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Geostatistical Analysis of Pattern of Rainfall Distribution and Prediction in Taraba State, North-East Nigeria

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Abstract

Acquisition of up-to-date and reliable data has been a great obstacle for researchers in the fields of climatology and climate change. The manual instruments earlier used for acquisition of climatic data were prone to errors and inconsistencies ranging from inadequate skill, negligence, mechanical problems, inaccessibility due to hazards or related occurrences and insurgency. Automatic whether instruments were latter designed to solve or at least minimize the problems faced with measurements. However, many institutions especially in developing countries found it difficult to procure due to the high cost. In recent years, on-line climatic data were made available, many of which are free for research and related purposes. These on-line data are still not yet known by many in the developing countries, while the problem of acquisition and use as well as the authenticity are still being studied by most people. Therefore, in this study, Diva-GIS which is one of the most popular on-line climatic data was used to generate, map and predict the mean annual rainfall distribution in Taraba State. The mean annual rainfalls (1950-2000) of Eighty (80) settlements in the state were obtained from Diva-GIS which were used to map the mean annual rainfall distribution in the state. Geostatistical analysis was also used to assess the randomness of the rainfall distribution in the State which was found to tend towards clustering and which means that rainfall distribution in the State is not random but influenced by some factors. The study revealed that the distribution is mostly influenced by altitudes and latitudes, since high altitude areas such as Mambilla Mountains and the lower latitudes of southern parts of the State receive more rainfall than the plains and the higher latitudes of the northern parts respectively. It was recommended that if Taraba State Government and all other stakeholders imbibe this technique, most of the climatic data and maps that are not available either as data or information will not only be made available but will also be highly accessible with minimal cost.

Keywords: Autocorrelation; Geostatistical analysis; spatial analysis; rainfall pattern; Taraba State.

Introduction

Spatial patterns of many variables especially those that are geographic in nature are often represented on maps with dots. For instance, settlements, tree species, road junctions or buildings of interest in a place are usually represented on maps as dots commonly referred to as dot maps. It must however be noted that these variables are geographic in nature if and only if their actual positions are located using appropriate projection such as latitudes, longitudes (LATLONG), decimal degrees, Universal Transverse Mercator (UTM) among others. When the dots are plotted, different patterns depending on the nature of the data are portrayed. Some are scattered or random in nature, while others are clustered in specific parts of the area.

Point pattern are always classified into three (Luc, 2016, Biologuforfun, 2017):

(i) Clustered Point Pattern**:** In clustered point pattern, the density of the points appears to vary significantly from one part of the study area to another. This type of points clusters around one or numerous locations which suggest that some factors are responsible for the distribution.

(ii) Random Point Pattern: The spatial patterns in random point pattern appear random or scattered in nature with no dominant trend towards either clustering or dispersion. A random point pattern logically suggests no specific factor or factors are responsible for such pattern.

(iii) Regular Point Pattern**:** If the set of points in dispersed point pattern appears uniformly distributed across an area, it suggests that a systematic spatial process produced the locational pattern. For instance, it may be as a result the plan by the government or community. A good example of such pattern is a large housing estate where the houses are uniformly located.

In most cases, point pattern will not provide a totally clear indication that the pattern is clustered, dispersed or random, but rather shows a combination of these arrangements with tendencies from random towards either clustered or dispersed (Thorsten and Kirk 2013, Keron 2015). For instance, if the points of occurrence of accidents on a particular road are recorded and plotted, the output dots will definitely belong or tends towards any of the three pattern categories, that is, regular, random or clustered. If the points pattern are scattered, it means that such occurrences happen by chance and that no specific factor is responsible, hence no need for research into any possible factor(s) responsible for the pattern. However, assuming the pattern is clustered, it suggests that something or some factors are responsible for accidents on that part of the road, and therefore investigations of the causal factors becomes necessary.

One of the greatest challenges of researchers especially in the developing countries is the problem of non-availability or incomplete, inadequate and unreliable climatic data (Karthika, 2015, Tufa 2018). It is unfortunate that in most part of Nigeria for instance, climatic data are not available at all except in few places where institutions, agencies, parastatals among others exist and provide such data. In most cases, the data provided by these few places are unreliable especially in places where manual methods are used to record such data. Some of the data are either not recorded at all or recorded haphazardly resulting into incomplete or subject to errors or inconsistencies. Among the reasons for these problems are negligence on the parts of the recorder, faulty instruments, environmental problems such as floods and the recent insurgency and other social problems which may deny the recorder access to the stations as at when due. To overcome some of these problems, automatic whether stations are now available which reduces the problems of human interference and recording but not without its major problems of high cost which make most of the institutions unable to afford them. One of the most reliable sources of climatic data in Nigeria is that of the Nigerian Meteorological Agency (NIMET), but their data are expensive to be procured by ordinary researcher as the costs are too high. Moreover, according to Okechukwu (2017), the agency has very few stations from where they derive their data as confirmed by the Director-General/Chief Executive Officer, Nigerian Meteorological Agency, Prof. Abubakar Mashi on June 11, 2017 that:

> *Nigeria is a massive country with a total land mass of about 940,000sqkm and if we should go by the recommendation of the World Meteorological Organization that between 100 to 300sq.km you must ensure that there is at least one observatory, then it means that technically speaking we should have nothing less than 9,000 stations across the country…. on the number of stations, we have 54 only.*

The easiest and very reliable climatic data are those that are globally available and accessible on-line. There are several of its kind among which is the Diva-GIS that is used in this study. Diva-GIS has global climatic data on maximum, minimum and precipitation of every point on the globe from 1950 to 2000 and once the coordinates of a point is known, the climatic data of such places can be retrieved without any cost. As the records from 2000 to 2050 are being awaited, the existing data have been used by numerous authors worldwide (Olusina and Odimade 2012, Luis, Edmundo, Giorgio, Luis, Jael, et al 2015, Clement, Ezekiel and Zodanqi 2018), for climatic data modeling and analysis

Rainfall is a natural phenomenon, their intensities and durations vary from place to place and from region to region depending on the factors that are responsible for such rain. For instance, rainfall are said to be higher on mountainous areas or at the leeward of such mountains. The lower latitudes or regions around the coast are also said to receive more rainfall than locations which are far from the coast. Taraba state is located in a region with some parts along the River Benue, on the Mambilla Plateau and some other parts on the wide Benue floodplains. Therefore in this study, the spatial patterns of rainfall in the state was assessed so as to conclude whether or not the spatial pattern of rainfall in the state occurred by chance or is attributed to some factors using spatial autocorrelation statistics.

According to Mark (2017), spatial autocorrelation is simply looking at how well objects correlate with other nearby objects across a spatial area. Positive autocorrelation occurs when many similar values are located near each other, while negative correlation is common where very different results are found near each other. The importance of spatial autocorrelation is it helps to define how important spatial characteristics affect a given object in space and if there is a clear relationship (i.e., dependency) of objects with spatial properties. Strongly positive or negative results indicate that a clear spatial property is found in the object with a high correlation. If a significant non-random such as clustered pattern arrangement is identified in a point pattern, spatial auto correlation is said to exist. The clustered pattern exhibits positive spatial auto correlation with adjacent or nearby locations having similar values. The dispersed pattern has negative spatial auto correlation with nearby locations having similar values. Random point pattern have no spatial auto correlation (Murat, 2017; Mar, 2017).

Therefore, the aim of this study is to apply statistical applications for the assessment of spatial pattern and prediction of mean annual rainfall distributions in Taraba State. The specific objectives include:

(i) To map the spatial pattern of the mean annual rainfall distribution in Taraba State
(ii) To examine the randomness of the rainfall pattern using geostatistical techniques
(iii) To examine the factors responsible for the rainfall pattern in the State.
(iv) To predict mean annual rainfall distribution in the state using geostatistical technique.

The Study Area

Taraba State which was carved out from the former Gongola State on 27th, Aug. 1991 comprises the study area. The State is bounded in the west by Plateau, Nassarawa and Benue States and on the east and south by the Cameroon, and in the north by Bauchi and Gombe States (Figure 1). Taraba State has a population of 2,294,800 (NPC 2007), while the land area of the State is 59130.79km^2 (Daura and Ikusemoran, 2015), which means that the State has a population density of 39 persons per square kilometer. The combinations of the Benue and the numerous tributaries (Rivers Shemanker, Wase, Donga and Taraba) created large floodplains within the State. The state is also endowed with highlands and mountains, such as Shebsi, Wonka, Fali, Chappal Hendu, Chappal Wade, Gotel and Wanga Mountains (Daura and Ikusemoran 2015).

Taraba state has sixteen (16) Local Government Areas (LGAs). It is the second largest State in Nigeria in terms of area landmass after Borno State. The State extends from about latitudes 6˚ 30' to 9˚40'N and longitudes 9˚ 00' to 11˚00E'. This means that the state has more than three (3) degrees latitudinal and two (2) degrees longitudinal extents (Figure 1). Taraba state has a tropical wet and dry climate. Dry season lasts for a minimum of five months (November to March) while the wet season spans from April to October. Mean annual rainfall ranges from 800mm in the northern part of the state to over 2000mm in the southern part. Generally, mean annual rainfall is less than 1000mm above latitude 9° comprising Lau and Karim Lamido areas (Adebayo and Orunoye, 2013). In the study of Agbidye, Emmanuel and Ogbuche (2015), it was reported that the temperature of Taraba State ranges between 33°C and 37C; but could rise to 40˚C in the driest month (March). They also described the vegetation of Taraba state as comprising three types of vegetation zones namely: the Guinea Savannah, which is marked mainly by forest and tall grasses and found in the southern part of the state like Wukari, Takum and Dunga, the sub-sudan type characterized by short grasses is found in Jalingo, Lau, and Ardo-kola, interspersed with short trees, while the semi-temperate zone is found in the central part of the state.

Adebayo and Oronye (2013) reported that Taraba State is a multi-ethnic state and is home to about eighty ethnic groups speaking approximately seventy-three languages, making it one of the most diverse in Nigeria. Among its major ethnic groups are the Jukun, Mambila, Fulani, Jango, Kuteb and

Mumuye. The major occupation of the people of Taraba State is agriculture. Cash crops produced in the state include coffee, tea, groundnuts and cotton. In addition, cattle, sheep and goats are reared in large numbers, especially on the Manbilla Plateau, and along the Benue and Taraba valleys. Communities living on the banks of River Benue, River Taraba, River Donga and Ibi engage in fishing all year round. As calculated in this paper, Gashaka Gumti National Park covers a total land area of about 3846.39km^2 constituting 6.59% of Taraba State. The park covers a large portion of Gashaka LGA extending a little into Sardauna LGA.

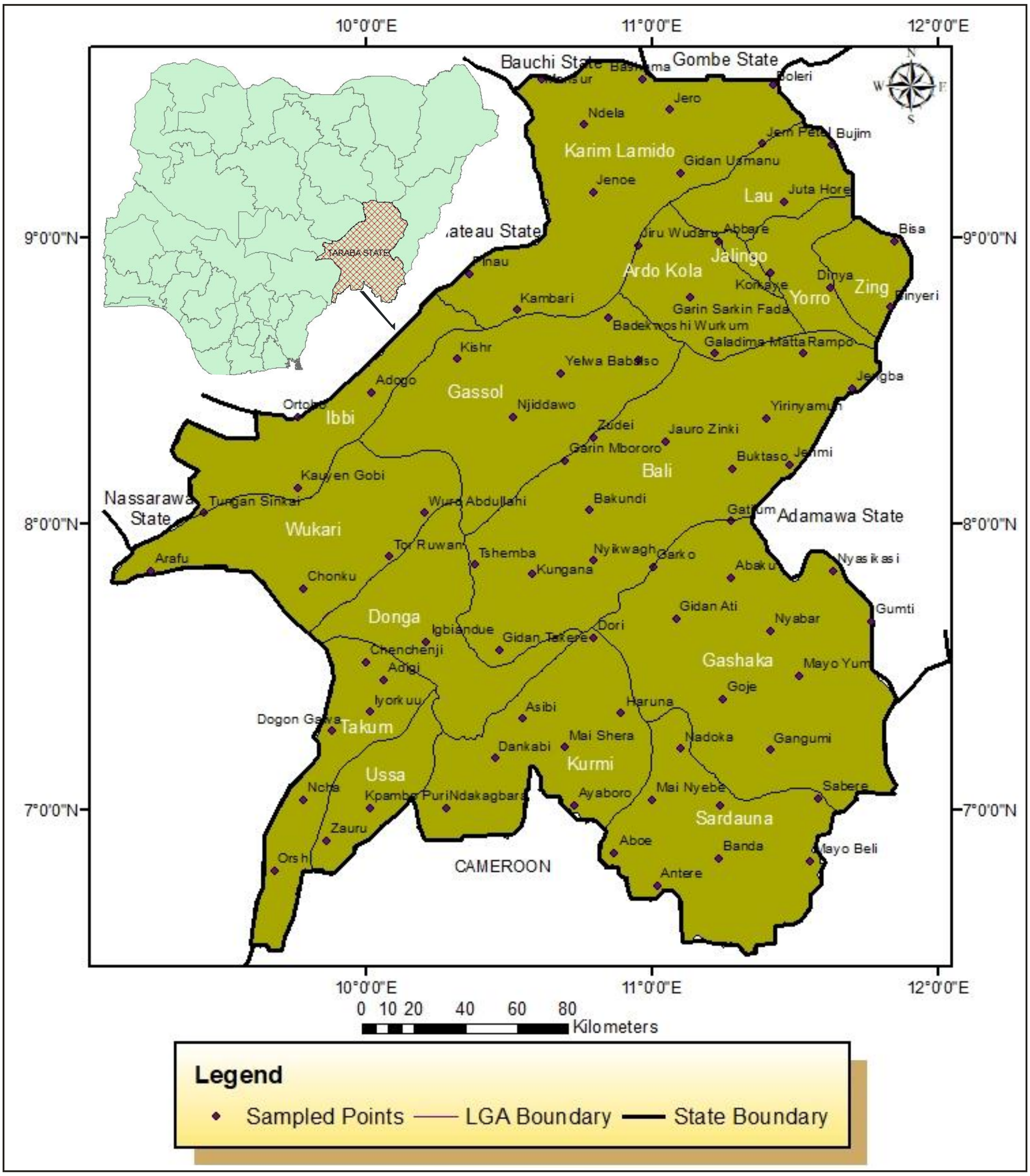

Figure 1. The Study Area

Materials and Methods

The following materials were used for this study: computer, statistical packages such as SPSS, geostatistical package such as spatial autocorrelation, Geographic Information System (GIS) software especially ArcGIS 10.3.

Required Data

Table 1 shows the types, sources and the importance of data that were in for this study

Table 1: Types, sources and importance of data

Data Required	Sources	Importance
Political Map of Taraba State		To serve as base map from which state and LGA boundaries will be digitized
Digital Elevation Models (DEM) of Taraba State	ASTERGDEM v.2 (2011) obtained online: earthexplorer.usgs.gov	For generating the topography of the State which is considered more reliable than those generated from points
Coordinates of all the 75 sampled settlements	Use of Global Positioning System (GPS), Google Earth Pro and World Atlas from the Microsoft Encarta Premium	To generate the latitudes, longitudes and elevation of all the settlements
Mean Annual Rainfall Data of each of the sampled settlements	Roberts, Luigi and Prem (2014) Diva_GIS v.7.5 climate data (1950-2000)	To obtain the mean annual rainfall of the sampled settlements for a period of ..
In-Situ Mean Annual Rainfall between 1991 and 2017 of six sampled settlements spread across the state	Taraba State Agricultural Development Project (TSADP)	For ground-truthing and confirmation of the accuracy of the on-line rainfall data

Mapping and Generation of Rainfall Pattern

Geographical Information System (GIS) was used to generate and calculate rainfall spatial patterns of the state. The steps include:

(i) The base map of the state was obtained, georeferenced and digitized in ArcGIS 10.3 environment.

(ii) The coordinates of the actual locations of each of the eighty (80) sampled settlements in the state were acquired using GPS or obtained from World Atlas (2009), Google Earth Pro, existing data among others.

(iii) All the coordinates were converted into decimal degrees and imputed into excel, all other attributes such as names of each settlement and the amount of mean annual rainfall are added as fields in the excel environment and then converted into text file. the text file was exported to the digitized map in ArcGIS software

(iv) The exported points automatically appear on their exact positions with their attribute information such as names of settlements and their amount of annual rainfall

(v) The Kriging module of the ArcGIS software was used to interpolate the points (using the rainfall data) in order to generate the spatial pattern of rainfall within the State.

Generation of Autocorrelation Analysis

The Global Morgan's 1 in the Spatial Autocorrelation module of the ArcGIS from the Geostatistical wizard of the Geostatistical Analyst was used to generate the autocorrelation of rainfall in the State. The results show the index, z-scores and p-values which are used for the interpretation of the rainfall's spatial pattern. The Spatial Autocorrelation tool evaluates whether the pattern expressed is clustered, dispersed, or random. When the z-score or p-value indicates statistical significance, a positive Moran's I index value indicates tendency toward clustering while a negative Moran's I index value indicates tendency toward dispersion. When the p-value is very small, it means it is very unlikely that the observed spatial pattern is as a result of random processes, hence, the null hypothesis can be rejected.The Global Moran's I tool calculates a z-score and p-value to indicate whether or not one can reject the null hypothesis. The z-scores and p-values obtained from the pattern analysis helps us to know whether or not the null hypothesis can be rejected. Generally, clustered spatial patterns are evidence of some factors or processes at work or in what makes such distribution to be clustered.

Hypothesis

In this work, the hypotheses are stated as:

H_o: Mean annual rainfall is randomly distributed across Taraba State.

H_1: Mean annual rainfall is not randomly distributed across Taraba State

Prediction of Rainfall Distribution

Like the generation of auto correlation, rainfall prediction was also generated using the Geostatistical wizard of the Geostatistical Analyst. The prediction of the ordinary Kriging module of the ArcGIS was used to predict rainfall values for each of the 80 sampled settlements. The results showed all the observed rainfall values as well as their corresponding predicted values for each of the settlements.

Data Validation

To validate the data (since they were obtained online), in-situ data of mean annual rainfall from 1991 to 2017 of six settlements within the state were obtained from Taraba State Agricultural Development Project as presented in Table 2. The values of rainfall data in the settlements were correlated to those obtained online using SPSS statistical package in order to observe how strong or weak the relationships were. The results as presented in Table 3 revealed that there is a very strong positive relationship of 0.99, and no significant difference at 0.001

Table 2: Observed and On-line Mean Annual rainfall of some settlements in Taraba Sate

Towns	Observed Rainfall	On-line Rainfall
Gashaka	1544	1484
Gassol	1084	1095
Gembu	1804	1764
Ibbi	1072	1093
Wukari	1260	1234
Zing	1155	1095

Table 3: Correlation analysis between Mean Annual rainfall of some settlements in Taraba Sate

		In_Situ	Online
In_Situ	Pearson Correlation	1	.995**
	Sig. (2-tailed)		.000
	N	6	6
Online	Pearson Correlation	.995**	1
	Sig. (2-tailed)	.000	
	N	6	6

**. Correlation is significant at the 0.01 level (2-tailed).

Results and Discussion

Rainfall Pattern in Taraba State

The rainfall pattern of Taraba state using the mean annual rainfall obtained online is shown in Figure 2. In Figure 2, the amount of rainfall is highest (ranging from 1624 to 2004mm) in the southern part of the state comprising main parts of Sardauna LGA as well as the south western region of Kurmi LGA. The southern parts of Ussa and Takum LGA also fall within the region. Notable towns and villages within this zone among others include; Gembu, Mayo Beli, Banda, Antere, Aboe and Rorel Borle all in Sardauna LGA. Ndakagbare in Kurmi LGA, Zauru, Kwamba (Ussa LGA) and Ncha in Takum LGA. Mean annual rainfall is least in the northern parts covering the entire Karim Lamido, Jalingo and Lau LGAs and most parts of Ibbi and Ardo Kola LGAs. The southern parts of Gassol, Yorro and Zing LGAs also receive least rainfall which ranges from 946 to 1112mm. Among the several towns and villages within the zone are: Gassol, Lau, Zing, Ardo Kola and Ibbi.

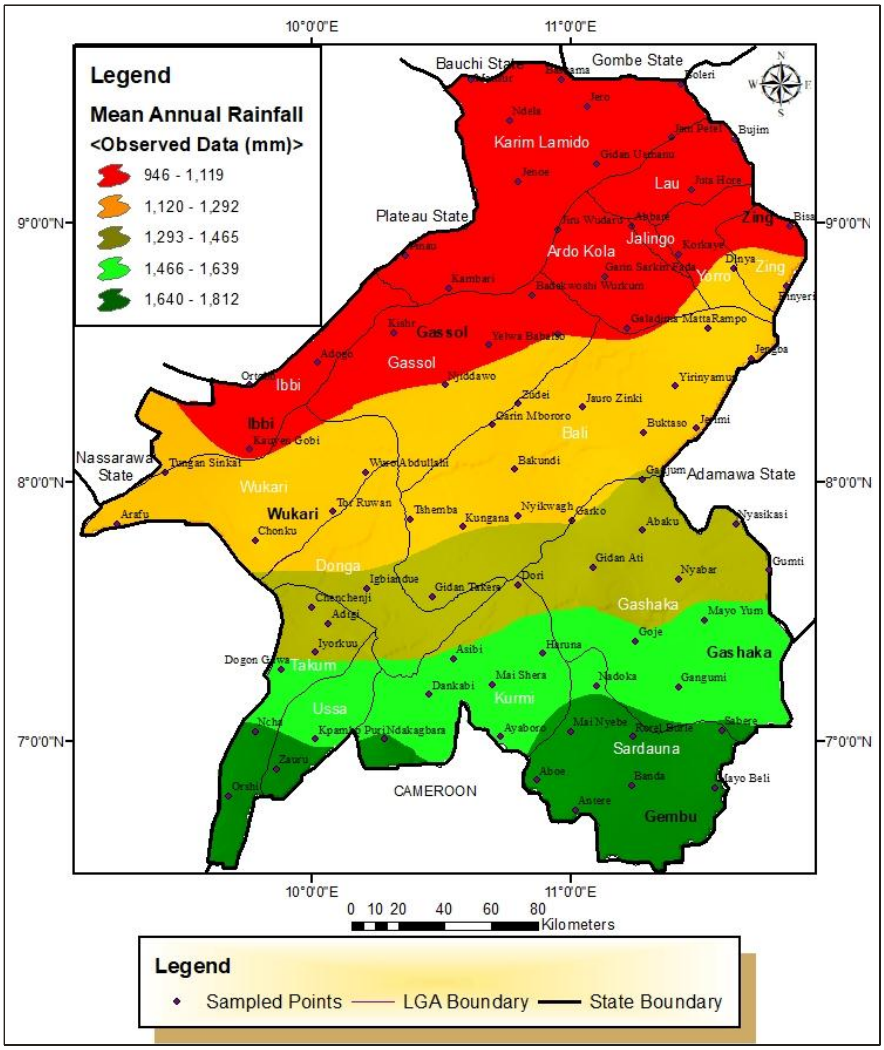

Figure 2: Mean Annual rainfall in Taraba State

The rainfall pattern as revealed in Figure 2 is very similar to some previous description of the rainfall pattern in the State. For instance, Adebayo and Orunoye (2013), reported that the mean annual rainfall of Taraba State ranges from 800mm in the northern part of the state to over 2000mm in the southern part and that generally, mean annual rainfall is less than 1000mm above latitude 9° comprising Lau and Karim Lamido areas. In the same work, mean annual rainfall of Lau, Gassol and Gembu which was obtained from Upper-Benue River Basin Development Authority from 1977 to 2011: a period of thirty five (35) years revealed 866mm, 957.7mm and 1807mm respectively.

While the data on Gembu and Gassol fits perfectly into that in Figure 2, that of Lau was a bit different. The mean annual rainfall of the six towns (Gashaka, Gassol, Gembu, Ibbi, Wukari and Gassol obtained from TSADP, were interpolated on the generated mean annual rainfall maps in Figures 4and 5 and all the six towns fall in their appropriate classe ranges on the map

Moreover, the vegetation of the state which is a function of rainfall intensity also aligns with the rainfall pattern of the state. For instance, Agbidye *et al.* (2015), reported that the vegetation of Taraba state comprises three types of vegetation zones: the Guinea Savannah, which is marked mainly by forest and tall grasses and found in the southern part of the state like Wukari, Takum and Donga, the sub-Sudan type characterized by short grasses is found in Jalingo, Lau, and Ardo-kola, interspersed with short trees. The Guinea savannah region is the area with heavy rainfall, while the sub-Sudan is the low rainfall areas (Figure 2).

Autocorrelation Analysis

Once the rainfall pattern of the state has been mapped, the next task was to found out the randomness of the pattern, that is, whether the pattern occurred by chance or tends towards clustering or uniformity which suggests that some factors or processes are responsible for such pattern. The result of the autocorrelation is shown in Figure 3.

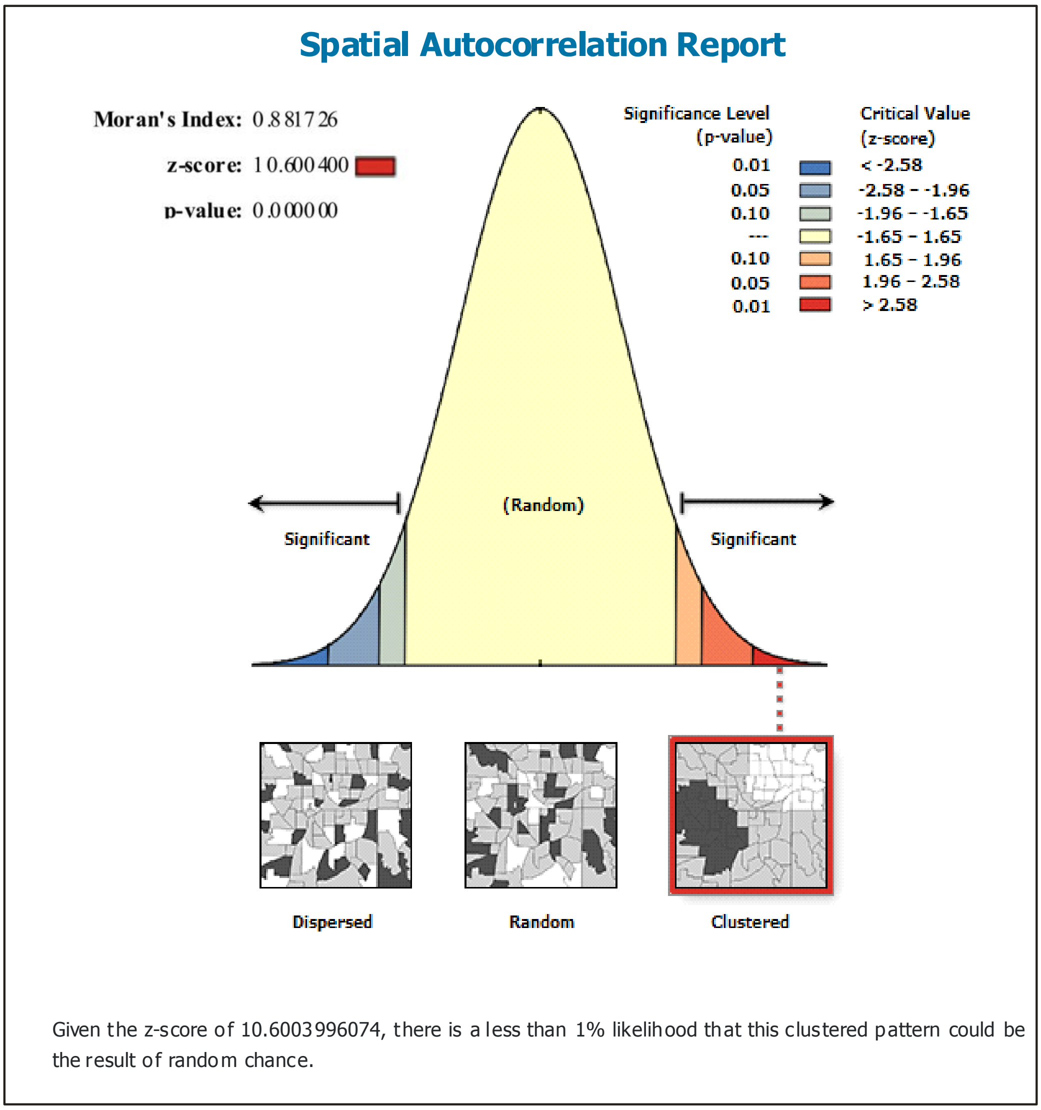

Figure 3: Autocorrelation analysis of the mean annual rainfall pattern in Taraba State

(i) The Moran's index value is 0.88, (Figure 3) which indicates positive tendency towards clustering, and which means that the pattern is not random, that is, some factors are responsible for the pattern

(ii) The z-score of the correlation is 10.60, (Figure 3) which was interpreted by the software that there is less than 1% likelihood that this clustered pattern could be the result of random chance, hence, also suggest that some processes lead to such pattern

(iii) The p-value of 0.001 is very small; it means it is very unlikely that the observed spatial pattern is as a result of random processes, hence, the null hypothesis was rejected, while accepting the alternative hypothesis that mean annual rainfall is not randomly distributed across Taraba State.

All the above are proves that the pattern of rainfall distribution in the state is not randomly distributed, and that some factors make the distribution to tend towards clustering.

Factors Responsible for Pattern of Rainfall Distribution in Taraba State

The rainfall pattern map in Figure 3 shows that two principal factors are responsible for the pattern of rainfall distribution in the State: Relief (altitudes) and latitudes. The relief of Taraba Sate is shown in Figure 4.

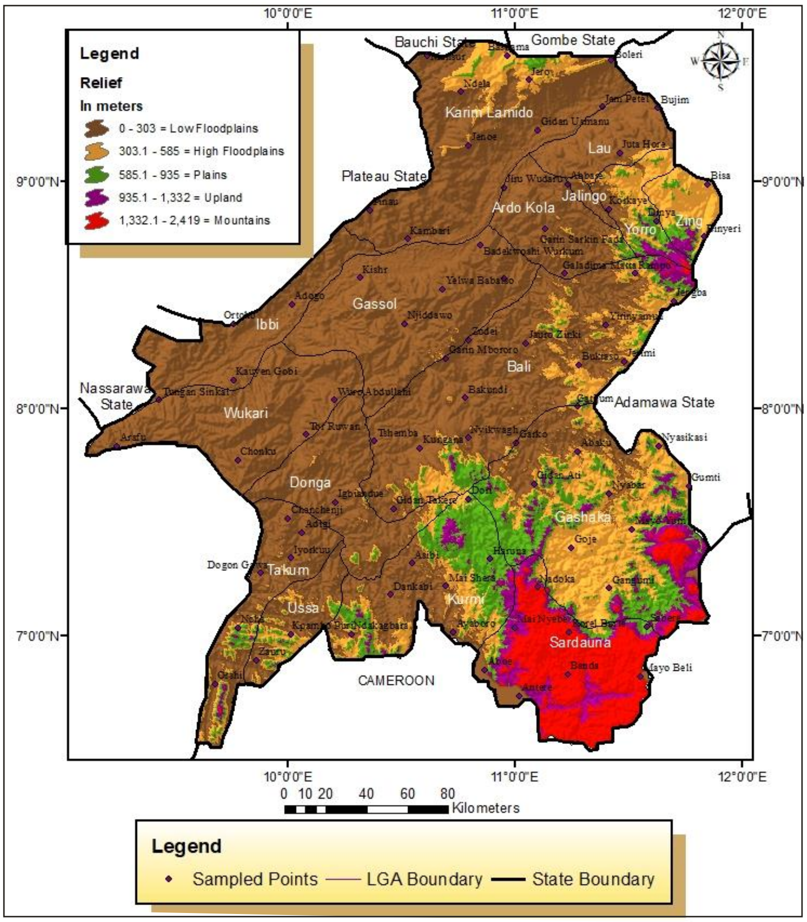

Figure 4: Relief of Taraba State

The highest mountain ranges in the state which are mainly found in the Mambilla plateau as well as the Nigeria-Cameroon border in Gashaka LGA has elevation ranging from 1332m to 2419m above the sea level. The low floodplain of the Benue River has the least elevation which ranges from 0-303m above the sea level. It is therefore expected that there should be different climatic zones based on wide difference in the altitudes in the state (Figure 4). Looking at the pattern of rainfall distribution in Figure 2, it was revealed that rainfall is higher in the higher altitudes comprising Sardauna, Gashaka, Kurmi, Ussa and Takum LGAs (Figures 2 and 4 compared). Rainfall in low altitudes, especially in the northern region of the state is far lower than the high altitudes. This finding has long been established by numerous studies. For instance, Udo (1978) reported that both climate and vegetation of various parts of the eastern borderline (of Nigeria) are influenced by latitudes and altitudes. Another major altitudinal effect is the influence of orographic rainfall where the windward side of highlands usually records more rainfall than the leeward sides. Figure 4 shows that Kurmi, Ussa and Takum LGAs are located in the windward side of the Mambilla plateau which increases their amount of rainfall (Figure 2). This also confirms the finding of Adebayo and Orunoye (2013) that annual rainfall decreases with increasing latitude, and that altitude contributes significantly to rainfall distribution in Taraba state because of orographic factor.

The influence of latitudes on rainfall pattern is also revealed in Figure 2. Rainfall is higher in the lower latitudes in the southern part of the state than the higher latitudes of the north. Moreover, despite the fact that some parts of Karim Lamido, Yorro and Zing LGAs are highlands, rainfall in these areas are low because of the influence of the latitudes. The State has a relatively high latitudinal extent of about 345kms by crow flies. For this reason, there is every tendency of variance in rainfall from the north to the southern part of the state (Walkley 2018).

Prediction of Rainfall Distribution

The Geostatistical wizard of the Geostatistical Analyst was used to predict the mean annual rainfall of each of the eighty (80) sampled points in the State. The results are presented in a tabular form as shown in Plate 1.

The first column shows the serial assigned numbers to all the sampled points, the observed mean annual rainfall and their corresponding predicted ones are shown in column two and three respectively. The inset graph shows the linearity of the points around the straight line suggesting a good relationship. Correlation analysis was run on the values of the observed and the predicted mean annual rainfall in the state and the result as presented in Table 4 shows that there exist a very high positive correlation of 0.99 and a very low significant value of 0.001 which means that there is no significant difference between the observed and the predicted mean annual rainfall in the State.

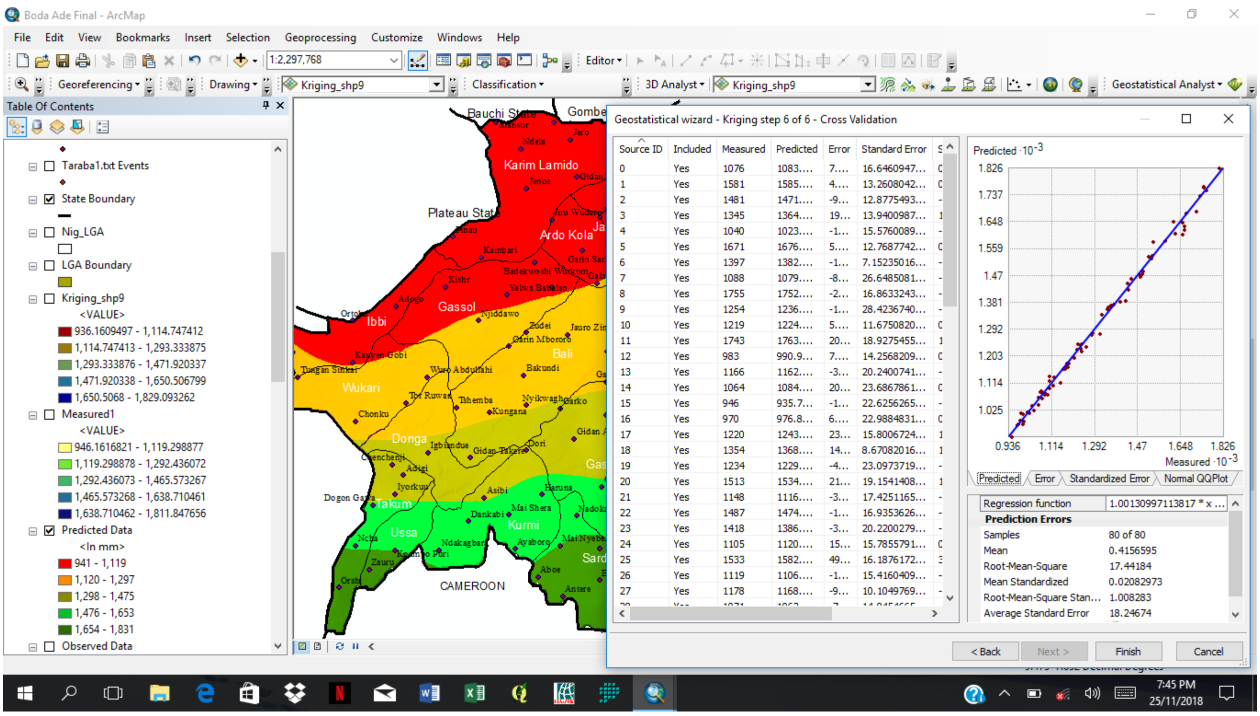

Plate 1: Result of the predicted mean annual rainfall

Table 4: Correlation between observed and predicted mean annual rainfall

Correlations

		Observed	Predicted
Observed	Pearson Correlation	1	.997**
	Sig. (2-tailed)		.000
	N	80	80
Predicted	Pearson Correlation	.997**	1
	Sig. (2-tailed)	.000	
	N	80	80

The acquired observed and predicted values in Plate 1 were used to generate the mean annual rainfall maps as presented in Figures 5 and 6. The maps revealed that the spatial patterns of the observed and the predicted maps are very close. The only observable difference of the mean annual rainfall pattern between the observed and predicted maps was found in the south western part of Kurmi LGA where observed data shows more rainfall than the predicted. It is therefore concluded that the spatial autocorrelation analyst is very effective for predicting rainfall distribution.

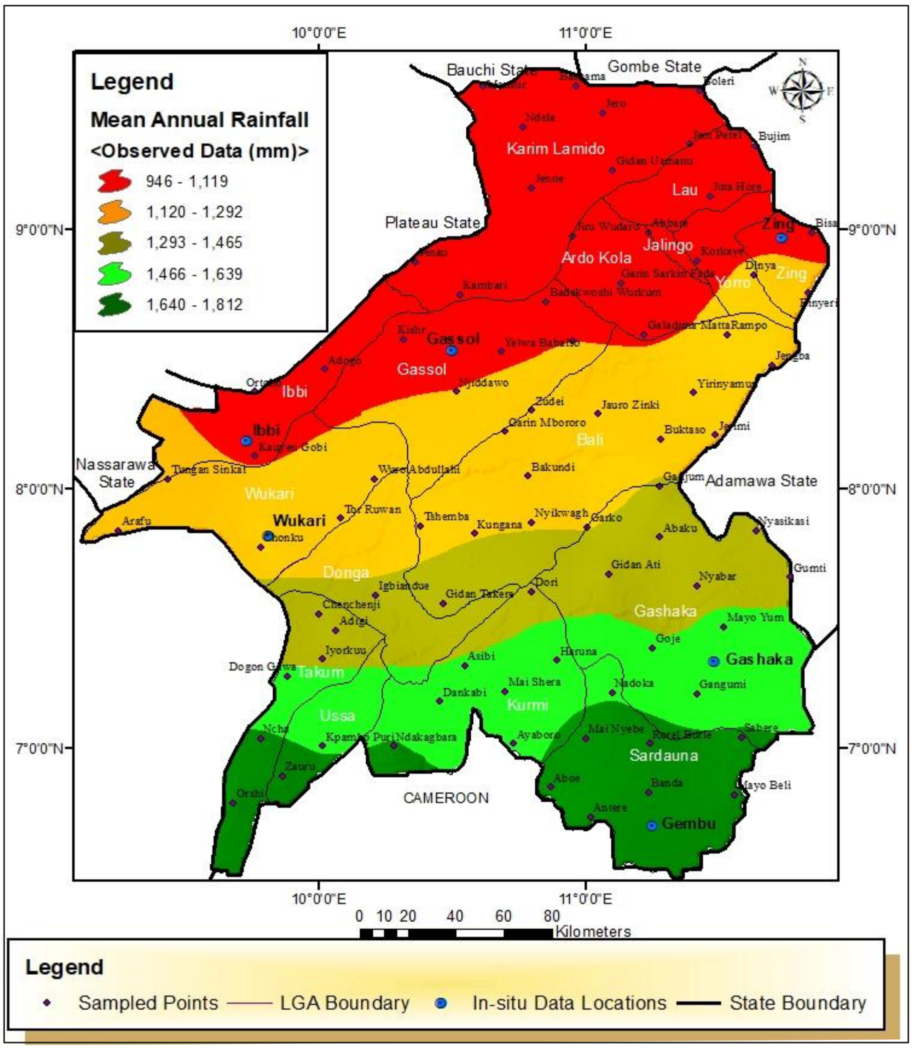

Figure 5: Mean Annual Rainfall Distribution in Taraba State using observed data

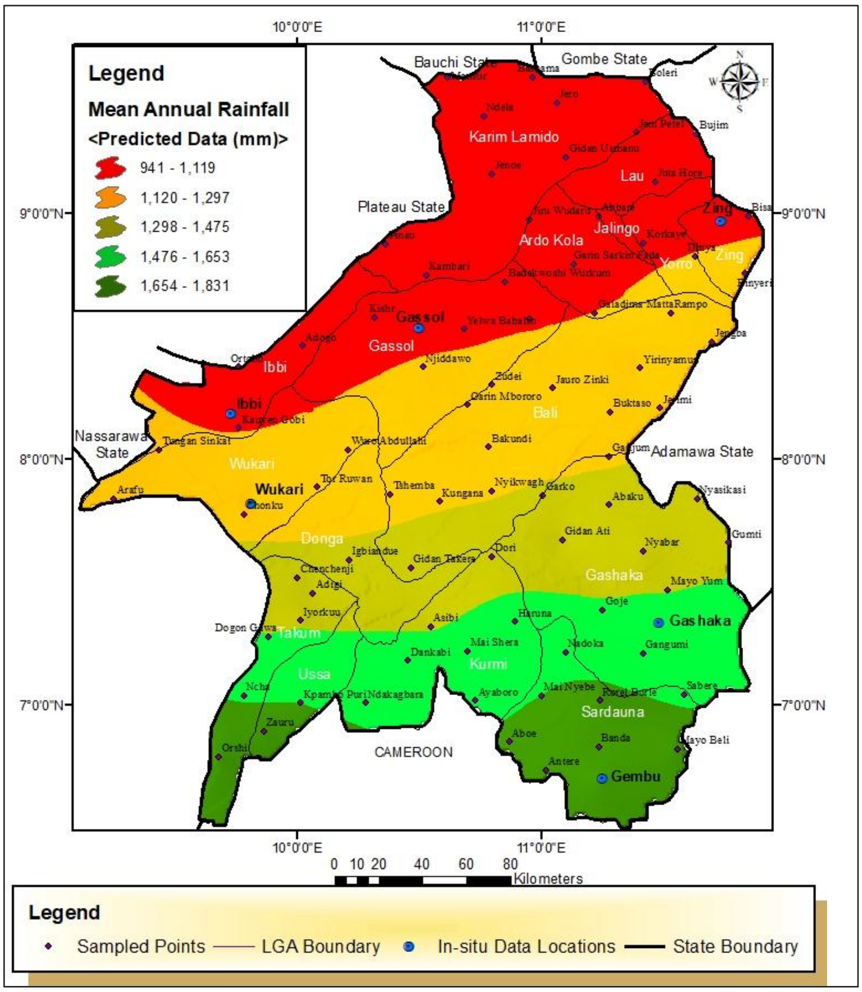

Figure 6: Mean Annual Rainfall Distribution in Taraba State using predicted data

Conclusion

The use of spatial autocorrelation statistics for analysis, mapping and prediction of mean annual rainfall distribution in Taraba State has been demonstrated in this work. The reliability of online climatic data especially the Diva-GIS has also been carried out. The available online climatic data may not serve as substitute to in-situ data but has proven to have the capability of complementing or to verify the authenticity of in-situ climatic data especially when large area are taken into consideration. If these sources of climatic data for research and other purposes are imbibed, it will help a long way in solving the problem of non-availability, incomplete and the unreliable data that are characterized by in-situ data. While Diva-GIS has two major advantages: that is, the climatic data of any point can be obtained and the data can also be retrieved without connection to network services, the limitations of this source of online data are: only minimum and maximum temperature as well as rainfall data are available. Moreover, only monthly and annual data are presented, that is, daily data are not available. The results in this study revealed that Diva-GIS climatic data can be used to compliment or as substitute areas without in-situ data as their correlation has been proved in this study to be very high (though depending on the authenticity of the in-situ data). The spatial pattern and their possible causal factors were also proved to be achievable using spatial autocorrelation analysis as the results in this study show that mean annual rainfall in the state tends towards clustering suggesting that they did not occur by chance. Relief (altitudes) and latitudes were found to be the main factors responsible for the spatial pattern of mean annual rainfall distribution in the State. Finally, the predicted values obtained by the correlation analysis was also found to be very reliable as reflected from the high positive correlation values of 0.99, the non significance difference between the two data and the similarity between the maps generated by each of the two variables. Further studies are suggested on the comparative analysis of the various on-line climatic data and their reliability if compared to in-situ data.

Recommendations

(i) It is high time on-line climatic data are appreciated and encouraged to be used for research and other related activities as the competition will ginger those in charge of in-situ climatic data to make their data to be more reliable and cheaper to obtain

(ii) The use of spatial autocorrelation analysis of the GIS software should also be encouraged in research as it combines both statistical and spatial functions as revealed in this study

(iii) Prediction of rainfall distribution has been found in this study to be achievable and reliable. Therefore, meteorologists and climate change analyst among others should make use of this techniques especially since the generated maps can easily be visually assessed for comparisons

(iv) If Taraba State Government and all other stakeholders imbibe this technique, most of the climatic data and maps that are not available either as data or information for further studies will not only be made available but highly accessible with minimal cost.

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