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Relative Comparison of Resultant Effects of Global Warming on Variability of Rainfall and Water Resources in Saki and Osogbo, Western Nigeria.

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Abstract

In recent times, there has been mounting concern by individual and international bodies over global warming.The rapid rate at which Carbon-monoxide (Co) and other anthropogenic gases are generated have been projected to create major global environmental changes, including sea level rises.It is now a common knowledge that climate and weather are non-stationary stochastic processes, consequently climatic and hydrological variables have continued to exhibit much variability and change. Moreover, since water resources in general and river charges in particular, are of a stochastic nature, low water (drought) and high water (flood) episodes of different duration and depths are unavoidable now and in future under all scenarios of climate.This study is therefore concerned about the dig-dipping into the issues of rainfall variability as caused by the global warming effects. Secondary data were used in this research; in which surface temperature over time were collected to represent global warming effects and also rainfall data over time were collected from a related work in the study area; Saki and Osogbo. Analyses were carried out using inferential statistics such as: Difference Means test would be used to determine the wetter in the areas and Coefficient of Variation would determine the variability of the rainfall in the areas. Correlation Coefficient was used to test whether rainfall variability is significant in the areas and test of randomness was used to determine the degree of occurrence of rainfall in both areas and comparisons were made between the two areas.Conclusion; This study concluded that effect of global warming on rainfall was much more significant in Osogbo than Saki, but both are humid area, as the variability of rainfall there is very low. It was affirmed that water resources in Osogbo is higher both in quantity and quality than that of Saki.

Keyword: Global-warming; Rainfall-Variability; Water-resources; Anthropogenic.

Introduction

Climate has major influence on human activities. The climate of Nigeria has been a source of concern especially over the past five decades (Udoeka,1998). It has been with so much variability that some awareness on climate variability, as well as implications on socio-economic life including water resources in the country had been generated.

The characteristics of variability and fluctuation of climate in the country has thus been one of the most engaging subjects of debatein the last few decades. Floods, drought, soil erosion, and such other consequences of climatic variability in the country; are of disturbing concern among the governments and have led to the issue of environmental sustainability of and renewable of resources. In south western Nigeria the consequence of recent hydro-climatic variations and climate change have generated a lot of concern among the people and government in relation to water resources, agriculture and environmental management (Ojo 1987, Oyebande 1992, and Udoeka&Ikoi 1998). Rainfall is the main source of water supply and ground water discharge in Nigeria hence detail knowledge of its spatial, temporal and seasonal variation and annual distribution are very essential in water balance determination.

This study is intended to investigate how global warming have affected rainfall variability in term of spatial temporal and seasonal distribution and in turn influenced the availability of water resources to people or the degree at which people were able to access water.

The concept of climatic change as being used nowadays refers to global warming which had been observed over the past centuries, particularly since the period of industrial revolution (Olayanju 1990). It has been observed that global temperature was increasing due to human activities. According to climate models, a doubling of carbondioxide concentrations in the atmosphere is expected to raise the atmosphere's average temperature by 1.5 to 4.5^0C by the year 2050 (World Meteorological Organization, 1999).

Change in temperature and the wind would clearly have profound effects on water cycle. It is likely that precipitation would increase in some areas and decline in others. Even in areas where it increases, higher evaporation may lead to reduce water percolation and ground water availability. In areas where climate change cause reduced precipitation fresh water storage in the form of ground water will sink. On water resources, the quality and quantity of drinking water, water availability for irrigation, industrial use, electricity generation, and the health of fish may be significantly affected by changes in precipitation and increased evaporation. Increased rainfall may cause flooding, climate change would likely add stress to major river basins world-wide. For instance (Rasheed, 2007); reported that decadal trends in rainfall variability in Bangladesh, it has been observed that there are some atmospheric and climatic changes undergoing in the hydro-meteorological system in the (GBM) Gange-Brahamputra-Meghna river system. Changes in the length of monsoon are significant and increase in precipitation in monsoon generates additional volumes of run-off. Changes in the length of the monsoon are significant in increasing in precipitation and soil moisture deficits in some areas (especially in Ganges basin). Prolonged monsoon are also contributing to more frequent flooding and increasing the depth of inundation in many parts of Bangladesh (1998 flooding).

Observations revealed that significant deviation in monthly rainfall from one decade to the other occurred. In the Ganges basin the June rainfall in 1970-60 displayed positive anomaly(higher rainfall than average), which now shows negative anomaly (lower than average) in recent decade 2000-90. It has also been observed that, as compared to 1970-60, there is a considerable increase of (10-15%) in September rainfall of recent decade. All other monthly deviations are noticeable too. Rainfall in the Brahmaputra basin also displayed similar trends. The percentage of August-September as compared to 1970-60 significantly increased in the recent decade. Other months displayed considerable variation too.

Therefore, some atmospheric and climatic changes in hydro-meteorological system in the Ganges-Brahmputra basin system in Bangladesh are very distinct (rainfall anomaly in the Meghna basin is not reported here). These findings show that the variations of total seasonal rainfall, the timing of onset, peak, and recession are changing considerably at a dramatic pace. Factors related to climatic and human induced interferences are hypothesized to be responsible for these changes. If preventive measures are not taken immediately, these changes will have serious impact on the livelihood of the people in the lower riparian countries like Bangladesh.

The atmosphere and the ocean respond to unevenly distributed driving force of relative energy from the sun by storing, distributing and re-emitting in various ways. The dynamic and thermodynamic manifestations of these responses are instantaneous as weather, while over a long time span they are described as climate. Climate is simply defined by the intergovernmental Panel on Climate Change (IPCC,1990) as '' the average weather '' a description of climate over a period could typically cover anything from a few years to a few hundreds of years with average of appropriate components of those components. Each quantifiable parameter of weather such as rainfall varies with time, on all time scales resulting in variability of climate.

Global warming can be considered as an important aspect of climate change, global warming is the popular term used today to describe the increase in temperature of the earth's surface due to the emission of carbon-dioxide and other gases into the atmosphere. There is a concern that human activities have inadvertently changed the global climate.

The global warming of the earth-atmosphere system is brought about by the so-called Green House effect. The atmosphere and the ocean are powered by the solar radiation and are constantly in motion. As monsoons are manifestation of air in motion, so too are typical cyclones, trade winds, sea breezes, waves, swells and current manifestation of water in motion. There are systems in both the sea and atmosphere, the different scale of motion between them are linked through interactions. These interactions tend to be complex so that distinguishing between causes and effects is not always easy.

It is now a common knowledge that climate and weather are non-stationary stochastic process. Consequently, climatic and hydrological variables have continued to exhibit much variability and change. More over since water resources in general and river discharges in particular are of a stochastic nature, low water (drought) and high water (flood) episodes of different duration and depths are unavoidable now and in future, under all scenarios of climate.

Research and human experience have shown that the majority of water resources problems are located in the detail of distributions of hydrological and meteorological processes that decide on water shortage or water excess. However, the greatest threat to human activities including water resources availability would be floods and drought induced by climate change that are not only longer in magnitude but more frequent and persistent than in the past. Regrettably, until a few decades ago planning, decision making and management of water resources were based on the assumption that water availability or supply will be much like in the past. However recent concern by the scientists world- wide over the reality

of climate change, brings to focus the need for water managers to always consider the stochastic nature of climate variables in their estimate to assess the performance of water resources systems.

Climate affects water resources most directly in terms of precipitation (P). Temperature affects water availability through the process of evapotranspiration (E). The rate of change in water bodies, soils water and groundwater in an area, over a specified time interval, is equal to the rate of water supplied in the form of precipitation minus the combined outflow from that area in terms of run off (R) and evapotranspiration (E). The relationship is expressed by the hydrologic mass balance equation:

$P = E \pm R \pm \cong s$ ---------- (i) where $\cong S$ – the change in water storage,

$P - E = R \pm \cong S$ ---------- (ii)

P- Precipitation
E- Evaporation
R- Run off

Hydrology is concerned with terrestrial water generally whereas water resources relates to water availability for human exploration that is water at right time and place in the right quantity and quality. From equation (i) above, water resources is define thus; $P - E = R \pm \cong S$ ------- (ii)

Changes in climate, whether linked to anthropogenic force such as increasing concentration in greenhouse gases or through natural variability, will have impacts on water resources through changes in the hydrological regimes. In effect a consideration of climatic impacts on water resources involves:

Water treatment and domestic drinking water supply
Water supply for industry, irrigation and power production
Agricultural water use
Sewage, sewage treatment, effluent disposal and dilution
Land drainage and flood protection
Navigation
Fisheries, conservation and recreation

Objectives of the Study

i.To determine the wetness and variability of rainfall in the study areas.

ii. To examine the effect of increase in air temperature on occurrence of rainfall in the areas

iii. To examine the randomness of occurrence of the rainfall in the area.

Areas of Study

Osogbo is a capital city of Osun State in Nigeria. In addition the city of Osogbo is the seats the Headquarters of both Osogbo Local Government Area (situated at OkeBaale Area of the city) and Olorunda Local Government Area (situated at Igbonna Area of the city). It is some 88 kilometers by road Northeast of Ibadan. It is also 100 kilometers by road South of Ilorin and 115 kilometers Northwest of Akure;Osogbo shares boundary with Ikirun, Ilesa, Ede, Egbedore and Iragbiji and is easily accessible from any part of the state because of its central nature. It is about 48 km from Ife, 32 km from Ilesa, 46 km from Iwo, 48 km from Ikire and 46 km from Ila-Orangun; Osogbo is located between the Longitudes $4^0 32'$ and $4^0 56'$ East, also between Latitudes $7^0 46'$ and $7^0 76'$ North .The City boasted of a population of about 156,694 people, based on the 1991 Census; the postal codeof the area is 230.

Osogbo has a tropical climate. In winter there is much less rainfall in Osogbo than in summer. According to Köppen and Geiger climate is classified as Aw (Tropical wet and dry Savanna). The average annual temperature in Osogbo is 26.1 °C. The average annual rainfall is 1241 mm.

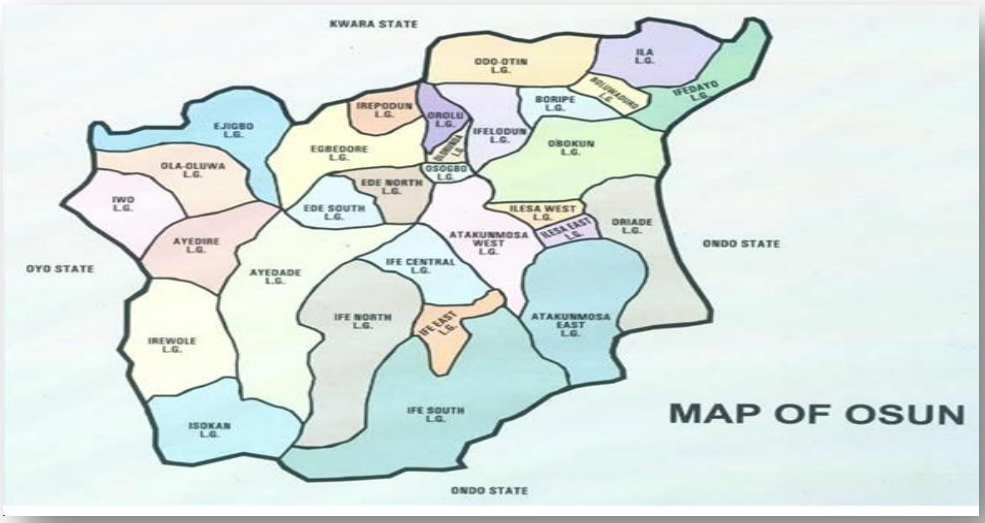

Fig 1: Map of Osun

Fig 2: Map of Osogbo

Source: Google Map; Map of Osogbo

Saki is a town situated in the northern part of Oyo State in western Nigeria. The terrain is hilly. The town lies near the source of the Ofiki River, the chief tributary of the Ogun River, about 40 miles (60 km) from the Benin border. Saki is located within Latitudes $8^0$40' and 8.667^0 North, also Longitudes $3^0$24' and 3.400^{0}East. It is referred to as the food basket of Oyo State because of its agricultural activities. It is the Headquarters of Saki West Local Government Authority. Saki is an exporter of cotton, swamp rice, teak, and tobacco. The flue curing of tobacco has been important in the area since 1940. Indigo is grown in the area for local dyeing, and the town is a centre of cotton weaving. Yams, cassava, corn (maize), sorghum, beans, shea nuts, and okra are grown for subsistence. Cattle raising is increasing in importance, and there is a government livestock station. A 1,600-foot (490-metre) inselberg rises above the surrounding savanna

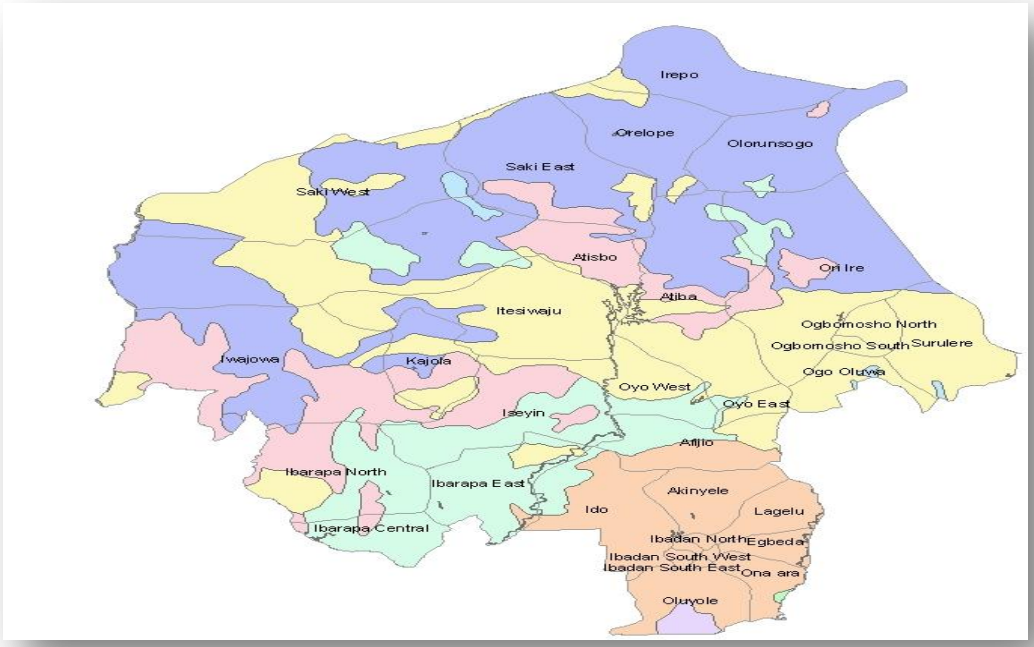

Fig 3: Map of Oyo States

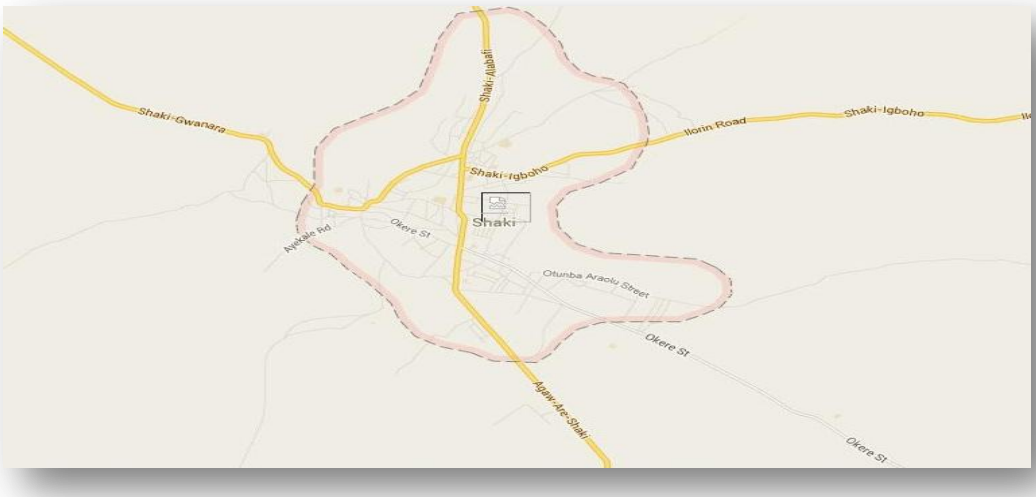

Fig 4: Map of Saki

Source: Google map; Map of Saki

Research Methodology

Data collection: Secondary data were used for this research. Climatic elements like rainfall and temperature were collected from 1984 – 1997 for bothOsogbo in Osun State and Saki in Oyo State respectively (Ayeni, B.R. 2002).

Table1: Mean Annual Rainfall &Temperature of Osogbo

Year	Rainfall (mm)	Temperature (^{0}C)
1984	92	30.8
1985	142	31.4
1986	104	30.5
1987	103	32.3
1988	118	30.7
1989	130	30.9
1990	106	30.9
1991	119	30.6
1992	118	30.5
1993	109	30.3
1994	100	31.2
1995	121	31.4
1996	119	31.4
1997	106	31.2

Source: Ayeni, 2002; Temp & Rain of Osogbo

Table 2: Mean Annual Rainfall &Temperature of Saki

Year	Rainfall (mm)	Temperature (^{0}C)
1984	145.0	30.4
1985	100.0	30.6
1986	82.0	30.2
1987	64.0	31.4
1988	115.0	30.8
1989	71.0	30.8
1990	76.0	31.0
1991	110.0	30.6
1992	93.0	30.7
1993	85.0	30.8
1994	99.0	31.0
1995	122.0	30.4
1996	86.0	31.2
1997	84.0	31.4

Source: Ayeni, 2002; Temp & Rain of Saki

Data Analyses

The data for thisresearch were analysed using: i. Difference of Means test; t= /a-b/ was used to determine which area is wetter and Coefficient of Variation was used to determine the variability of rainfall in the study areas,ii. Correlation Coefficient was used to examine the extent to which global warming influence rainfall variability with the consideration of temperature and rainfall of the areas concerned. Iii.A run test of randomness was also used to determine whether the occurrence of rainfall in the areas is random or not.

$\hat{U} = 2n_1n_2/n_1+n_2+1$

$\delta^2 = 2n_1n_2\,(2n_1n_2 - n_1-n_2)/(n_1+n_2)^2\,(n_1+n_2-1)$ and $Z = U - \hat{U}/\delta$

(where $\hat{U}$ is mean, n_1,and n_2 are the number of positive and negative runs respectively,δ^2 is the variance and U is the number of runs altogether and Z is the z-test).

Limitation of the Research

There are some short comings to the evidence of facts in this study: i. One of the limitations of this research was that considering more number of years say 25 or 20 years even up to date would have made the result more valid but secondary data for longer periodis very difficult to come-by, where it is accessible is very expensive.ii. Inadequate finance and time to recruit research assistants and secure the apparatus to collect data for the current year. iii. The duration at which the research was carried out was very short just within 3 months.

Discussion of Analyses and Finding

Determination of Rainfall Variability in the Area

The wetness and variability of rainfall in the two study areas were determined by the use of Difference of Means test and Coefficient of variation respectively. Difference of Means test; $t = {}^{/a-b/}/\sqrt{\delta a^2/na+\delta b^2/nb}$ where a and b are mean rainfall of Stations A (Osogbo) and B (Saki) respectively, δa and δb are the standard deviation of the rainfall for the two stations and na and nb are number of occurrence of the rainfall in the two stations, a=113 and b=95, δa= 13, δb=21, t=2.7272 (calculated) >table t under 0.05 values which means that station A Osogbo is wetter than station B. Coefficient of variation= mean/std*100, Station A =11.5% and Station B= 22.5% which means that annual rainfall is less variable in Station A than B.

Effect of increase in temperature on the occurrence of rainfall

Table 1 seems to show that rainfall and temperature same pattern with Table 2; however staggered level of conformitybetween temperature increase and rainfall occurrence were observed. For instance 31.4^0C, rainfall was 142mm, when temperature was 30.3, rainfall was 109mm even though the trend was not linear yet it still reflects that temperature has effect on rainfall.

Table 2 shows that variation in temperature and rainfall did not follow a definite trend. Also relationship between them could not be precisely defined. For instance when temperature was 30.4^0C, rainfall was 145mm when temperature was 31.4^0C, rainfall was 64mm, when temperature was 30.4^0C in 1985 again rainfall was 122mm, when temperature also rose to 31.4^0C in 1997 rainfall was 84mm, so there seemed to be less effect of temperature on rainfall in Saki during the period because the variables were not following similar pattern but there were still some reflection of uniformity within the period.

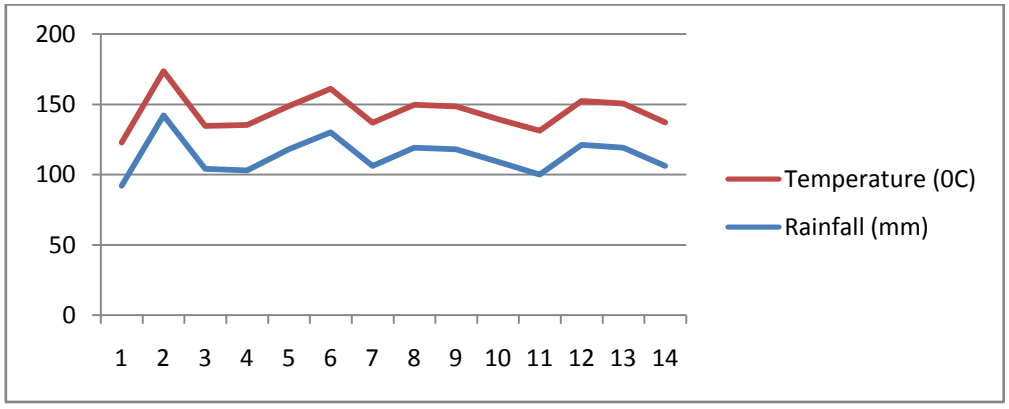

Fig 5: Mean Annual Temperature and Rainfall of Osogbo over 14 years (1984-1997

The graph in Fig5 clearly corroborates the fact that temperature influences rainfall in Osogbo as the lines show uniform pattern almost through the period. This means that temperature increase influence rainfall in the area.

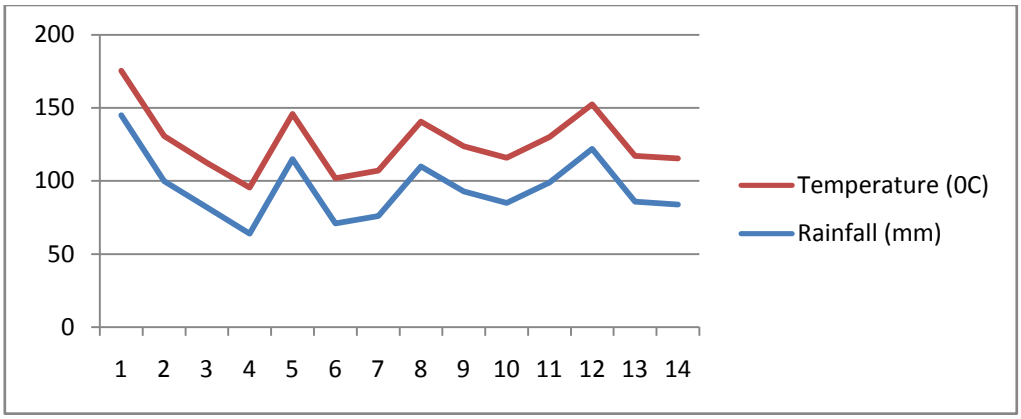

Fig 6: Mean Annual Temperature and Rainfall of Saki over 14 years (1984-1997)

The graph in Fig 6 depicts uniform trend between temperature and rainfall, even though it was not obvious in the Table 1, but that inherent uniformity was conspicuously displayed in the graph that temperature and rainfall were shown to actually follow the same pattern, so it is clear from the graph that temperature has its influence on occurrence of rainfall in Saki during this period.

Correlation Analysis of Temperature and Rainfall of Saki

Correlations

		Temperature_0C	Rainfall_mm
Temperature_0C	Pearson Correlation	1	-.549
	Sig. (2-tailed)		.052
	N	13	13
Rainfall_mm	Pearson Correlation	-.549	1
	Sig. (2-tailed)	.052	
	N	13	14

Correlation Analysis of Temperature and Rainfall of Osogbo

Correlations

		Temperature_0C	Rain
Temperature_0C	Pearson Correlation	1	.044
	Sig. (2-tailed)		.881
	N	14	14
Rain	Pearson Correlation	.044	1
	Sig. (2-tailed)	.881	
	N	14	14

Considering the Correlation analysis of Saki, the values of Pearson Correlation of Temperature and Rainfall show a negative relationship that is 1 and -0.549 which is an indicator that Temperature does not influence the occurrence of Rainfall. The Significant value at 2-tailed is 0.052 means that effect of Temperature over Rainfall is not significant, that it has the contribution of about 5% on the occurrence of Rainfall in the area. Occurrence of rainfall in this area could be influenced by a number of factors like topography or presence of large water body. Also, Considering the Correlation analysis of Osogbo, the values of Pearson Correlation of Temperature and Rainfall show a positive relationship that is 1 and 0.044 which is an indicator that Temperature increase influences the occurrence of rainfall. The Significant value at 2-tailed is 0.881 which means that the effect of Temperature over rainfall is very significant that is, Temperature has the contribution of about 88% on the occurrence of Rainfall in the area. Significanttemperature increase over the years is believed to be mostly influenced by anthropogenic factors in the area that is one of the reasonsthat could also contribute to rainfall in the urban areas. That is why temperature effect is less in Saki compare to Osogbo. The anthropogenic effect on temperature is global warming.

Randomness of occurrence of Rainfall in the Areas

In determining the Randomness of the occurrence of rainfall in these two study areas, runs test of randomness was used. The sampling distribution of this test has the following mean ($\hat{U}$) and variance (δ^2):$\hat{U} = 2n_1n_2/n_1+n_2+1$

$\delta^2 = 2n_1n_2\,(2n_1n_2 - n_1-n_2)/(n_1+n_2)^2\,(n_1+n_2-n_1-n_2)$ and $Z = U - \hat{U}/\delta$

Where n_1 is the number of positive runs and n_2 is the number of negative runs

After the computation of these runs the Z value for Saki=2.29 and Z value for Osogbo = 2.61. The interpretation of this runs says that the hypothesis that the series contain the number of runs expected in random sequences is rejected if the Z lies outside -1.96 and +1.96. Considering the Z for both Saki and Osogbo, both lies outside the stated range of stated values therefore it is concluded that annual rainfall series in both Saki and Osogboover the period of 1984-1997 were not random, which could simply be elaborated further that the occurrence of rainfall over the years were unevenly distributed.

Conclusion

The exploration and findings of this research discovered that there rainfall variability is very low in both areas of study which then revealed that they are humid area. This study also in its investigation made it clear that global warming has effect on rainfall in the areas but the effect is not significant in Saki but very significant in Osogbo and contributed positively to water availability as such made water availability in Osogbo to be far more than Saki which make Osogbo to have higher water in both quantity and quality. It was also established that rainfall was not random in both areas.

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