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Time Series Analysis of Climatic Factors and Forest Resources Availability In Central Cross River State, Nigeria

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Abstract
The study examined Time series analysis of climatic factors and forest resources availability in Central Cross River State, Nigeria. The volumes of rainfall, temperature and relative humidity with other climate characteristics have posed serious threat to forest resources availability and livelihood leading to continuous loss of forest land to agriculture, livestock grazing, development of residential areas, flooding, woodland for timber logging and extractions. The attainment of this purpose led to the formulation of four research questions and one null hypotheses at 0.05 level of significance. There was review of literatures from relevant Scholars in accordance with the variables of the study. Survey research design was adopted for the study. Stratified random sampling techniques was used to select local government and communities used for the study, with the sample of three hundred and fifteen (315) respondents used for the study. A twenty item four point modified likert scale questionnaire was the instrument employed for data collection. The research instrument was properly vetted to ensure validity. Cronbach Alpha method was employed to establish reliability of the research instrument. The testing of the hypotheses was done with analysis using analysis of variance (ANOVA) and Auto regressive integrated moving average (ARIMA). The result that was obtained from analysis of data and hypotheses testing revealed that there was a significant influence of three climate variables on forest resources availability in the study area. Based on these findings it was recommended among others that; Organic farming should be introduced to reduce excess pressure on forestland conversion to farmlands to other uses. The introduction of bag farming and other organic agricultural practices should be encouraged to reduce pressure on forest land. Afforestation and reafforestation should be carried out to at least replace the natural forest landscape with plantation agriculture.

Introduction
Nigeria's population and economic development are linked to climate sensitive activities including rainfall, temperature, and humidity; an understanding of the current and historical

climatic factors trends and variation is inevitable to the country's future economy. Climatic factors are the most important natural factors that go a long way in determining a lot of things in Nigeria, especially in the southern part of Nigeria where Ikom Education Zone falls under.

The changes and variability associated with this climatic factors and the pattern of extreme high or low temperature and precipitation are very important for agriculture as well as the economic development of the Ikom Education Zone (Hulme, 2011; Kayamo, 2008). As the move to encourage the agricultural sector in order to avoid food scarcity continues to gain ground and acceptability, information on climatic factors variability are of essence for the design of water supply, understanding of temperatures, relative humidity and forest resources abundance in the study area and beyond. Much as long rainfall, temperature and humidity records are mostly available in many countries, little use is made of this information because of the unpredicted nature of the records (Mina & Sayedul, 2012). It is important to state that, rainfall, temperature and humidity of Nigeria and West Africa in general are influenced by the dynamics of continental air mass and maritime air mass which meet along a slanting surface called inter-tropical discontinuity (Odekunle, 2014).

Due to human activities, climate change manifest in different forms like increase in temperature, change in precipitation and sea level rise and the intensification of natural hazards like wild bush fires, rainstorm, floods, droughts and landslide among others (IPCC, 2017). One major implication of global warming is greater scarcity and variability of renewable resources in many parts of the world (IPCC, 2014). Outside agriculture, which has been seen as the major economic mainstay of most rural and urban communities, dependence on forest resources for human existence is almost equaled agriculture for food, fiber, jobs. These activities are directly dependent on climate conditions; it is highly exposed to the effect of climate change. Forest specie diversities, specie abundance and continuity, sustainable and availability are all characteristics of forest that are dependent on climate factors.

Rainfall and Temperature Distribution, Anomaly and Trend in Nigeria was carried out by Adeleke and Orebayo, (2020) to examine 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 (28C) and mean sunshine (4.7) hours. Temperature anomaly ranged between -2.31C and 1.73C. The correlation coefficient revealed average temperature (0.867) 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.

Detailed observations of surface temperature assembled and analyzed by several different research groups showed that the planet's average surface temperature was 1.4°F (0.8°C) warmer during the first decade of the 21st century than during the first decade of the 20th century, with the most pronounced warming over the past three decades (Hood, 2019; Herrig and Lindsey, 2020).Since 1980s, temperature has increased significantly (Federal Ministry of Environment, 2014). Also, weather events in different ecological zones revealed that temperature will continue to increase in the foreseeable future (Akande et al 2017). There have been records of farmlands reduction, poor crop yields and lower agricultural productivity, loss of biodiversities and forest species due to harsh climatic conditions as a result of higher temperatures, lower rainfall, drought and desertification (Ogbuabor and Egwuchukwu, 2017).

Statement of the problem

The pattern of rainfall, temperature and humidity in Ikom Education Zone 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 the performance of agricultural production and environmental sustainability (Adejuwon & Ogundiminegha, 2019). There are some important climate elements that appear to have some level of influence on environmental resource abundance and availability which include solar radiation, topography, temperature, rainfall, precipitation, sunshine, relative humidity among others (Elijah, 2018, Eneji, et al., 2022a). The relationship between climate variability and forest resources availability has attracted multiple interests from scholars (Jermeh, 2018, Elijah et al. 2018, Eneji, et al., 2022b). It is however rhetorical to think the extent to which some climatic factors influence forest resources abundance and availability either positively or negatively in the study area.

Forest resources availability in Ikom Education Zone is essentially the prominent features of farmers' dependent activities, accounting for nearly 90% of forest cover depletion, with livestock husbandry and fishing comprising the remaining 100% (Asoko InSight, 2019). Farmers in the study area enormously rely on forest resources that nature provides for them. They open up new forest land for their farmland, wood and other non timber forest products. The volumes of rainfall, temperature and relative humidity with other climate characteristics have posed serious threat to forest resources and livelihood. The efforts made by Nigerian Meteorological Agency (NIMET) or weather forecasters to predict rainfall and temperature trend yield little or no significant result in the past in practical terms. This is observed in the

continuous loss of forestland to agriculture, livestock grazing, development of residential areas and built areas and above all the woodland for timber logging and extractions.

Purpose of the study

The main purpose of the study is to carry out a time series analysis of climate factors on environmental resources availability in Central Cross River State. Specifically, the study seeks:

1. To investigate the trend of relative humidity in the study area from 1988-2023.
2. To ascertain the influence of temperature, rainfall and relative humidity on environmental resources availability in Ikom Education Zone between 1988-2023.

Research questions

The following research questions are posed to serve as a guide for the study;

1. What is the trend of relative humidity from 1988-2023 in Ikom Education Zone?
2. How do temperature, rainfall and relative humidity influence environmental resources availability in Ikom Education Zone?.

Statement of hypotheses

One hypothesis was designed to direct the study thus:

1. Rainfall, temperature and relative humidity do not significantly influence environmental resources availability in Ikom Education Zone.

Significance of the study

The study aimed to investigate and present findings on time series analysis of climatic factors on environmental resources availability in Ikom Education Zone, Cross River State. The outcome of this study will be beneficial to climatologist, environmentalists, both States and Federal Ministries of Agriculture and Rural Development, Environment, researchers, policy makers from government, universities, students and other researchers.

To the universities, the outcome of this research can be used to design course curriculum to enhance their teaching on climate and environmental resources conservation. To the climatologist, the outcome of this study shall provide climate data that can be used for climate factor projections and how these can influence forest resources and agricultural activities.

Literature review

Rainfall and forest resources availability

In 2010, Nigerian Meteorological Agency (NIMET) reported that warmer than normal temperatures prevailed over most parts of Nigeria with very high positive values of between

1.9-2.9 ^{0c} over Yelwa, Bauchi, Maiduguri, Potiskum and Ogoja. However colder than normal weather conditions were experienced in few other places like Eket, recording negative normal maximum temperature departures as low as 0.5-1.5^{0c} during the cold season in January, over most parts of the country, with places like Enugu, Gusau, Ibadan, Oshogbo, Owerri, and Ikeja recording higher values. On the other hand, places like Ibi, Yelwa, Jos and Kaduna were 0.8-1.8^{0c} colder than normal

In the northern parts of the country (Nigeria) extremely higher temperatures of about 40 ^{0c}were recorded for consecutive days beginning from the third week in February to the end of May. In Potiskum and Maiduguri, these places recorded the highest daily temperatures of between 46.1^{0c} and 45.5^{0c} respectively (NIMET, 2010). It was further reported that rainfall anomaly with a wetter than normal conditions were experienced in extreme Northeast, Northwest and some cities such as Bauchi, Jos and Minna in the central states. Other areas that recorded wetter than normal rainfall conditions included Southwest, Ogoja, Calabar and Eket in the south-south.

Some isolated cases of drier than normal rainfall was also recorded at Ilorin. It was concluded from the study that in the last three years, the extreme northeast had experienced drier than normal rainfall and temperatures but became wetter than normal in the year 2010. It was also reported that daily heavy rainfall raining from 103.00mm^3 and 199.50mm^3 were also recorded. Highest daily rainfall of 199.5mm^3 and 184.8mm^3 were also recorded at Uyo in June, Benin in September, Umuahia in June respectively (NIMET, 2010).

Looking at these weather events and comparing these with vegetation distribution in Nigeria, it is common sense to understand that the amount of rainfall determines the extent to the lushness of vegetation cover including forest resources distribution. In effect, the more the frequency, volume and amount of rainfall, the more the extent of forest diversities. So also is the temperature. Globally, climate determines the extent of forest and vegetation cover of an area, local, regional or globally. These climate factors include the volume, amount, intensity, frequency and periodicity of rainfall, temperature, sunshine, relative humidity, cloud cover, atmospheric moisture and precipitation.

Relative Humidity and Forest Resources Availability

In this study, it was also found that other ectoparasites were not significantly affected by the treatment; relative humidity was high even in the heated nests, rising more than 60%. Sand flies prevalence was higher in nests located in isolated farm houses and near sand stone walls. It was also observed that heat treatment, nest sites types and ectoprasites abundance did not

affect the nestling body mass, wing length or their growth at different nestling ages. The authors therefore 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. The average nestling body mass or wing lengths was not affected by heat treatment, including nest site types or ecoparasites abundance. From this study, the results suggested that climatic conditions in arid environment could serve to understand the adaptations of multitude of parasites to these areas and highlight the importance of high humidity level for some parasites in roller nests.

Brooks and Kyker-Snowman, (2008) studied forest floor temperature and relative humidity following timber harvesting in Southern New England, USA, in this study, 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, (Vaugoyeau, Meylan & Biard, 2017; Gehman , et al., 2018). There is a direct proportional relationship between the degree of forest floor disturbance and the intensity of harvesting, though studies opined that the duration is unknown. The authors studied forest floor temperature and relative humidity over a period of 12 years chronosequence (1993-204) of timber harvests. The authors compared simultaneous, paired measurements of temperature and relative humidity at three positions (soil, forest floor, air) in harvested and control sites over three seasonal survey sessions.

Research methodology

Research design

The research design adopted for this study is the time series analysis and the survey research design using both qualitative and quantitative methods. Time series analysis is an environmental research design used to make a prediction of climate events over a period of time to identify or examine whether they exists variations in the trend analysis of certain climate variables over a long period of time and the effects such variation in climate elements have on certain characteristics of the environment. Usually, results generated from such research can be used to make future prediction and forecasting about climate events and their impacts.

The survey research design on the other hand is used to select a representative fraction of a larger population for an in-depth study to allow for inferential generalization of results on the entire population. These research designs are adopted because after the administration of the research instrument for the study, data generated including the climate data for the 35 years including the landsat imageries would be analyzed and inferential generalization would then be drawn for the study. It is expected that data for this study will include both quantitative and qualitative data. Climate data from the weather stations and questionnaire shall form the quantitative data, while the landsat (satellite maps) images shall constitute the qualitative data for this study.

Area of study

The Central Cross River comprises six (6) Local Government Area (Boki, Ikom, Etung, Obubra, Abi and Yakurr) Local Government Areas. With the help of a handheld Germin-14 (GPS) Global Positioning System (GPS), the geographic coordinates of Ikom Education Zone located 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 was taken. The education zone is bounded in the North by Obanliku, Obudu and Ogoja LGA, in the South, the zone is bounded by Akamkpa and Biase LGAs, in the West, the Ikom Education zone is bounded by Ebonyi State, while in the East, the zone is bounded with the Republic of Cameroun.

Central Cross River has an estimated combined 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 8116Km^2. Ikom Education zone is located within the tropical rainforest zone, with a lot of abundant forest and other natural resources beginning from Boki to Abi 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 where a lot of endemic species are found. There are other wildlife protected habitats like the Afi Mountain Wildlife Sanctuary, the Mbe and Buantsebe gorilla forest.

Population of the study

Population of the study area Central Cross River (Table 1) has a combined population of about one million, one hundred and forty eight thousand nine hundred and ninety nine persons (1,148,999) (Google 2023 population projection).

Sampling techniques

In the selection of samples for instrument administration, the multistage sampling was adopted. Three LGAs shall be selected, followed by the selection of 40% wards from the three LGAs selected (11 wards). The selection of communities would again be done using 10% of the communities listed in each Ward. After the selection of communities, the selection of sample was done using 3% of the numbers of each community on the register. The sample selected is as shown on table.

Sample

Using this sampling technique as enunciated above, a sample of three hundred and fifteen (315) respondents was selected for the administration of the instrument. This instrument is intended to gather data on the extent to which the respondents believed that the combined impact of temperature variation, rainfall and relative humidity can influence the availability of forest resources in Central Cross River, while for the time series analysis, data shall be obtained from the weather stations in the local government areas and the weather station in Nigerian Meteorological Agency, (NIMET) offices in Calabar and Jos.

Results and discussion

The first purpose was to examine the rainfall trend between 1988 to 2023 and how the trend analysis could affect resource availability in Ikom. By 1988, the mean annual rainfall trend value was 1768.1mm^3, by 1998, the mean annual rainfall values was 2369.0mm^{3,} with a variance of +600.9mm^3. The implication here is that the mean annual rainfall increased from 1988 to 1998 by 600.9mm^3, an increase that was as a result of human induced activities. By 1998 to 2008, the annual mean rainfall value was 2369.0mm^3, while by 2008 (10 years after), the mean annual rainfall value was 2057.6mm^3, the variance in the volume of rainfall between 1998 and 2008 was -311.4mm^3. The implication her is that, the ten years period under study, (1998 to 2008), there was a decrease in the annual amount of rainfall by -311.4mm^3. This decline was again attributed to human livelihood activities like deforestation for timber exploitation, agriculture and residential or infrastructural development activities within the forest areas.

The two decades under discourse show that between the first decade and the second decade, there was rainfall fluctuation, in the first decade (1988-1998), rainfall increased by 600.9mm^3, while by the second decade, the rainfall trend nose-dived to -311.4mm^3, indicating a serious reduction in the volume of rainfall in the study area within the period under study. By the year 2008, the mean annual rainfall trend was 2057.6mm^3, while by 2018, the mean annual rainfall was 2849.3mm^3, the difference between 2008 and 2018 in terms of mean annual rainfall was +791.7mm^3. The implication here is that there is a mean annual increase in the volume of rainfall between 2008 and 2018. The rainfall mean annual changes show that there

is an increase in the amount and volume of rainfall within the study area by +791.7mm^3. It was also discovered that between 2018 and 2023, the mean annual difference was again compared to note if there are any changes in the rainfall pattern. By 2018, the mean annual rainfall value was 2849.3mm^3 and by 2023, it was 2221.3mm^3. The result shows a variation in the amount of rainfall from 2849.3mm3 to 2221.3mm^3(2018 -2023). The variance in the amount of rainfall between this period is -628mm^3. The implication of this result is that there was a serious decrease in the trend in rainfall of the study area with a mean annual difference of -628mm^3.

Summary of findings

The main purpose of this study is to do a time series analysis of climate variables from 1988 to 2023 and its influence on natural resources availability in Central Cross River of Cross River State, Nigeria. Three climate elements were studied to include rainfall trend from 1988 - 2023; minimum and maximum temperature trend from 1988 – 2023, relative humidity between 1988-2023 and how these three climate trend analyses of these three variables influence natural resources availability (forest resources) in Central Cross River.

Four purposes were pursued to identify and examine the rainfall trend between 1988-2023, minimum and maximum trend between 1988-2023, relative humidity trend between 1988-2023 and how these trend analyses influence forest resources abundance. Four research questions were formulated and one hypothesis was also formulated to guide the study. The research design adopted for this study is the time series analysis and the survey research design where both qualitative and quantitative methods were used. Time series analysis is an environmental research design used to make a prediction of climate events over a period of time to identify or examine whether they exists variations in the trend analysis of certain climate variables over a long period of time and the effects such variation in climate element have on certain characteristics of the environment. Usually, results generated from such research can be used to make future prediction and forecasting about climate events and their impacts.

Conclusion

From the result of the trend analysis, it was found that there are marked changes in the climatic elements analyzed. There was a change in the mean annual rainfall between 1988 and 2023, the changes signify an increase in the annual volume of rainfall within the study area. Within the thirty five years studied there are marked changes, where there were reductions in the annual volume of rainfall within the study area, but however, between the period under study, rainfall values fluctuated, but the fact that between 1988 and 2023, the values are positively different implies that there are changes in the volume of rainfall in the study area.

Recommendations

Based on the result of the time series analysis and the finding of this study, the following recommendations were made:

1. There should be the provision of alternative sources of feedstuff to reduce too much pressure on the remaining forest within the study area. For example, instead of deforestation to harvest snails from the forest, snail farming should be encouraged, instead of harvesting cutting grass from the forest, cutting grass farming can be encouraged. Instead of fishing with dangerous chemicals from the rives and streams, fish farming (cat fish, tilapia etc0 can be farmed.
2. Organic farming should be introduced to reduce excess pressure on forestland conversion to farmlands to other uses

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