were 22.0, 22.3 and 22.4^{0c} respectively. For 2014 and 2015, the temperatures were 22.4 0^{c} and 22.6 0^{c} respectively. For 2016, 2017 and 2018, the mean annual minimum temperatures were 22.9^{0}c, 23.0^{0}c and 22.7^{0}c respectively. Table 2 further show some changes in the minimum annual mean temperatures between 2008 and 2018, (22.9^{0}c and 22.7^{0}c), with

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a variation of -0.2^{0}c. The result presented on Table 2 shows that by 2008, the difference in temperature was 9^{0}c, while by 2009, 2010, 2011 and 2012, the mean annual difference in temperatures between minimum and maximum temperatures were 9.6^{0}c, 10.0 ^{0}c, 9.9^{0}c, and 9.5^{0}c respectively.

Relative Humidity Trend between 2008 and 2018 in Central Agro-Ecological Zone

Table 2 indicates that by 2008, the mean annual relative humidity of the area was 81%, 82% in 2009, and 81% in 2010. The relative humidity was 82% in 2011, 80% in 2012, 79% in 2013, and 81% in 2014 respectively. By 2015, it was 80%, in 2016 it was 83%. By 2017 and 2018, the relative humidity was 82% and 82% respectively. There were some variations in the relative humidity between 2008 and 2018; the trend shows that by 2008, the relative humidity of the area was 81%, while by 2018, the relative humidity of the area was 82%, the difference or variation between 2008 and 2018 was +1%.

Rainfall Trend Analysis between 2018 and 2023

Table 3 and figure 5 shows that by 2018, the mean annual rainfall was 2849.3 mm^3, in 2019 was 2953.4 mm^3, while in 2020 it was 2126.5 mm^3. In 2021, the mean rainfall was 2239.0 mm^3. In 2022, the mean rainfall was 2421.4 mm^3 and by 2023, it was 2221.3 mm^3. Table 4 again revealed a marked decrease in the mean rainfall between 2018 and 2023.

Table 3: Selected climate element variations from 2018-2023

Elements	Years	2018	2019	2020	2021	2022	2023	Change
Rainfall in mm^3	Max	2849.3	2953.42	2126.5	2239.06	2421.4	2221.3	-628
Temp in ^{0}c	Max	32.8	32.4	32.6	33.2	34.3	35.4	+2.6
	Min	22.7	21.2	22.0	23.2	24.3	24.9	+2.2
	Diff	10.1	11.2	10.6	10.0	10.0	10.5	+0.4
Relative Humidity %	Max	82	84	81	82	81	79	-3

By 2018, the mean annual rainfall data was 2849.3mm^3, while by 2023; it was 2221.3mm^3, indicating a variance of -628mm^3. This implies that there is a serious reduction in the annual of rainfall trend from 2018 to 2023 in the study area.

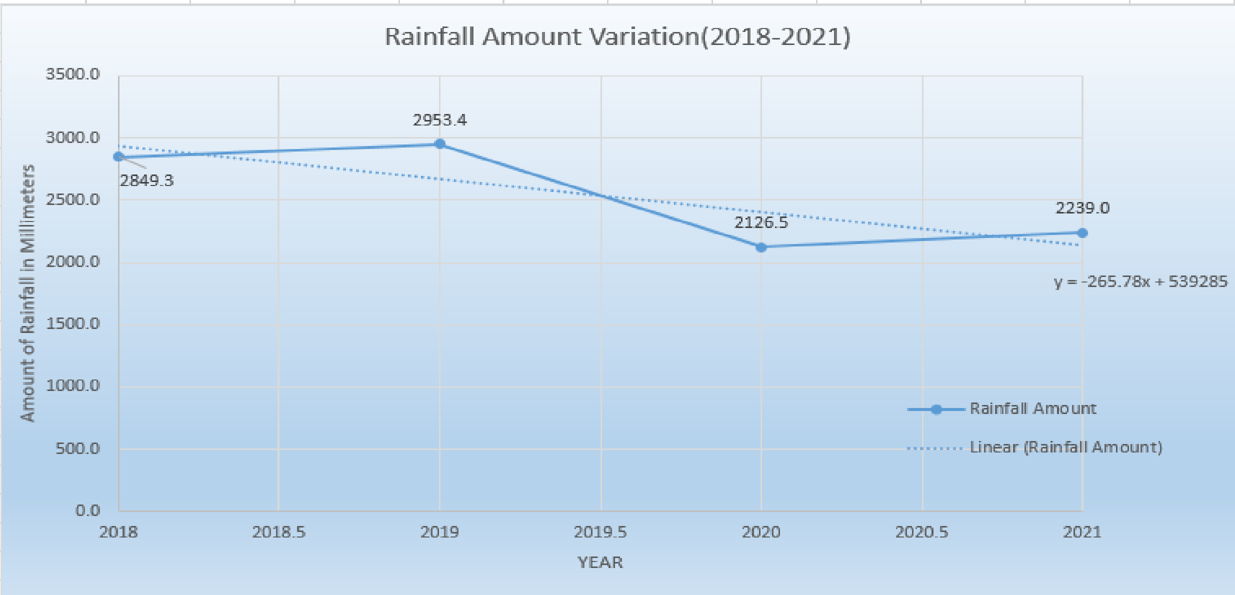

Figure 5: Mean annual rainfall trend between 2018 and 2023

Maximum Mean Annual Temperatures between 2018 and 2023

The result of maximum temperature trend analysis on Table 3 and figure 6 shows that by 2018, the mean annual temperature was 32.8^{0}c, while by 2019 and 2020, the mean annual maximum temperature was 32.4^{0}c and 32.6^{0}c respectively. By 2021, it was 33.2^{0}c, by 2022, it was 34.3^{0}c, and by 2023, the mean annual maximum temperature was 35.4 0^c. The temperatures between 2018 were 32.8^{0}c and 2023 is 35.4^{0}c respectively, producing a variance of +2.6^{0}c over a period of six years, meaning an annual increase of +2.6^{0}c.

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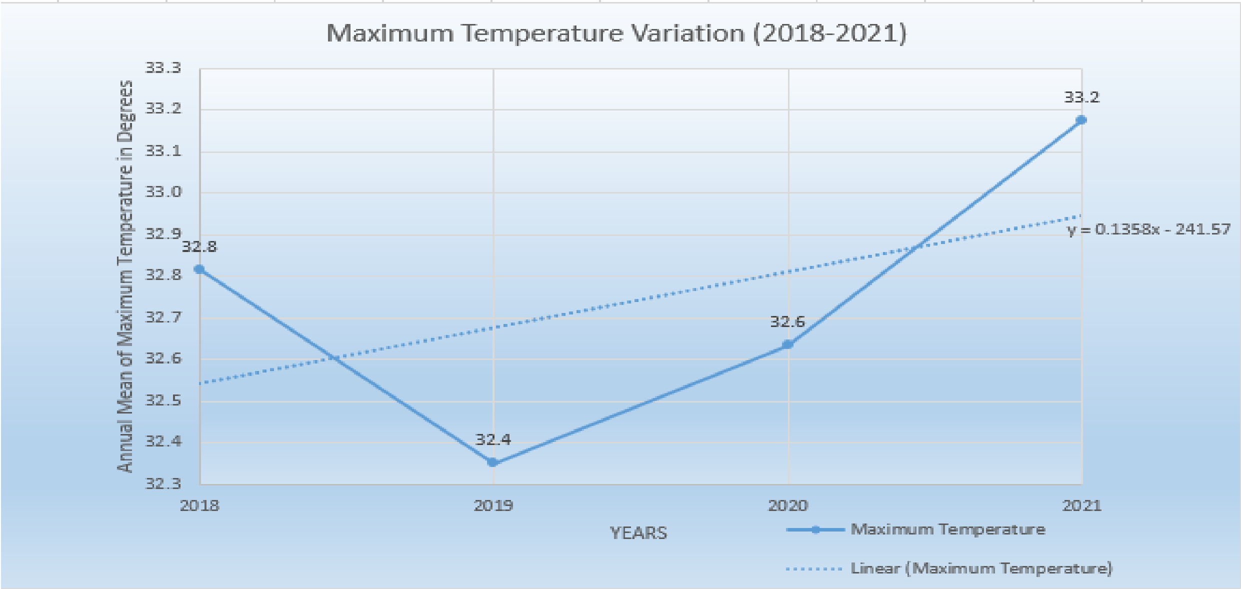

Figure 6: Mean annual maximum temperature trend between 2018 and 2023

Mean Minimum Temperature Trend Between 2018 And 2023

Table 3 and figure 7 on mean annual minimum temperature shows that by 2018, the temperature was 22.7^{0}c, by 2019, the temperature was 21.2^{0}c. Table 3 and figure 7 shows that the mean minimum temperature by 2020 was 22.0 0^c, 2021 was 23.2^{0}c and 2022 was 24.3^{0}c. 2023 shows a value of 24.9 ^{0}c. There were some variations in the mean annual minimum temperature. By 2018 it was 22.7 ^{0}c, while by 2023, it was 24.9 ^{0}c. The variation produced a mean annual minimum temperature of +2.2 ^{0}c.

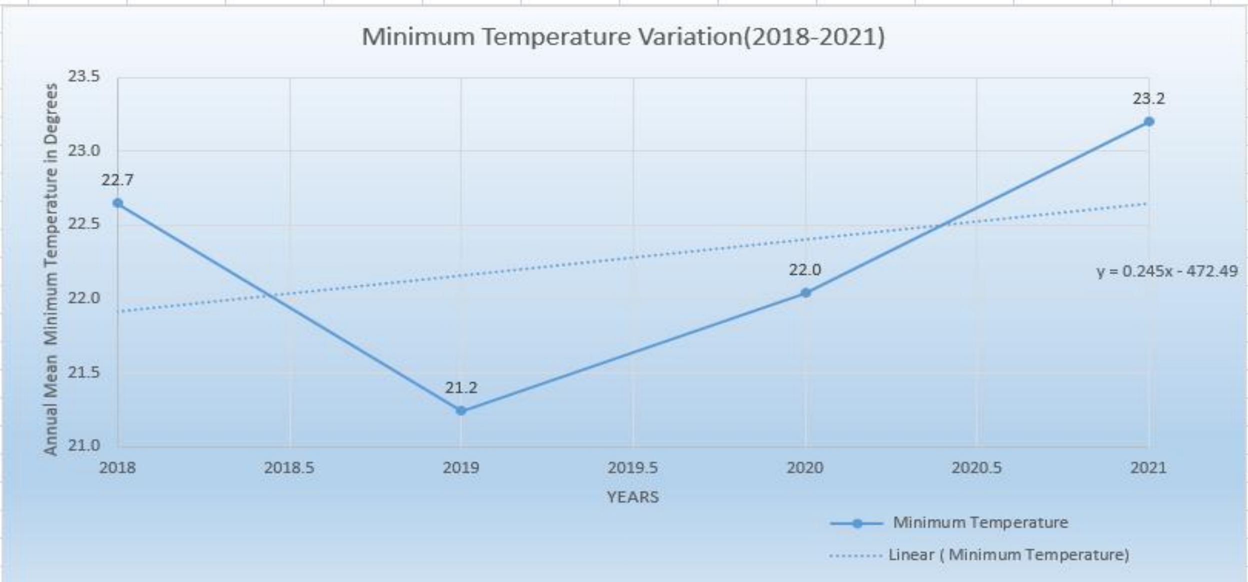

Figure 7: Mean annual minimum temprature trend between 2018 and 2023

The result on Table 3 figure 7 revealed that some differences occurred in the minimum and maximum temperatures of the study area between 2018 and 2023. By 2018, the difference between the maximum and minimum temperature was 10.1^{0}c, while by 2019, 2020, 2021, the differences between the minimum and maximum temperatures were 11.2^{0}c, 10.6 0^c, 10.0 ^{0}c respectively. The mean difference was 10.5^{0}c, the difference further shows that between 2018 and 2023, the mean annual temperature between maximum and minimum temperature was +0.4 ^{0}c.

Relative Humidity Trend Between 2018 And 2023

The relative humidity trend shown on Table 3 and figure 8 indicates that by 2018, the relative humidity was 82%, 2019 was 84%. In 2020, it was 81%, by 2021, it was 82% and by 2022 and 2023, it was 81% and 79% respectively. There exists a variation in the relative humidity between 2018 (82%) and 2023 (79%), the variance

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shows a -3 % difference. The implication of this result is that the relative humidity values dropped by 3% from 2018 to 2023.

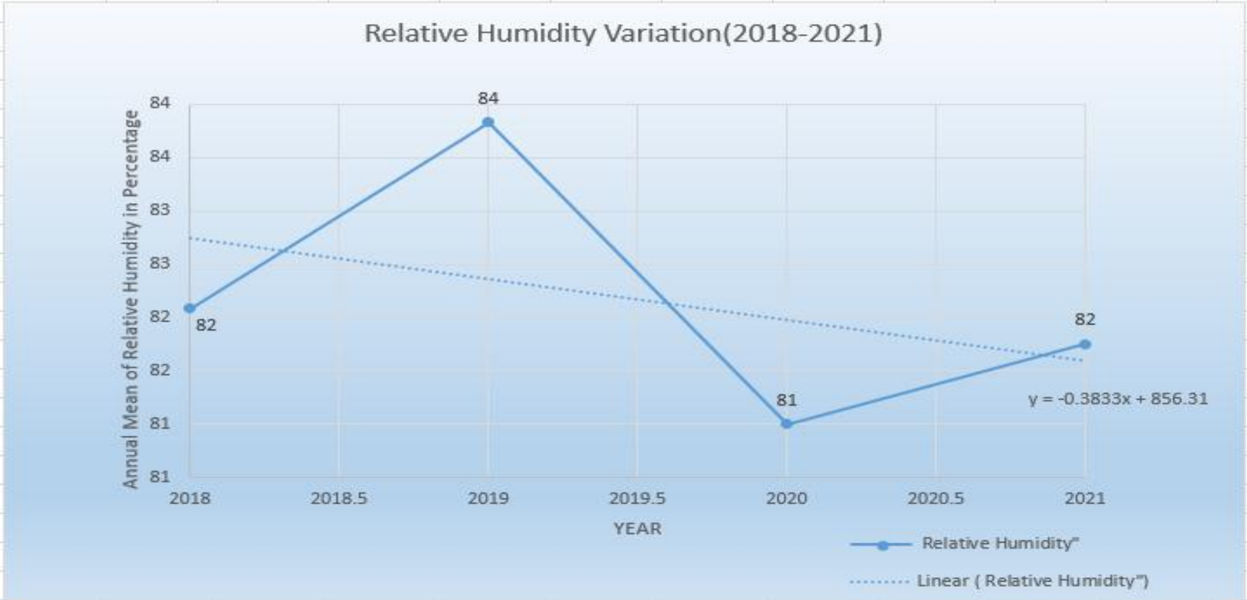

Figure 8: Mean annual relative humidity trend between 2018 and 2023

Rainfall, Temperature and Relative Humidity and Environmental Resources Availability

To assess the influence of these three climate variables of rainfall, temperature and relative humidity trend analysis on environmental resources availability and abundance in the central Agro-ecological Zone of Cross River State, a null hypothesis was formulated thus:

Rainfall, temperature and relative humidity (RTR) do not significantly influence environmental resources availability in the study area. The independent variables are Rainfall, temperature and relative humidity (RTR) which was categorized into low, moderate and high, while the dependent variable is environmental resources availability and abundance. This hypothesis was tested using one-way analysis of variance (ANOVA) at .05 level of significance and result presented on Table 4.

The result on Table 4 shows that 78 respondents posited for low rainfall, temperature, and relative humidity had a mean of 14.23 and standard deviation of 1.53, while 148 respondents who had moderate rainfall, temperature, and relative humidity had a mean of 22.01 and standard deviation of 1.89, whereas 89 respondents who had high rainfall, temperature, and relative humidity had a mean of 30.81 and standard deviation of 3.65. This implies that when the rainfall, temperature and relative humidity (RTR) were low the environmental resources were also low when compared to others. It was also observed that the F-ratio of 956.02 obtained with a p-value of .000 at 2 and 312 degree of freedom was statistically significant, implying that there is a significant influence of rainfall, temperature, and relative humidity (RTR) on environmental resources availability and abundance. In order to determine the amount of influence of each of the sub-variables of the independent variable: rainfall, temperature and relative humidity (RTR) has on the dependent variable: environmental resources availability, a Fisher Least post-Hoc test was conducted as observed in Table 5. When the RTR is high the influence is higher than when RTR is low (mean difference = 16.58, $p < .05$). In the same vein, when RTR is high the influence is higher than when RTR is Moderate (mean difference = 8.80, $p < .05$). Moreover, moderate RTR had more influence than low RTR (mean difference = 7.78, $p < .05$). All the differences between the various groups were significant at .05 level of significance.

Table 4: One-way Analysis of Variance of the influence of Rainfall, temperature and relative humidity (RTR) on environmental resources availability

RTR	N	$\overline{X}$	SD
Low	78	14.23	1.53
Moderate	148	22.01	1.89
High	89	30.81	3.65
Total	315	22.57	6.53

Source of variance	Sum of Squares	Df	Mean Square	F-ratio	p-level
Between Groups	11512.69	2			
Within Groups	1878.59	312	5756.35		
Total	13391.28	314	6.02	956.02*	.000

** Significant at .05 alpha level; p<.05. RTR = Rainfall, temperature and relative humidity*

Table 5: Multiple comparisons

(I)RTR	(J) RTR	Mean differences (I-J)	Std Error	Sig.
Low	Moderate	-.7.78*	.343	.000
	High	-16.58*	.381	.000
Moderate	Low	7.78*	.343	.000
	High	-8.80*	.329	.000
High	Low	16.58*	.381	.000
	Moderate	8.80*	.329	.000

Dependent Variable: Environmental Resources
RTR = Rainfall, temperature, and relative humidity

DISCUSSION OF FINDINGS

The result of this study is a confirmation of the earlier finding of Kyei-Mensah, et al. (2019) whose works on rainfall variability and crop production within the Worobong Ecological Area of Fanteakwa District, shows that the variability in rainfall has caused crop production unpredictability. Crop productivity is tailored toward the frequency, volume and duration of rainfall in the area. The finding of the study has also come to affirm Addisu, et al. (2015) whose work on trend analysis of temperature and rainfall in Lake Tana Subbasin, Ethiopia, found that within the period under study, there were variations in rainfall, wind speed, cloud cover, temperature, relative humidity and species abundance in the study area. This result also affirmed the works of Diress and Bedada, (2021) on precipitation and temperature trend analysis using Mann Kendall test in Addis Ababa methodological station, Ethiopia, the research found series of variation of some climate factors as climate change occasioned by human activities. Sathyan, et al. (2018) work on small anomalies in dry-season greenness and chlorophyll fluorescence for Amazon moist tropical forests during El Niño and La Niña decreasing the forest composition and specie diversities, making the forest ecosystem undergo some stress has also been confirmed.

Once this occurs, biodiversity abundance and sustainability are threatened and eventually becomes extinct. Other scholars like Sathyan, et al. (2018) looked at drought impact on forest carbon dynamics and fluxes in Amazonia; Martínez-Camilo, et al. (2018) also looked at the extent to which the Amazon Forest structure generates diurnal and seasonal variability in light utilization and how they affect species diversity and abundance. These changes according to these authors in some places are negative, while in others, there are positive. However, authors like Chen, et al. (2022) also looked at the negative impact of excessive moisture contributing to the seasonal dynamics of photosynthesis in Amazon moist forests; they concluded that excessive moisture becomes detrimental to the tree species diversity and abundance of the Amazonian Forest composition. This study by Chen, et al. (2022) appears to refute the result of this current finding, but that does not mean it completely refuted the result, but rather stated that the excess of moisture is not too good for the rainforest zone.

The implication of this result is that between 2008 and 2018, there was a maximum temperature increase of $+0.9^{0}$c. A change which authors like Castaño-Vázquez, et al. (2018): Demirhan, (2020) and Ayeni and Oloukoi, (2022) all confirm that is taking place in most parts of the world as a result of human activities. This position was confirmed by Ayeni and Oloukoi, (2022) on the analysis of temperature trend as an indicator of climate change using land surface temperature (LST) and meteorological data in Akure, Southwest Nigeria. The authors found that there has been increasing amount of surface temperature as a result of global climate change. These changes did not only occur in terms of land surface temperatures, but also in the rainfall trend, with other weather or climate elements (Castaño-Vázquez, et al. 2018).

This study had also confirmed the works of Castaño-Vázquez, et al. (2018); Demirhan, (2020), discovered that human or anthropogenic causes influence temperature fluctuation, where the removal of trees from forest land

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increases the ambient carbon dioxide, thereby exacerbating the ambient temperatures. When human activities like deforestation, species and habitat decimation destroy species and protected habitats, especially when most species do not have the resilience capacity of being exposed to harsh environmental conditions. These conditions are detrimental to the health and wellbeing of biodiversity in their natural ecosystems. However, authors like Ye, et al. (2020); Gebeyehu and Hirpo, (2019) did not find any association between temperature fluxes and forest resources availability.

This result is in line with Castaño-Vázquez, et al. (2022) whose work looked at humidity in a cavity-nesting bird influences ectoparasites' abundance, the implication to the current work is that relative humidity was manipulated to examine the relative abundance of ectoparasites. Here relative humidity is one environmental factor that influences species abundance and diversities in every ecosystem. Where there is high relative humidity, the species abundance of that ecosystem is enhanced through the species abundance, but when the relative humidity is low; species decimates and begin to disappear either by natural processes or by human induced causes.

Getachew, (2018) and Gogoi, (2019) also found that relative humidity is a very essential element that both plants and animals need for their optimum growth and development. When there is abundance of relative humidity, environmental resources are at their best in terms of species diversity, abundance and availability. The implication is that there are already some noticeable changes in the climate regime where there are fluctuating rainfall, temperatures and relative humidity which are all indicators of global climate change.

Due to anthropogenic activities and influence, the central Agro-ecological Zone within the last twelve years (2010-2023) had experienced a lot of flooding, forest bush fires, excessive hunting, deforestation and other unsustainable practices which had resulted in serious environmental hazards: flooding and landslides in Bomaji, Danere all in Boki LGA, and increased temperatures in virtually all the communities among others.

The result on Table 5 where climate elements (rainfall, temperature and relative humidity-RTR) were analyzed against forest resources abundance showed that when the RTR is high the influence is higher than when RTR is low (mean difference = 16.58, $p < .05$). The implication of this result is that climate elements have significant influence on forest resources abundance, the higher the mean value for rainfall, temperature and relative humidity, the higher their influence on forest resources abundance. The result also shows that the lower the mean value of the influence of climate elements, the reduced or lower the mean influence on forest resources abundance in the Zone. It is however observed that data generated from the study shows that there are changes in the climate elements studied and these changes are orchestrating climate change occurrence and this is affecting the abundance and availability of forest and other environmental resources in the central Agro-ecological Zone of Cross River State, Nigeria.

CONCLUSION

The study found marked changes in the climate elements analyzed and concluded that the various changes observed in the trend of rainfall, minimum and maximum temperatures and relative humidity shows changes in the climate regime of the study area. These changes are perceived to have negatively influenced the abundance and availability of forest resources in the Central Agro-ecological Zone of Cross River State, Nigeria. These changes are orchestrated by human activities like hunting, deforestation, opening up of new farmland within the fringes of forestland, exploitation of timber and non-timber forest products for survival among others reasons.

RECOMMENDATIONS FOR POLICY DIRECTIONS

It is recommended that:

1. There should be provision of alternative sources of livelihoods to reduce pressure on the remaining forest within the study area
2. Organic farming, bag farming and other organic agricultural practices should be introduced to reduce pressure on forestland conversion.
3. Agroforestry and silviculture (afforestation and reforestation) should be carried out to replace the natural forest landscape with plantation agriculture
4. The rural farmers should be encouraged to practice zero tillage agricultural system, where the soil would not be disturbed.
5. Serious environmental resources conservation awareness campaigns should be mounted in the communities to further expose them to the harmful effects of their livelihood activities in the study area.

6. Government should distribute funds from carbon sales to the residents, this will enable them reduce their dependence on forest resources, knowing full well that the denser and abundant trees and green vegetation they have, the more money would come from carbon sales to them as forest communities.
7. All concession licenses should be revoked and withdrawn.
8. Furthermore, it is recommended that future research should evaluate the effectiveness of these interventions over time.

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