ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites,com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

RESEARCH ARTICLE

SPATIO-TEMPORAL FLUCTUATIONS IN RAINFALL DURING THE GROWING SEASONS AND ITS IMPLICATION ON SUSTAINABLE AGRO-LAND USE AND PRACTICES IN IMO STATE

Ambrose Oluchukwu ABANEME [1]; Ikpong Sunday UMO [2]; Ifeanyi Gerry UKWE [3], Christian E. OGU [4]

[1] Department of Political Science, Alvan Ikoku Federal University of Education, Owerri; [2&3] Department of Geography & Environmental Sustainability, AIFUE, Owerri, Nigeria; [4] Department of Agricultural Science, AFUE, Owerri

ABSTRACT

The collective efforts in tackling climate change impacts are gaining popularity at the global level, but regional and local agro-land users tend to suffer failures due to limited capacity to adapt. In this study, Imo State was stratified into three agro-land zones and rainfall data were generated from secondary sources using gridded method from 19981 to 2023 (43) climatic years and analyzed using descriptive and inferential statistics. The results reveal that Imo East recorded a highest mean value of 256.00, while Imo West recorded a highest standard deviation of 18.44 mm. Also, Imo East and Imo West recorded a homogenous value of 297 mm for the longest length of growing season during 2013 climatic year, while the shortest length of growing seasons converges in 1998 climatic year, but with diverse values recorded at distinct agro-land zones. The results of the time series models exhibited a uniform positive trend patterns with the Imo West revealing a highest regression model 0.510x + 244.5 and a highest co-efficient of 0.120 that accounted for 12.0 percent of the total variance in the series. A test of influence of variations in agro-land zones on rainfall fluctuations led to a conclusion that changes in the length of growing seasons are independent of locations of Imo agro-land zones. This study recommends for urgent places-centered policies and collaborated efforts to strengthen farmers' adaptive capacities to rain-induced hazards for sustainable agricultural land use and food security in Imo State.

Keywords: Spatio-temporal, rainfall fluctuation, growing season, agro-land use, geo-politic.

Corresponding Author
Dr. Ikpong Sunday Umo: **Tel. No.**: +2348037565958:
Email Address: umohikpong@yahoo.com **ORCID**: https://orcid.org/0000-0002-8424-6889

Received: 17/5/2025; **Revised:** 23/6/2025; **Accepted:** 19/7/2025; **Published:** 30/7/2025

ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

1.0. INTRODUCTION

It is estimated that 500 million smallholder farms in the developing world are supporting almost 2 billion people, while in Asia and sub-Saharan Africa, these small farms produce about 80 percent of the food consumed (Food and Agricultural Organization (FAO, 2015)). The reality of climate change-induced impacts of fluctuations in rainfall indices, most notably length of growing seasons on stable crop production constitute one of the major research concerns. Further still, empirical evidence indicates that with the severity of climate change impacts through rainfall fluctuations in areas suitable for agriculture, length of growing season with staple crop yield will decline (Duru, Ojinma & Umo, 2015). Collaboratively, the Inter-governmental Panel on Climate Change (IPCC) projected those sub-Saharan African countries 'may experience a decrease in agricultural yield by 50 percent by 2050 and a corresponding decline in net revenue by 90 percent respectively (IPCC, 2007; Duru *et al.*, 2015; Umo, Okoroafor, & Ukwe, 2021).

In a quantitative evaluation effect of rainfall anomaly at the global scale, Zaveri, Russa, and Damania (2020) 'confirms that rainfall anomalies lead to contemporaneous changes to agricultural production shocks and quantifies the magnitude of the impact globally'. The notion depicts that mean crop production increases in response to wet anomalies and decreases with dry anomalies. On the contrary, dry anomalies lead to an 11 to 12 percent decrease in agricultural productivity per year globally. Wet anomalies, on the other hand, increase crop productivity by ~8 to 9 percent (Zaveri *et al.*, 2020). Contextually, while the global scale of rain-induced productivity threats on changes in cropland is yet to be quantified within the regional scale, complexities manifest at the local level due to intervening opportunities that are place-specific.

Rainfall fluctuation during growing seasons hold high potentials to constraints the normal growth of staple crops in given agro-land zones due to the effects of temperature increase and low soil moisture. Yet, the tendencies towards drier conditions in some areas such as the West and Southern Africa may cancel, at least partially, the positive potential impacts due to higher carbon (iv) oxide or milder temperatures (IPCC, 2019). Such combined influence of climate indicators leads to a variety of discriminated impacts on crop production, depending upon the type, location, and the level of land users' adaptation. Within the Northwest

ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

Cameroun, it is established that 'farmers' perceptions were recorded on changing crop pattern, with decreasing trends in food and cash crops' (Tume, *et al.*, 2020).

An issue-based assessment of rainfall anomaly in Northwest Cameroun Most cash crops that are not applicable in all the three agro-ecological zones represent the lowest negative anomaly they include rice, soybeans, pineapple; whereas cattle, vegetable, tomatoes and cocoyam have positive change (Tume & Nyuyfoni, 2021). A contrast of the result of farmers' perception with field inventories led to a deduction that though respondents 'perceived decrease in groundnuts and cassava, field observations proved the contrary' (Tume & Nyuyfoni, 2021). The pattern confirmed the notion that 'geographers should focus on building a valid knowledge base on scientific facts and principles' (Umo & Ajoku, 2023:167). Research findings derived from direct field observations/ measurements offer more robustic avenues for valid prediction and generalization about extreme events (e.g. rainfall and crop production) within a given agro-land use practices. Proper land use planning and policy implementation usually avert future losses.

Rao *et al*. (2016) assessed the exposure of vulnerability of Indian agriculture at a local level to climate change and variability for the period 2021 to 2050. The robustic statistical analyses led to a conclusion that major determinants of exposure of the districts to climate change were proliferation in drought occurrence, rise in minimum temperature and reduction in rainfall amount during June and July, suggesting urgent needs capacity enhancements through possible technological and other interventions (Rao *et al*., 2016) to boost responsiveness to extreme cases. The exposure indicators include yearly rainfall, number of wet days, minimum and maximum temperature as well as cold and heat wave frequencies. Besides, frost occurrence, drought proneness, dry spells (≥14 days) and extreme rainfall events also constituted the exposure indicators. These indicators were normalized using the Mini-Max normalization framework proposed by USAID (2014).

Although the concerted efforts of the government, financial institutions, donor agencies, and other stakeholders to cope with the uncertainties in climate change indicators at the global level have yielded positive level of successes (Umo, Okoroafor & Ukwe, 2021), variations exist at both the regional and community levels (Nwafor 2006; Umo, Ojinma & Enwereuzor, 2014). The centripetal impacts of climate change-induced rainfall uncertainties had alters

https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

land capability for sustainable for agriculture in most local communities and regions, especially the Tropics (FAO, 2015). Thus, constituting major threat to the United Nation Sustainable Development Goal 2, Target 1 of 2025 “by 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round” (UNSDG, 2015).

Within the Niger Delta region, researches had established that there are statistical significant changes in rainfall and temperature indices as a result of climate change, leading to upsurge in temperature from normal over a considerable period (IPCC, 2014; Omonigho, 2022). However, the data recorded in both ecological zones are less than the global increase of 0.74 ^{0}C (IPCC, 2007) and also less than the temperature increase of 1.7 ^{0}C in Nigeria (Odjugo, 2010). It is argued that the variation might not be unconnected with the fact that the values used in determining the magnitude of change in Nigeria transcend through different ecological zones compared to the computation in this study which are limited to data generated for the Mangrove Swamp and Freshwater Swamp ecological zones (Omonigho, 2022).

Discounting the diversities researches on climate change indicators presented in the preceding background, studies on fluctuations in rainfall during length of growing seasons are either eclipsed or not gaining attention in the southeastern Nigeria and Imo State in particular. The lacuna orchestrated by apathy, paucity of place-specific rainfall data, and/or limited expertise to regional rainfall modellings constitute serious constraining variables to sustainable people-centered agro-land policy formulation or implementation of the existing. Such failures partly constitute major threats to regional staple crop production and food security. Hence, this study anchors on the fluctuations of rainfall during length of growing seasons in Imo State with a view to developing relevant policy framework for sustainable agro-land use practices and sustainable development.

1.1. Aim and Objectives of the Study

The aim of this study is to evaluate fluctuations in rainfall in length of growing seasons from 1981 to 2023 (43 climatic years) across the three agro-land zones in Imo State, Nigeria. To actualize the aim, the following specific objectives were investigated.

ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

1. To determine the pattern of fluctuations in rainfall in the length of growing seasons among the three (Imo North, Imo East, and Imo West) agro-land zones.
2. To comparatively evaluate the levels of spatio-temporal trends in rainfall during length of growing season among the three agro-land zones in Imo State.
3. To determine whether variations in geographic locations have statistical significant influence on rainfall fluctuations during growing seasons among the agro-land zones.

2.0. DESCRIPTION OF THE STUDY AREA
2.1. Location

Imo is one of the most popular States in the Southeast Nigeria. From the geographical perspective, the State is located between Latitudes 5^0 10^l 00^{ll} and 6^0 02^l 00^{ll} North of the Equator and Longitudes 6^0 7^l 11^{ll} and 7^0 28^l 03^{ll} East of Greenwich Meridian (Figure 1). Relatively, it is bounded by Anambra State in the East, Abia State in the West, and Rivers State in the South as encapsulated in Figure 1. The State has a total land area of 5,100 km^2 (Enwereuzor and Umo 2024). It has three senatorial districts (designated in this context as agro-land zones), and with a total of 27 Local Government Areas that are unevenly distributed within each agro-land zones. The State has 360 autonomous communities, but later increase to over 640 in 2016 (Enwereuzor *et al.*, 2021; Enwereuzor & Umo, 2024).

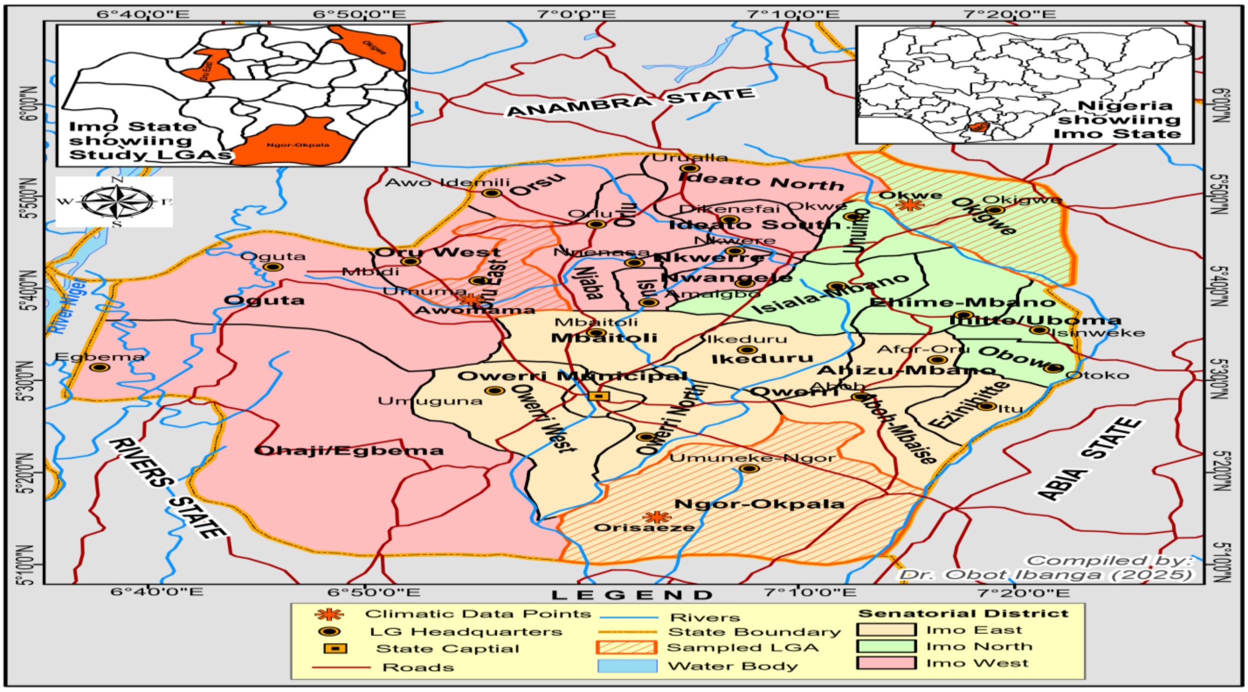

Figure 1: Imo State Showing Agro-Land Zones and Climatic Data Points.
Source: Compiled from Authors' Fieldwork (2025).

2.2. Vegetation and Land use

There are two dominant types of vegetation in the study area (Umo *et al.*, 2021). The upper and middle areas are dominated by the tropical rainforest belt with both primary and secondary vegetation. The secondary vegetation types are those that have been altered by diverse human occupations such as farming, urbanization, infrastructure, amenities, and housing development. On the contrary, pockets of primary forests exist majorly in some wetland area, community owned land, forest reserves, shrines, and allied cultural land and practices. These parts of the region are dominant source of water for domestic and agricultural uses (Umo, 2019; Umo et al., 2021). The soils are very rich in humus content and often favour diverging types of livelihoods.

2.3. Climate

Although weather and climate indicators especially rainfall, temperature, and moisture in Imo State vary across distinct agro-land zones, it is usually classified as humid tropical (*Af*) climate under Köppen's scheme (Umo 2019; Umo, Enwereuzor & Ukwe, 2020; Monanu, 1975). The monthly distribution of rainfall for many stations shows that is a long wet season from April to July, interrupted by a short dry season, in August and then another short wet season from September to October; thereby creating chance for a long dry season from November to March (Monanu, 1975). The distribution and effectiveness of rainfall is directly linked the movement and relative position of the Tropical Continental Convergence Zone (ITCZ). ITCZ is boundary between two dominant wind systems called Tropical Maritime Air Mass and the Tropical Continental Air mass. The mT originates from the Atlantic Ocean.

It is therefore damp and rain-bearing air mass due to the influence of the Ocean while the Tropical Continental (cT) air mass is usually characterized by dry and dusty wind with marginal effect. Recent empirical studies have shown that the climate of the study area is classified into four seasons (i.e. peak rainy, early rainy, peak dry and early dry seasons) (Umo, 2019). The mean annual rainfall is over 2250 mm with a mean temperature above 26.7^0 Celsius (Enwereuzor *et al.*, 2021). The relative humidity varies within the range of between 75 percent for dry season and 90 percent for rainy seasons. Recently, there are marked evidences of rising temperature and rainfall in the area due to global warming (Umo *et al.,* 2020). The state lies within the rainforest belt of Nigeria with the varying forest patterns enriched with high proportion of humus contents in the soils induced by decayed of vegetation materials. However, varying dimensions in rainfall indices have induced leaching and erosion of soil materials vertically across soil horizons and horizontally across location.

3.0. MATERIALS AND METHODS

3.1. Reconnaissance Survey

Series of preliminary field surveys were conducted by the researchers to diverse strategic geographical locations within the Imo Sate. The rationales were to acquaint themselves with the dominant geographical, agricultural, and political attributes that make each region unique, identify appropriate locations for sample collections/ area demarcations, and record of coordinates for rainfall data extractions.

3.2. Determination of Length of Growing Season

Research evidences had indicated that rainfall remains one of the most dynamics climate indicators at distinct geographic spaces and time (Umo, Ojinma, and Enwereuzor, 2014). Thus, it spatial and seasonal distributions during onset, cessation and length of growing for crops usually varied. That means, length of growing season converges between rainfall onset and cessation in given agro-land zone. In context of this study, the variance between the earliest cessation and latest onset is projected at a minimum of 10 day intervals. The rationales for the choice were to either avert or mitigate the challenges emanating from the complexities of climatic phenomena such as late shower and prolonged dry spelt. Consequently, the length of the growing season (i.e. rainy days) for each climatic year depicted the difference between the Julian day numbers of the determined cessation date and the determined onset date.

3.3. Sampling Techniques and Data Collection

The study area was stratified into three distinct agro-land zones comprising Imo North, Imo East, and Imo West senatorial district using politics as index for classifications (Figure 1). In each stratum, a strategic point was purposively selected for rainfall data extraction with emphasis on areal differentiation in spatial (locational) spread in the State as summarized in Table 1. Data for this study were generated form primary and secondary sources. The primary

E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

source of data comprises recording of locational (Longitudes and Latitudes) coordinates and determination of elevation; while secondary data compose of rainfall, published and unpublished documents.

Table 1: Data Sources and Extraction Methods

Agro-land Zones	Data Site Extraction	Longitudes	Latitudes	Elevation	Durations
Imo East	Orisaeze	7.0803	5.2708	52.43 meters	1/1/1981 – 31/12/2023
Imo West	Awomama	6.9329	5.6896	62.54 meters	1/1/1981 – 31/12/2023
Imo North	Okwe	7.2173	5.7757	105.73 meters	1/1/1981 – 31/12/2023

Source: Authors' Compilation (2025).

3.4. Method of Rainfall Data Extractions

To evaluate the fluctuations in rainfall during length of growing seasons for forty-three (43) climatic years (1981 to 2023), a global, gridded dataset were created, with the grid cells' specifications of 0.5° × 0.5° in size to extract monthly rainfall within the three distinct agro-land zones in Imo State, Nigeria. The extractions were carried out from the University of East Anglia Climatic Research Unit (Harris, Jones, & Osborn, 2021), supported by CRU time series version 4.05 of high resolution gridded data from January 1st, 1981 to December 31st, 2023 (43) climatic years. The rationale was avert the constraints of spatial/ locational coverage embedded in rainfall data archival from distinct Nigeria Meteorological Agency (NiMet's) weather stations in Imo State and Nigeria.

To ascertain the reliability test of the rainfall data sets from NiMet Station (at Imo Cargo Airport) and that of CRU from Imo East (Orisaeze) point were carried out using Cronbache test and the result attests very high level with a positive co-efficient of 0.91. It is worth emphasizing that the CRU raster data were finally collated monthly with annual sum calculated using a raster calculator as propagated and applied in recent studies (Okoro *et al*., 2014; Zhu *et al*., 2015; Chen *et al*., 2016; Zaveri *et al*., 2020; Omonigho, 2022) .

3.5. Methods of Data Analysis

The data from monthly and annual rainfall events were analyzed using descriptive and inferential statistics. The descriptive statistical tools such as range, mean, standard deviation,

https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

and variance were used for perusal and comparisons of patterns rainfall fluctuation between and across agro-land zones in Imo State. Inferentially, linearized regression model with time series were employed in elucidating the trend pattern and predictive in annual rainfall during length of growing season. Furthermore, a multiple linear regression model was adopted to determine the combined effect of variations among the variables, while test of multiple effects of variations was carried out using analysis of variance (ANOVA). Partial regression model and T-test were used as surrogate for determining the influence variations between each dependent and an independent variable in the agro-land zones of Imo State.

4.0. PRESENTATIONS OF RESULTS AND DISCUSSIONS

The statistical assessment of rainfall characteristics, annual trending patterns of onsets, and cessations across diverse agro-land zones of Imo State are chronologically presented and examined in the discourses that follow.

4.1. Determination of Rainfall Fluctuations during the Length of Growing Season

The rainfall data generated for the assessment of fluctuation in the length of growing season from 1981 to 2023 (43 climatic years) in distinct Imo agro-land zones were descriptively analyzed and the results presented in Table 2 reveal disparities based on the analytical tools employed and the agro-land zones. From Table 2, the highest range of 91 mm is associated with Imo East (Orisaeze) while the highest sum of 297.00 mm occurred homogenously at Imo East (Orisaeze) and Imo West (Awomama) agro-land zones.

The mean values of the length of growing season depict place-specific variations. Comparatively, a highest mean value of 256.00 mm is recorded at the Imo East (Orisaeze), flowed by a value of 255.77, while a lowest mean value of 249.63 mm for length of growing season is recorded in Imo North (Okwe).

Table 2: Descriptive Analysis of Spatial Disparities in the Length of Growing Season

Sampled Data Point	N	Range	Sum	Mean	Std Dev.	Variance
Imo East (Orisaeze)	43	91.00	297.00	256.00	16.77	281.24
Imo West (Awomama)	43	88.00	297.00	255.77	18.44	339.99
Imo North (Okwe)	43	76.00	279.00	249.63	15.34	235.24

Source: Authors' Analysis (2025).

ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

A further juxtaposition of the score values using standard deviation indicates that a least value of 15.34 mm is recorded at the Imo North (Okwe), while a climax value of 18.44 recorded at the Imo West (Awomama). A fairly similar pattern is associated with variance, where a highest value of 339.99 mm is recorded at Imo West (Awomama) and lowest scenario of 235.24 mm is associated Imo North (Okwe), while a moderate value of 281.24 mm occurred at the Imo East (Orisaeze) agro-land zone respectively.

From the dimension of pattern rainfall the length of growing season, the results of variability are descriptively summarized in Table 3 for easy perusal and comparisons. Comparatively, the climatic year 2013 maintains the unilateral longest values of length of growing season across the sampled agro-land zones. However, Imo East (Orisakwe) and Imo West (Awomama) agro-land zones recorded a uniform longest value of 297 mm, while Imo North (Okwe) exhibits a lesser long value of 279 mm in the State. On the perspective shortest length of growing season, the presented in Table 3 reveals uniformity in the 1998 climatic year across the sampled agro-land zones, whereas deviance exist in context lent of shortest rainfall values on the order of 209 mm, 206 and 203 mm respectively for the Imo West, Imo East and Imo North agro-land zones. The pattern in the results affirmed Duru *et al.* (2015) report that the effectiveness in soil management practices among crop farmers in Amucha, Imo State is dominantly constraint by uncertainties in climate change indicators (rainfall and temperature anomallies).

Table 3: Descriptive Characteristics of Length of the Growing Season in Imo State.

Agro-Ecological Zones	Rainfall Data Points	Longest LGS and Year	Shortest LGS and Year	Mean LGS
Imo North	Okwe	279 (2013)	203 (1998)	250
Imo East	Orisaeze	297 (2013)	206 (1998)	256
Imo West	Awomama	297 (2013)	209 (1998)	256

Source: Data Analysis by the Researchers (2025).

4.2. Comparative Evaluations of Trends in Rainfall during the Length of Growing Season

The evaluation of trends in rainfall during the length of growing seasons for the three g agro-land zones sequentially are carried out using regression models with time series and the results presented in Figures 2, 3 and 4 depict elements of homogeneity and diversity based on agro-land zones. Hence, the three distinct agro-land zones portray a generalized positive trend

ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

at varying scales. Contextually, the spatial and temporal fluctuations in Imo North agro-land zone presented in Figure 2 reveal complexities in annual rainfall trend in the length of growing season. From the results of the Imo North (Okwe) agro-land, the linearized model reveals that a total of 20 climatic years recorded rainfall in the length of growing season above the trend, a total of 16 climatic years converge below the average, while only 7 climatic years are traverse by the line of best fit (regression line).

A further assessment using extreme cases as indices reveal that longest length of rainfall of 279 mm during the growing season is associated with 2013 climatic year, followed by a value of 276 mm recorded in 2010 climatic year. Contrarily, a shortest event's value of 203 mm was recorded in 1998 climatic years, followed by a value of 219 mm recorded in 2018 climatic year. The dominant positive trend above the trend line suggests increase in climatic change-induced rainfall stressor on sustainable land use practices and crop production. Such excess rainfall stressors often instigate fluvial hazards especially when considering the land (morphological) vulnerability to soil erosion (by gullying, rill, splash), mass wasting, and weathering (Table 1) with their multiplier effects such as loss of vital soil nutrients, and poor plant growth/ yield, and constraining the land capability for staple crop as reported in Ofomata (1986), Umo *et al.* (2014) and Umo *et al*. (2021).

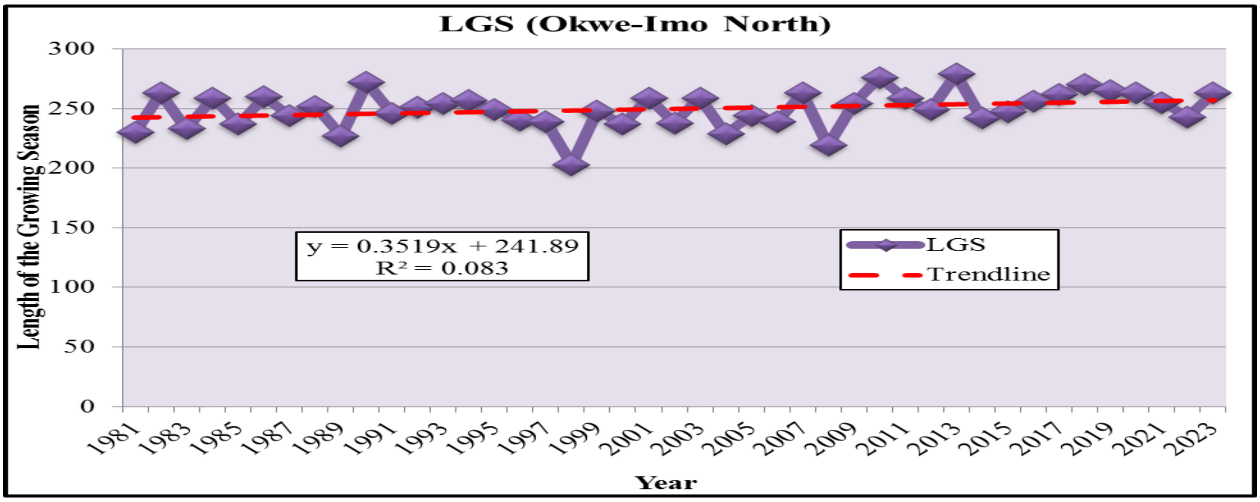

Figure 2: Temporal Trend of Length of the Growing Season in Okwe (Imo North)
Source: Data Analysis by the Researchers (2025).

In the Imo East agro-land zone, the results of the linearized model of rainfall in the length of growing season as summarized in Figure 3 differ in content and scale. Empirically, a total of

18 climatic years possess high positive mean rainfall distributions above the average (regression) line which implies dominant of excess annual rainfall amount during the length of (plant) growing season. On the contrary, a total of 14 climatic years converge below the trend line which indicate selective decline in annual rainfall pattern in the growing season in Imo East agro-land zone, while a total of 11 climatic years recorded normal rainfall events in the growing season that converge on the trend line.

A further juxtaposition of the pattern in rainfall based on extreme scenarios in the growing season indicate that a highest event of 295 mm was recorded in 2013, followed 280 mm for 2023 climatic years respectively. Contrarily, a least amount of 206 mm was recorded in 1003 climatic year, accompanied by a value of 219 mm recorded in 2008 climatic year for the length of growing season in the Imo East agro-land zone of Imo State. The dominant positive pattern and a corresponding high convergences of rainfall events within and around the line of best fit as presented in Figure 3 increase prospect for sustainable land use for optimum staple crops such as cassava, maize, fruit and vegetables production as well as limited vulnerability of land to rain-instigated fluvial and geomorphic hazards, coupled with low relief as portray in Table 1.

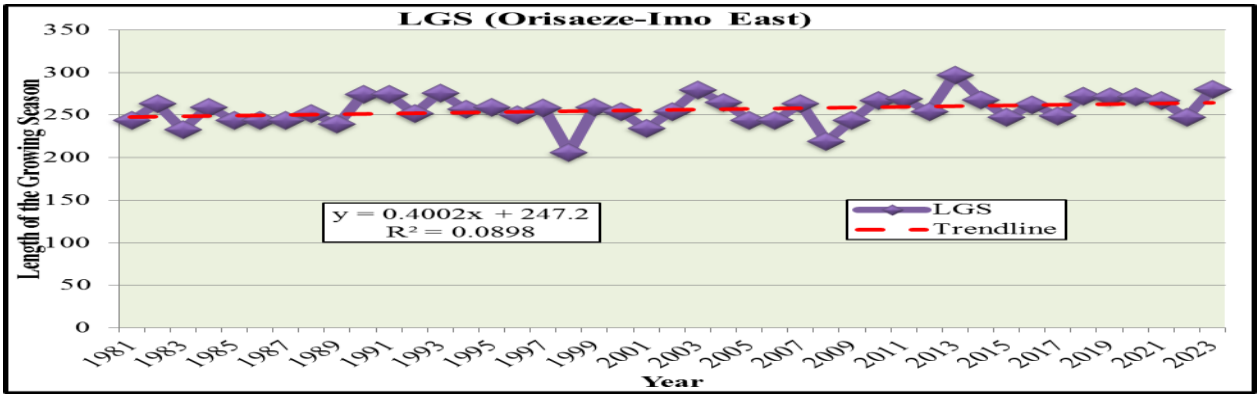

Figure 3: Temporal Trend of Length of the Growing Season in Orisaeze (Imo East).
Source: Data Analysis by the Researchers (2025).

At the Imo West agro-land zone, the regression model with time series presented in Figure 4 reveal dimensional deviation in rainfall during the growing season across the 43 climatic years. Comparatively, a total of 19 climatic years recorded positive rainfall value in the length of growing season above the trend (average) line, while 14 climatic year exhibit values

ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

that converge below the average line. Contrarily, the residual of 10 climatic years converge on the regression line in the series.

The further comparative assessments using extreme rainfall fluctuations in the length of growing season revealed that a longest value of 297 mm was recorded in 2013 climatic year and this was closely accompanied by 280 mm recorded in 2010 climatic year. On the contrary, a shortest length of growing season of 209 mm was recorded in 1998 climatic year, followed by 219 mm recorded in 2008 climatic year for Imo West agro-land zone. In contrast, some water-loving crops such as plantain, banana, pineapples, and palm tree may increase productivity/ yield, while others such as cassava, maize, yam, pumpkin,

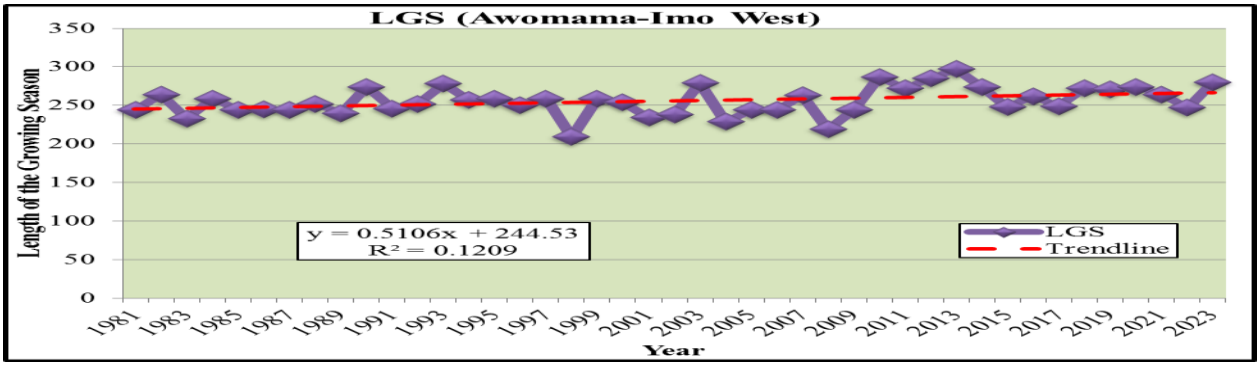

Figure 4: Temporal Trend of Length of the Growing Season in Awomama (Imo West)
Source: Data Analysis by the Researchers (2025).

In consideration of the established generalized positive trend patterns of rainfall for the length of growing across the distinct agro-land zone of Imo State as discussed using the preceding Figures 2 – 4, attempt were made to present the results of the linearized regression equations and time series in very concise manner as evidence in Table 4 and the results differ based on the predictive powers and their regression co-efficient across distinct agro-land zones in Imo State.

The location based discourse reveals that the Imo West (Awomama) agro-land zone possesses a highest predictive power with a regression equation of y = 0.510x + 244.5, and a corresponding highest positive regression co-efficient of 0.120. That accounted for 12.0 percent of the total variance in rainfall during the length of growing season. The pattern has close analogy with the Imo East (Orisaeze) agro-land zone with the regression equation of y = 0.400x + 247.2, and a corresponding moderate low regression coefficient of 0.089 that

https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

explained 8.90 percent of that total variance in annual rainfall during length of growing season in Imo East agro-land zone. A further comparison of the results indicated that Imo North (Okwe) possesses a lowest predictive power with a regression equation of y = 0.351x + 241.8 and collaborated lowest positive regression co-efficient of 0.083, that explains 8.30 percent of the total change in rainfall during length of growing season in the sampled agro-land zone of Imo State (Table 4).

The varying positive trend patterns across the agro-land zones of Imo State collaborated Tume & Nyuyfoni (2021) dominant positive anomaly of rainfall in the three agro-ecological zones of Northwest Cameroun. A further contrast of the results of homogenous positive trends across the agro-land zones suggest increase in rain-induced stressor such as flood, Tropical storms, and changing weather patterns during length of growing season. The pattern of positive trends partly affirmed Assaduzzaman *et al*. (2020) and Zaveri *et al.* (2020) linked the multiplier effects rain-induced stressors to forced displacement, loss of yield per farmland, loss of livelihood in Bangladesh.

Table 4: Spatiotemporal **Trend of** Length of the Growing Season in Imo State.

Ecological zones	Data Points	Regression Equation	Pattern of Trend
Imo North	Okwe	y = 0.351x + 241.8; R^2 = 0.083	Increasing
Imo East	Orisaeze	y = 0.400x + 247.2; R^2 = 0.089	Increasing
Imo West	Awomama	y = 0.510x + 244.5; R^2 = 0.120	Increasing

Source: Data Analysis by the Researchers (2025).

4.3. Assessments of the Effect of Location on Rainfall in the Length of Growing Season

To assess the combined influence of geographic locations on rainfall during the length of growing season in the three agro-land zones of Imo State, linear regression model was used and the results show that the co-efficient of multiple determinations offers a very low value of 0.082. The implication of the result is that the influence of geographic location on the linear combination of variations in rainfall in the growing season across the three agro-land zones in Imo State is expressed for by only 8.20 percent. Other factors such as land use type, soil, relief, vegetation, river and allied local geographic variable could probably be the major agents.

Table 5: Regression Model of Influence of Location on Rainfall in Growing Season

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.082[a]	0.007	0.070	0.851

a. Predictors: (Constant), LG_Imo North, LG_Imo East, LG_Imo West.

To test for the influence of location on rainfall pattern in the length of growing season in the distinct agro-land zone in Imo State, ANOVA model was employed and the results is summarized in Table 6. From the results, sum of squares of the regression offer 0.193, the residual association with the regression gives 28.784 while the sum of squares for total regression gives 28.977. Further still, mean square for the regression gives 0.064 with a residual of 0.738 respectively. However, the calculated ANOVA value gives a very low value of 0.087 that statistically insignificance at 0.05 confidence level. It is therefore infers from the results that “variations in geographic locations have no statistical significant influence on rainfall during growing seasons among the agro-land zones in Imo State”.

Table 6: ANOVA Test of Effect of Location on Rainfall in Length of Growing Season

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.193	3	0.064	0.087	0.967[b]
	Residual	28.784	39	0.738		
	Total	28.977	42			

a. Dependent Variable: Location. b. Predictors: (Constant), LG_Okwe, LG_Orisaeze, LG_Awomama

Discounting the established pattern in Table 6, partial regression model and T-test statistics are further employed to determine the influence of location on each individual variable across the agro-land zones in Imo State and the results presented in Table 7 depict disparities in standardized partial regression co-efficient, T-test values and level of significance. Specifically, the highest positive partial regression co-efficient of 0.130 is associated with length of growing season in Imo North, followed by a co-efficient of -0.057 for the Imo West agro-land zone, while a lowest value of -0.028 is recorded for the Imo East agro-land zone. A further probe on the model results using T-test indicate the rainfall concentration in the length of growing season give generalized low values of 0.493 for the Imo North, -0.163 for the Imo West, and -0.087 for the Imo East agro-land zones. Each sustains a statistical insignificant influence between subjects.

ALVAN JOURNAL OF SOCIAL SCIENCES (AJSS)
FACULTY OF SOCIAL AND MANAGEMENT SCIENCES
ALVAN IKOKU FEDERAL UNIVERSITY OF EDUCATION, OWERRI
https://www-ajsspub-org.b12sites.com https://www.ajsspub2.org
E- ISSN: 3043 – 5463 ISSN: 1595 – 5842 VOULUME 2, ISSUE 2, 2025

Table 7: Partial Model of Influence of Location on Rainfall during of Growing Season

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
1 (Constant)	1.229	2.273		0.541	0.592
LG_Imo_West	-0.003	0.016	-0.057	-0.163	0.872
LG_Imo _East	-0.001	0.016	-0.028	-0.087	0.931
LG_ Imo_North	0.007	0.014	0.130	0.493	0.625

a. Dependent Variable: Location

4.4. Implication of Findings on Agro-Land use Practices/ Policy in Imo State

The preceding discourses on rainfall during length of growing season with the homogenous outcomes of dominantly positive trend pattern across the distinct agro-land zones in Imo State is a clear affirmation of the reality of climate change stressor with adverse consequences on agricultural and allied land practices. Case-bound evidences reveal that the high values above the regression lines predominate. Comparative evaluations of the results reveal that the most focal extreme rainfall events of 20 climatic years was recorded in Imo North, followed by Imo West with 19 climatic years, while the Imo East attracted a total of 18 climatic years of events above average value in the series. It is therefore affirming Umo *et al.* (2015) and IPCC (2014) initial predictions of progressive rise in rainfall trends in coastal areas due to climate change impacts.

The extreme rainfall patterns suggest increase threats emanating from increase fluvial geomorphological and meteorological hazards such as flood, erosion, mass wasting, and sediment yield, usually with divergent catastrophic effects on agro-land use practices. The impacts are most severe in Imo North due to differences in local geography. The perspectives affirmed Kelly and Adger (2000) and Fussel (2007) reports that vulnerability is linked with increased climate-related hazards, physical trends or their physical effects. However, the effects or levels of vulnerability may vary due to key indicators such as nature of crops, geographic locations, soil characteristics, farmers’ adaptive capacities, years of past experiences, cultural practices, and climate change education in the three agro-land zones. The situation may be getting worse, if necessary agro-land zone practices and policy implementations to aid adaptation of vulnerable elements to extreme rainfall stressors are not considered.

The statistical exploration of influence of geographic locations on rainfall fluctuations during growing seasons in the agro-land zones in Imo State depict differences in the co-efficient of variations ad proportion of explainable variance based on the tools (multiple regression and p[atrial regression models) employed. However, test of variations among the groups of variables using ANOVA, and test of variations between dependent and independent variables age the generalized low calculated test values. The results led a deduction of statistically insignificant influences; which implied that disparities of rainfall during length of growing seasons in Imo State are independent of locational controls (influences). In most cases, agro-land zones must be properly guided to conformed Tume and Nyuyfoni (2021) observation that crop production require to embark on proactive and reactive adaptive measures to further increased general outputs or the trend might easily be negative in the nearest future if quick measure to improve on agricultural activity with variation in rainfall patterns is not taken.

5.0. CONCLUSION AND RECOMMENDATIONS

From the preceding discourses, it is clearly established that the patterns in rainfall fluctuations during length of growing seasons in the agro-land zones of Imo State vary across spatial and temporal scales. However, the rate of fluctuations are zone-specific and independent, but with generalized increasing trends. The established dimensions of variations between and among agro-land zones in Imo State are statistically insignificance at 95 percent confidence interval. It is thus, concluded that oscillation in geographic locations have no statistical significant influence on periodic rainfall during length of growing season in agro-land zones of Imo State.

On the zonation of agro-land of uses and practices, the none significant level of rainfall base on tested index suggests that it is expedient to cultivate and promote of drought tolerant staple crop species especially cereals, tree crops, root and tubers mostly on farmland away from riverine areas. On the contrary, genetically modified crops species with high yield and early maturity (e.g. rice, plantain, and banana) should be planted along wetland (e.g. Rivers, their tributaries, and flood vulnerable) areas in the State to boost sustainability in crop production and regional food security.

The reality of climate change-triggered oscillations in length of rainfall during growing season suggest potential and real threats to agricultural land uses across the three zones in Imo State. Therefore, to increase food availability/access/affordability/, promote food security, improved nutritious and sufficient food all year round as encapsulated in UNSDG 2, Targets 1, 3, & 4 of 2015; there is urgent need to boost partnerships among stakeholders and mobilize instruments (at both local, state, national, regional, and international) especially in areas of financing, social protection, capacity building, adaptation, and education on climate change impact on rainfall fluctuation. Such radical movements with keen interest and focus on agriculture, insurance, and allied primary livelihoods at different levels will improve resilience to hazards, agricultural land uses/ practices, and sustainable food systems/ security.

Competing Interest

The authors have declared that no conflicting interest exist in this paper.

Funding Statement/ Acknowledgement

This work is fully funded by the Tertiary Education Trust Fund/ Institutional Based Research for 2024/ 2025 Intervention Project Allocated for and Supervised by the TETFund Committee, Alvan Ikoku Federal University of Education, Owerri, Nigeria.

REFERENCES

Assaduzzaman, M., Filatova, T., Coenen, F., & Lovett, J. (2020). Freedom of Choice to Migrate: Adaptation to Climate Change in Bangladesh. *International Journal Sustainable Development and World Ecology, 27*, 652 – 661.

Chen, D.L., Tian, Y.D., Yao, T.D., & Ou, T.H. (2016). Satellite measurements reveal strong anisotropy in spatial coherence of climate variations over the Tibet Plateau. *Scientific Reports*, *Number 6*, 484 – 504.

Duru, P.N., Umo, I.S. & Ojinma, C.C. (2015). Enhancing the capability of rural farmers towards effective soil management in Amucha community of Njaba, Imo State. *Journal of Emerging Trends in Economics and Management Sciences, 6*(8), 381 – 385. http://journals.co.za/doi:10.10520/EJC174483

Enwereuzor, A.I. & Umo, I.S. (2024). Water supply as and index for assessing sustainable rural development in Imo State. *NIPES Journal of Science and Technology Research, 6*(2), 260. https://doi.org/10.5281/zenodo.12562166

Enwereuzor, A.I., Umo, I.S., & Charles-Akalonu, C.A. (2021). The condition of infrastructure and the development of rural communities in Imo State, Nigeria. *Social Sciences, 10*(3), 132 – 139. https://doi.org/10.11648/j.ss.20211003.18/8H0SG

Food and Agricultural Organization (2015). Climate change and food security: Risks and responses. Accessed 22/4/2023 from www.fao.org/publications

Fussel, H.M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*, *17*, 155 – 167.

Intergovernmental Panel on Climate Change (2007). Climate change: Synthesis report. *Contribution of working groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change*. Pages, *95* – 212.

Intergovernmental Panel on Climate Change (IPCC, 2014). *Climate change: Fifth assessment synthesis report*. Intergovernmental panel on climate change, Geneva

Intergovernmental Panel on Climate Change-IPCC (2019). *Special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. IPCC Secretariate, Bonn, Pages 1 – 35.

Kelly, P. and Adger, W. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change*, *47*, 325 – 352.

Monanu, P.C. (1975). Rainfall. In G.E.K. Ofomata Editor. *Nigeria in maps: Eastern States*. Benin City, Ethiope, Publishing House.

Nwafor, J.C. (2006). *Environmental impact assessment for sustainable development. The Nigerian perspective*. Enugu, El'Demark Publication.

Odjugo, A.O. (2010). General overview of climate change impacts in Nigeria. *Journal of Human Ecology*, 29(1), 47 – 55.

Okoroh, U.K., Chen, W., Chineke, T.C. and Nwafor, O.K. (2014). Recent monsoon rainfall characteristics over the Niger Delta region of Nigeria. *A Causal Link International Journal of Science, Environmental and Technology*, *3*(2), 634 – 351.

Okoro, U.K., Chen, W., Chineke, C., and Nwofor, O. (2014). Comparative analysis of gridded datasets and gauge k measurements of rainfall in the Niger Delta Regio. *Research journal of Environmental Science*, *8*(7), 373 – 390. https://doi.org/10.3923/rjes.2014.373.390

Omonigho, G.M. (2022). *A Comparative Analysis of Rural Livelihoods Vulnerability and Adaptation Strategies to Climate Change in the Mangrove Swamp and Freshwater*

Swamp Ecological Zones of Delta State, Nigeria. Unpublished PhD Synopsis, Department of Geography and Regional Planning, University of Benin

Rao, N. Lawson, T.E, Raditloaneng, W.N., Solomon, D., and Angula, M.N. (2019). Gendered vulnerabilities to climate change: insights from the semi-arid regions of Africa and *Asia. Climate and Development, 11*(1), 14 – 26.

Tume, S.J.P & Nyuyfoni, S.R. (2021). Rainfall anomaly index valuation of agricultural production in Jakiri Sub-Division, Northwest Region, Cameroon. *Journal of Ecology and Natural Resources, 5*(3), 1 – 14. https://doi.org/10.23880/jenr-16000255

Tume, S.J.P., Zetem, C.C., Nulah, S.M., Ateh, E.N., Mbuh, B.K., *et al.* (2020). Climate change and food security in the Bamenda highlands of Cameroon. In: Squires VR, (Eds.), *Food security and land use change under conditions of climate variability: A multidimensional perspective*. Springer Cham, 107 – 124.

Umo, I.S. (2019). *The dynamics of sediments, heavy metals and nutrients in the Kwa Iboe River, Southeastern Nigeria*. Unpublished Ph.D. Thesis, Department of Geography and Regional Planning, University of Benin, Nigeria, 229 pages. TETFund Sponsored.

Umo, I.S. and Ajoku, B.C. (2023). *Geographical philosophy and historical development*. Owerri, Ekene-Grace. Chapter, 14.

Umo, I.S., Okoroafor, P.E.N., & Ukwe, I.G. (2024). Climatic season, critical metal patterns, and health risks in the humid tropical River, southeastern Nigeria. *Alvan Journal of Social Sciences*, 1(1), 1 – 14.

Umo, I.S. & Enwereuzor, A.I. (2021). The implications of area morphology and particulate matters' distributions on the Kwa Iboe River Basin restoration, Southeastern Nigeria. *Journal of Water Resources and Ocean Sciences*, 10(3), 53 – 60. Retrieved 20/5/205 from https://doi.org/10.11648/j.wros.20211003.13

Umo, I.S., Enwereuzor, A.I., & Ukwe, G.I. (2022). *A dimension of physical geography*. Owerri, Ekene-Grace Publication.

Umo, I. S., Ojinma, C. C. & Enwereuzor, A. I. (2014). The impact of the Ibiono-Itu dam project on the downstream crop productivity of the Ididep and Itam Communities in Akwa-Ibom State. *African Science and Technology Journal*, *8*(2), 23 – 30.

Umo, I.S., Okoroafor, P.E.N., and Ukwe, I.G. (2021). Climate variability and the issues in flood disaster risk awareness in Nigerian communities. *NIPES Journal of Science and Technology Research, 3*(4), 271 – 282. https://doi.org/10.37933/nipes/3.4.2021.26

United Nation Sustainable Development Goal (2015). Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. Official Statistics, A/RES/71/313, Resolution 68/261.

University of East Anglia Climatic Research Unit; Harris I.C., Jones, P.D., Osborn, T. (2021). *CRU time series version 4.05 of high resolution gridded data*. Centre for Environmental Data Analysis. https://catalogue.ceda.ac.u/uuid/c26a650

USAID Project (2014). *Vulnerability assessment, Published for USAID, Bureau for Africa, Disaster response coordination*. USAID/FEWS, Arlington, VA.

Zaveri, E., Russa, J. and Damania, R. (2020). Rainfall anomalies are a significant driver of cropland expansion. *PNAS, 117*(19), 10225–10233. www.pnas.org/cgi/doi/10.1073/pnas.1910719117

Zhu, X.F., Zhang, M.J., Wang, S.J., Qiang, F., Zeng, T., Ren, Z.G., and Dong, L. (2015). Comparison of monthly precipitation derived from high-resolution gridded datasets in arid Xinjiang, central Asia. *Quaternary International*, *358*, 160 – 170.