American Journal of Earth and Environmental Sciences
2019; 2(1): 9-14
http://www.aascit.org/journal/ees

AASCIT American Association for Science and Technology

Temporal Variations of Selected Climatic Parameters in Osogbo, Nigeria for the Period of four Decades (1975–2014)

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Citation
Salami Afeez Alabi. Temporal Variations of Selected Climatic Parameters in Osogbo, Nigeria for the Period of four Decades (1975–2014). *American Journal of Earth and Environmental Sciences*. Vol. 2, No. 1, 2019, pp. 9-14.

Received: January 22, 2018; **Accepted**: January 28, 2019; **Published**: May 5, 2019

Abstract: Drastic changes in society such as fast urbanization, globalization, economic changes and the need for more sustainable solutions for spatial problems lead to new urban forms. These have led to changes in the climatic parameters which are most noticeable effects of climate. To study the changes and/or patterns of climatic elements in the study area, the paper examined the temporal variations of some climatic parameters in Osogbo, Nigeria for a period of 40 years (1975-2014). The patterns of climatic parameters in the study area over the four decades were studied for any observable changes. The selected climatic data were collected from the archive of Nigerian Meteorological Agency (NIMET), Oshodi, Lagos and analysed using Mann-Kendall trend test. The results obtained revealed that there are positive trends in mean annual temperature (minimum and maximum) with Zs statistics ($\tau/\sigma\tau$) values 2.14 and 2.44 which are outside the limit of +/-1.96. The result also revealed that rainfall amount was statistically significant over the period of 1975-2014 with $\tau/\ \sigma\tau$ value 2.07 while relative humidity showed a negative trend and significant decrease with Zs statistics ($\tau/\sigma\tau$) value -1.48. These changes in temperatures can influence precipitation characteristics and indirectly affect the flux and storage of water in surface and subsurface reservoirs. This study noted that factors responsible for changes in rainfall include fluctuation in evapotranspiration, nature of the surface, air masses and human activities such as construction, felling of trees, and release of pollutants into the air. The study concludes that, if actions are not taken, changes in climatic parameters would pose challenges on socio-economic, health, agriculture, as well as human discomfort in the study area. Therefore, there should be a number of strategies for developing and integrating Green Infrastructure (GI) in human settlement.

Keywords: Climate, Mann-Kendall, Statistically Significant, Variability, Nigeria

1. Introduction

Climate can neither be experienced directly by our senses, nor measured indirectly by our instruments. Unlike the wind which we feel in our face or a raindrop that wets our hair, climate is a constructed idea". This idea seems to carry much "richer and longer tradition of meaning than is captured by the rather unimaginative convention that defines climate as 'being the average course or condition of the weather at a place usually over a period of years and exhibited by temperature, wind, velocity and precipitation' [10]. Although climate is, by definition, a statistical concept representing frequencies of surface variables, assessed over months to millions of years [26], people possess subjective, full of preconceptions and marked by feelings and experiences, perspectives on weather.

Climate is defined as the manifestation of a highly complex system consisting of five interacting components: the atmosphere (air), the hydrosphere (water), cryosphere (frozen part of the earth), the land surface, and the biosphere (part of the earth where life exists) [7]. Climate is defined as a synthesis or an amalgam of weather. It is the mean expectation of weather at a given period over a location or area [21]. It can also be regarded as the statistical abstraction of actual weather experienced in an area over a long period of time. This is why man sees climate as the average weather condition. This notion of climate is not strictly correct. Because, climate includes average weather conditions; the study of weather extremes and deviations from those average conditions; and the probability of occurrence or re-occurrence of a particular weather event [6].

The changeability of weather is a common phenomenon;

this is because weather variations occur frequently, often on a timescale of a few hours. Weather itself is the daily fluctuating state of the atmosphere around us, characterized by the temperature, wind, precipitation (rainfall), clouds and other weather elements [23]. Climate variability is a significant addition to the spectrum of environmental health hazards faced by mankind. Climate variability refers to shorter term (daily, seasonal, annual, inter-annual, several years) variations in climate, including the fluctuations associated with El Nino (dry) or La Nina (wet) events. It also refers to variations in the mean state of climate on all time and spatial scales more than that of individual weather events. Urbanization makes significant changes in the climatic parameters which have the potential to change the local climate in cities [28]. Population growth and urbanization have warming effect on climates.

Weather and climate "play a vital role in individuals' perceptions and interpretations of the world they live in" [2], as well as it plays a relevant role in the way people conducted their activities, practices and lives. Climate issues such as temperature, precipitation and winds, integrate individual and social beliefs, narratives and condition peoples' practices [27]. The profound influence of climate and weather over man's activities can be seen from his everyday life. Forces of nature have regulated to a very great extent the sort of food we eat, what we wear, how we live and our mental alertness, our physical characteristics and even our radical differences when closely examined have at least some relationship with climate.

Intergovernmental Panel on Climate Change stated that there is strong evidence that the global warming over the past 50 years has been essentially contributed by the increase in greenhouse concentration resulting to increase in temperature. Furthermore, the global temperature has increased by 0.74°C ± 0.18°C over the last 100 years (1905-2005), and precipitation is likely to increase by 0.2 to 0.3% per decade over tropical land areas in the 21st century [11]. Scientists have suggested that temperature changes will increase the average worldwide rainfall; but decrease rain in some areas as rainfall is tied to temperature changes on the earth. Studies have reported that the observed increasing temperature over several decades is associated with changes in some of the components of the hydrological cycle such as increasing atmospheric water vapour, increasing evaporation, changing precipitation patterns, intensity and extremes [11]. Warmer temperatures are very likely to produce more vigorous variability in climate such as increase evaporation, capacity of air to hold more moisture and thus heavier rainstorms.

In Nigeria, studies have shown that changes in the parameters of weather and climate could lead to negative effects such as loss of lives, famine, flood, and emergence of diseases to mention but a few [3, 18, 19]. In Osogbo, the changing patterns of temperature, relative humidity and rainfall are noticeable in the form of climatic variability, which results in unpredictable changes in the frequency and intensity of extreme weather events such as increased temperature, floods and erosion. The ultimate effect is an alteration of the normal climate of the area. The typical climate of the area is altered as a result of various processes such as global warming resulting from increasing levels of greenhouse gases in the atmosphere. The area is greatly affected by climate variation which has affected agricultural activities in the area, excessive rainfall has also led to incidences of flooding in the area.

Climate possesses, therefore, both cultural and biophysical interpretations [10]. It can be assessed using meteorological instruments and knowledge and it can be constructed through memories, experience and social imaginary. Climate and weather are vitally important in agriculture. For instance, some climatic effects such as frosts at critical times can wipe out crops, while dearth of rain will hinder pasture and crops from growing. This will in turn brings about food scarcity in the affected regions and may further have a debilitating impact on world economy. Therefore, a better understanding of climatic variability is essential in the agriculture of nowadays. This study examines the temporal variations of selected climatic elements in Osogbo, Nigeria.

2. The Study Area

Osogbo, Osun State Capital, is situated between Latitude $7°43^{l}$ and $7^{0}58^{l}$ north of the Equator and Longitude $4°31^{l}$ and $4°37^{l}$ east of the Greenwich Meridian (Figure 1). Osogbo and Olorunda Local Government Areas which constitute the study area (Osun State Capital) occupies an area of about $144km^2$ (55.6 sq. mi) with the total population of 288,455 [24, 15]. Osogbo shares boundary with Ede, Egbedore, Ilesa, Ikirun and Iragbiji and is easily accessible from any part of the State because of its central nature.

The climate of Osogbo city is considered to be Equatorial Savannah with dry winter (Aw) according to Koppen-Geiger climate classification [23]. It has a tropical dry and wet climate. The wet season starts in April and ends in early October, while dry season starts in November and ends in March. The mean annual rainfall is about 1,241 mm while the mean annual temperature is 26.1°C. The relative humidity for the area is between 77-86%. The variation in annual temperature is around 4.6°C. Recently, Osogbo came under drastic unpredictable climate change like other cities in Nigeria [23-24].

According to Salami, the vegetation of the area constitutes a transition between the rain forest and tropical equatorial in the South and Guinea and tropical Savannah in the North [23]. Most of the lowland tropical rain forest vegetation of the area had given way to secondary and derived savannah. Such secondary vegetation are due to fuel wood production, quarrying and traditional farming practices as well as other developmental projects like road constructions. Hence, the vegetation of the area is described as derived savannah characterized by gallery of forest along stream sides and tall grasses with scattered perennial trees over land [13].

Geologically, the study area lies largely within the Pre-cambrian Basement Complex of Southwestern Nigeria and belongs to the Pan African mobile belt east of West African Craton [13]. According to Rahaman, the major rock groups in

the study area are migmatite complex (including banded and auguen gneisses as well as pegmatites) and metasediments (consisting of schists quartzites and amphibiolites in places) [22]. The dominant basement rocks in Osogbo area are schist and migmatites, associated with quartzite ridges forming the characteristic undulating terrain [24].

According to the 2006 population census estimate, the population figure of the entire city (Osogbo and Olorunda LGAs) has increased to 288,455 [15]. Urban sprawl in Osogbo was at a rate of 4.9km^2 per annum, indicating that the city which was 3.95km^2 (395 hectares) in 1962 had increased to 241.79km^2 (24,179 hectares) by size in 2011 [1]. Urban expansion creates unique microclimate due to the replacement of natural vegetation with artificial surfaces. This affects climatic elements such as air temperature, relative humidity, wind and rainfall patterns among others. Most of the socio-economic activities as well as engineering constructions taking place in the city influence climate change through deforestation and emission of greenhouse gases.

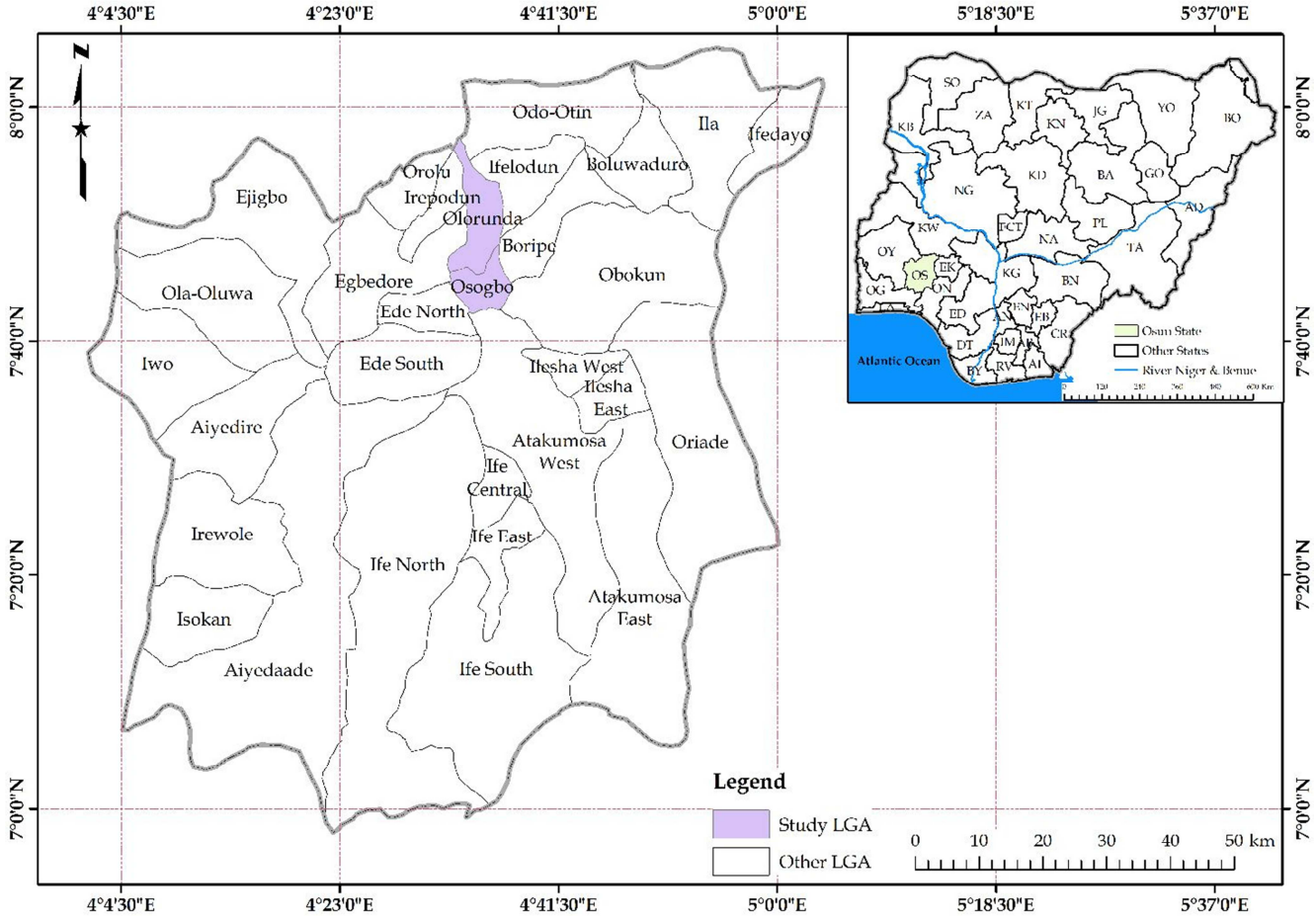

Figure 1. *The Study Area with Nigeria as inset.*

3. Materials and Methods

Data used were selected climatic parameters (minimum and maximum temperature, rainfall amount and relative humidity) which were collected for a period of forty years (1975-2014) from the Nigerian Meteorological Agency (NIMETs), Oshodi, Lagos. The Mann-Kendall test was used to test the nature and significance of trend in the distribution of the data. The Mann-Kendall test is more effective to detect trend in climatic series than other methods [30] and has been successfully applied in several studies [4, 9, 12]. The fluctuations in the mean annual values of the climatic variables were also presented in trend graphs. The Mann-Kendall test (τ) is given as:

$$\tau = [4\Sigma ni/N\ (N-1)]-1 \quad (1)$$

Where ni is the number of values larger than the ith value in the series subsequent to its position in the series of N values of Mann-Kendall test (τ) in a random series is zero and its variance or the square of its standard deviation is given as:

$$\sigma\tau = (4N + 10)/[9N\ (N-1)] \quad (2)$$

The ratio of Mann-Kendall test value (τ) and its standard deviation (στ) is an indication of trend in the data set. If the ratio lies outside (within) the limits of +/-1.96, then there is significant (no significant) trend in the series at 95% confidence level.

4. Results and Discussions

The lowest and highest annual mean minimum temperature of 19.1°C and 23.3°C were observed in 1997 and

2008 (Figure 2). The S statistics, Zs statistics and Kendall's tau for minimum temperature were 183, 2.13897 and 0.240, respectively at 95% confidence level. The positive value of Kendall's tau and S statistics shown increasing trend in the time series data of minimum temperature. From Zs statistic, it was revealed that trend was statistically significant over the period of 1975-2014 because the positive trend in mean annual minimum temperature has τ/ στ value of 2.14 which is outside the limit of +/-1.96 (Table 1).

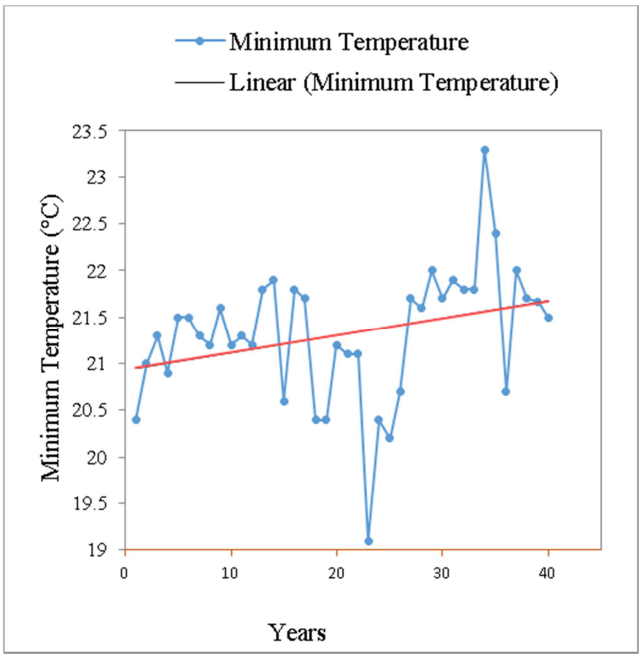

Figure 2. *Pattern of Minimum Temperature in Oshogbo, 1975-2014.*

In case of annual mean maximum temperature (Figure 3), the lowest and highest maximum temperature of 30.4°C and 32.2°C occurred in 1986 and 1987. The S statistic, Zs statistic and Kendall's tau for maximum temperature were 208, 2.43745 and 0.276, respectively at 95% confidence level. Positive Kendall's tau and S statistics show the increasing trend in time series of maximum temperature and the Zs statistics reveal the statistically significant trend with τ/ στ value of 2.44 which is outside the limit of +/-1.96 (Table 1). Increasing in air surface temperature as observed above might be due to an anthropogenic heat released by human activities. A change in temperature is an important indicator of global warming that directly determines the impact of climate change. This temperature increase may affects the hydrologic cycle by directly increasing evaporation of available surface water and vegetation transpiration.

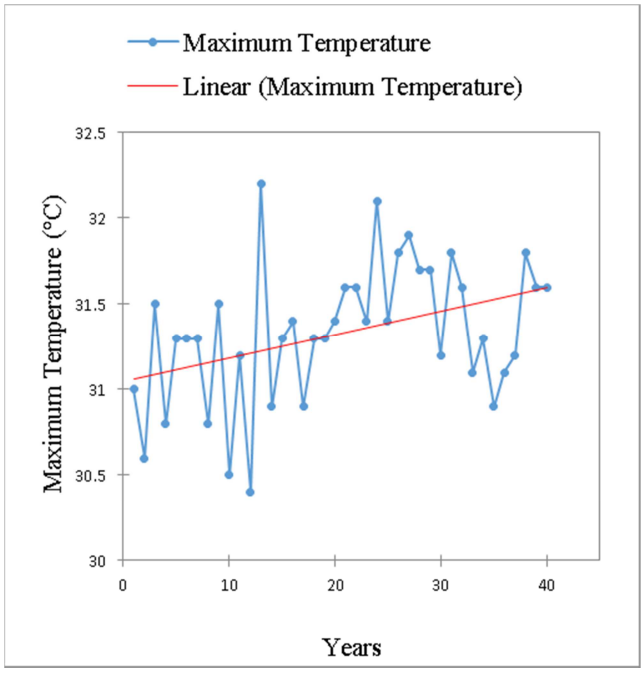

Figure 3. *Pattern of Maximum Temperature in Oshogbo, 1975-2014.*

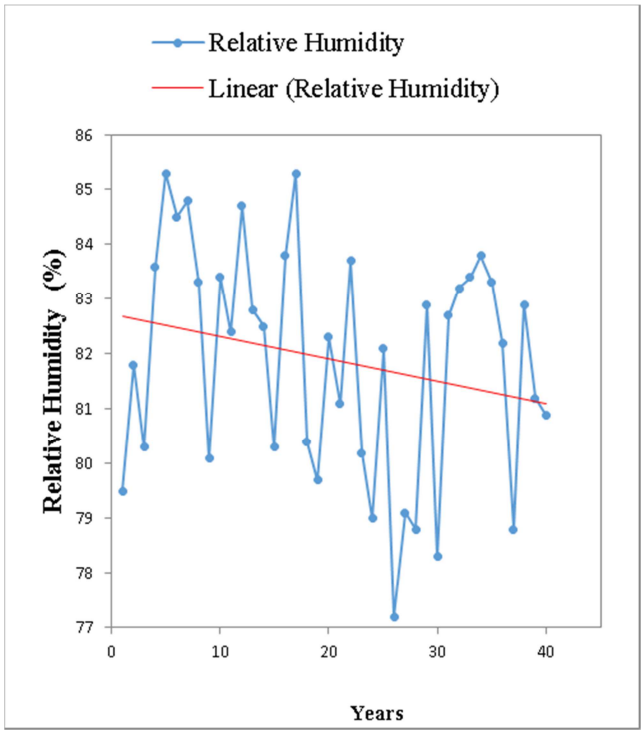

Figure 4. *Pattern of Relative Humidity in Oshogbo, 1975-2014.*

Table 1. *Mann-Kendall's Statistic for Climatic Parameters.*

Parameters	Kendall's tau	Var (S)	Standard Deviation (στ)	S Statistic (τ)	$Z_{crit,.05}$	Z_S (τ/ στ)	Tests results
Minimum Temperature	0.240	7319.667	85.555	183	1.96	2.13897	Significant Increasing
Maximum Temperature	0.276	7282	85.335	208	1.96	2.43745	Significant Increasing
Relative Humidity	-0.164	7359.667	85.789	-127	1.96	-1.4804	Significant Decreasing
Rainfall	0.228	7364.667	85.818	178	1.96	2.07416	Significant Increasing

In Figure 4, the lowest and highest relative humidity of 77.2% and 85.3% occurred in years 2000 and 1979. The S

statistic, Zs statistic and Kendall's tau for annual mean of relative humidity were -127, -1.4804, and -0.164, respectively at below 95% confidence level. Test results of S statistic and Kendall's tau showed the decreasing trend in the time series data of relative humidity but the Zs statistics does not reveal the statistically significant trend because the negative trend in mean annual relative humidity has $\tau/\ \sigma\tau$ value of -1.48 which is within the limit of +/-1.96 (Table 1). This signifies that decreasing in relative humidity will have effects on temperature and rainfall of the study area.

In case of mean annual rainfall, Figure 5 shows that the lowest and highest relative mean annual rainfall amount of 66.9mm and 169.2mm occurred in 1977 and 2010. S statistics, Zc statistics and Kendall's tau for rainfall were 178, 2.07416 and 0.228, respectively at 95% confidence level. The positive value of Kendall's tau and S statistics showed increasing trend in the time series data of rainfall. From Zs statistic, it was revealed that trend was statistically significant over the period of 1975-2014 (Table 1).

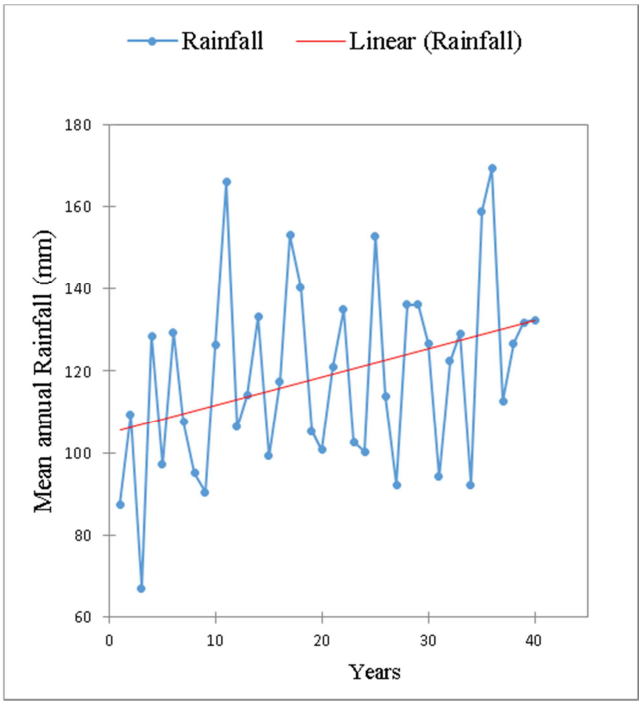

Figure 5. *Pattern of Mean Annual Rainfall in Oshogbo, 1975-2014.*

A study using satellite data confirmed substantial rainfall increases downwind of urban areas, with only slight increases over the centre itself [25]. Changes in radiation and heat balance due to changes in surface albedo and vegetation cover on the urban microclimate can have significant impacts on the rainfall patterns over urban centres and their surroundings [29]. These hydro-meteorological effects are caused by micro-physical changes resulting from urban pollution; increased surface roughness due to urban structures; and heat anomalies resulting from changes in albedo and latent heat flux [5]. Distortions in the pattern of rainfall will possibly lead to drought and/or flooding.

Changes in rainfall amount or departure of rainfall below normal is referred to as anomalies [19]. Rainfall trend on the other hand shows the pattern of the deviation over a given period. A persistent departure from the normal for example, above average rainfall of the same trend constitutes a climatic fluctuation. If the fluctuations persisted for along a time and were furthermore, statistically significant, then we might say, there had been a climatic change [8]. Changes in the pattern of rainfall could lead to loss of lives, properties, displacement of people and farmine [17]. Invariably, with further significant variations in the rainfall characteristics of the area, it is important that scientific studies be undertaken so as to provide the society with accurate information on the real and potential impacts of extreme climatic variability, as well as, the mitigation and adaptation options available.

These changes in climatic parameters could be linked with incidence of human activities such as indiscriminate deforestation, urbanization among others which have led to climate change of the area. Changes in individual weather events will eventually contribute considerably to changes in climatic variability. Intergovernmental Panel on Climate Change posited that climate change may cause variations in rainfall and temperature patterns which can be intensified or weakened [11]. Similarly, climate variability might result in inter-annual variations in rainfall, which are amplified by high run-off and evaporation rates [14]. Studies have also revealed that there is variability in climatic conditions especially rainfall in Nigeria [16, 20]. Many parts of the world, variability in climatic conditions is already resulting in wide ranging impacts especially on water reservoir and agriculture [14].

5. Conclusion

The study examined the changes and patterns of climatic variables of Osogbo, Nigeria for a period of four decades. Findings of the study revealed there are changes in the patterns of climatic elements between the periods under study with significant increase in the climatic variable (minimum and maximum temperature and rainfall) and a significant decrease in relative humidity. This is substantiated in table 1 and figures 2 - 5). Changes in temperature can influence precipitation amounts, timings, and intensity rates and indirectly affect the flux and storage of water in surface and subsurface reservoirs. In the case of rainfall, factors responsible for its changes include fluctuation in evapotranspiration, nature of the surface, air masses and human activities such as construction, felling of trees, and release of pollutants into the air could lead to fluctuations in rainfall. The implication of this study based on the confirmation of the patterns of selected climatic parameters, some imperative and holistic approach must be taken to safeguards the lives of urban residents and the global environments at large. There should be a number of strategies for developing and integrating Green Infrastructure (GI) in human settlement which should include green spaces in new development, green roots on new buildings, urban agriculture, tree planting and replanting among others. Efforts should also be made to enhance the use of technology options in managing climate variability risks.

References

[1] Aguda, A. S., & Adegboyega, S. A. (2013). Evaluation of spatio-temporal dynamics of urban sprawl in Osogbo, Nigeria using Satellite Imagery and GIS Techniques. *International Journal of Multidisciplinary and Current Research*, 60-73. Retrieved, March 23, 2015, from http://ijmcr.com.

[2] Akerlof, K., Maibach, E., Fitzgerald, D., Cedeno, A. Y., & Newman, A. (2013). Do people 'personally experience' global warming, and if so how, and does it matter? *Global Environmental Change*, *23,* 81-91.

[3] Akintola, F. O. (1992). *Rainfall, urbanization and occurrence of floods*. In Perspectives in applied climatology. Lighthouse Publishers. 15.

[4] Anyadike, R. N. C. (1993). Patterns and variations of rainfall over Banju, Gambia. *Singapore Journal of Tropical Geography*, *14* (1), 1-4.

[5] Assela, P., Hailu, B. D., William, V., Chris, Z., & Allan, T. B. (2013). *Impacts of urban growth-driven land use change on micro-climate and extreme precipitation- A Sensitivity Study*. UNESCO- IHE.

[6] Ayoade, J. O. (2004). *Introduction to climatology for the tropics*. Ibadan: Spectrum Books Limited.

[7] De Chavez, & Tauli-Corpus (Eds) (2008). *Guide to climate change*. Retrieved, 26th June, 2015 from www.tebtebba.org

[8] Farmer, G., & Wigley, T. M. (1985). Climatic trends for tropical Africa. *A research report for the Overseas Development Administration*, 136.

[9] Gerstengarbe, F. W., & Werner, P. C. (1999). Estimation of the Beginning and end of recurrent events within a climate regime. *Climate Research*, *11,* 97-107.

[10] Hulme, M., Dessai, S., Lorenzoni, I., & Nelson, R. D. (2009). Unstable climates: Exploring the statistical and social constructions of 'normal' climate. *Geoforum*, 40, 197-206.

[11] Intergovernmental Panel on Climate Change (2007). *Climate change 2007: Impacts, adaptation and vulnerability. Working group ii contribution to the IPCC fourth assessment report.* Cambridge University Press.

[12] Marry, O. M., & Bernard, T. T. (2011). Temporal variation in air temperature in Makurdi, Nigeria. *Proceedings of the International Conference of the Nigerian Meteorological Society. Climate Change Impact: Risks and Opportunities.* 171-177.

[13] Moshood, N. T., & Shinichi, O. (2009). Hydrogeochemical assessment of metals contamination in an urban drainage system: A case study of Osogbo Township, Southwestern Nigeria. *Journal of Water Resource and Protection*, *3,* 164-173. doi: 10.4236/jwarp.2009.13021. Retrieved on 10th, November, 2014 from http://www.SciRP.org/journal/jwarp/.

[14] Mukheiber, P., & Sparks, D. (2005). *Climate variability, climate change and water resources strategies from municipalities, University of Cape Town: Report to the Water Research Commission.*

[15] National Population Commission, (2006). *2006 Population and housing census of the Federal Republic of Nigeria: Priority TABLES.* Volume 1. Abuja: National Population Commission.

[16] Odjugo, P. A. O. (2005). An analysis of rainfall and its implication in Nigeria. *Global Journal of Environmental Sciences*, *4* (2), 139-145.

[17] Odufuwa B. O., Adedeji O. H., Oladesu J. O., & Bongwa A. (2012). Floods of fury in Nigerian cities. *Journal of Sustainable Development*, 5 (7).

[18] Oguntoyinbo, J. S. (1982). Climate and mankind. *An Inaugural Lecture Delivered on 24 Mar, 1982*, University of Ibadan.

[19] Olaniran, O. J. (2002). Rainfall anomaly in Nigeria: A contemporary understanding. *An inaugural lecture delivered 25th April, 2002*, University of Ilorin, Nigeria.

[20] Olaniran, O., & Summer, G. (1989). A study of climate variability in Nigeria Based on the onset, retreat and length of the rainy season. *International Journal of Climatology*, *22* (6), 731-742.

[21] Ologunorisa, T. E. (2011). In search of climate justice and equity. *1st Inaugural Lecture Delivered on 19th January, 2011, Osun State University, Okuku Campus, Nigeria*. 1-77.

[22] Rahaman, M. A. (1976). Review of the basement geology of Southwestern Nigeria. In Kogbe, C. A. (Ed.), *Geology of Nigeria* (pp. 41–58). Elizabethan Publishers, Lagos, Nigeria.

[23] Salami, A. A. (2018). Constraints to effective climate change adaptation policies and programmes in Osun State, Nigeria. *Journal of Social Sciences and Humanities, 1* (1), 9-14.

[24] Salami, A. A., Olanrewaju, R. M., & Tilakasiri, S. L. (2016). Perception and awareness of climate change in Osogbo Metropolis, Nigeria. *Journal of World Development Studies,* 2 (2), 111-127.

[25] Shepherd, J. M., Pierce, H., & Negri, A. J. (2002). Rainfall modification by major urban areas: Observations from spaceborne rain radar on the TRMM Satellite. *Journal of Applied Meteorology 41,* 689-701.

[26] Solomon, S. (2007). *Glossary. In climate change 2007: the physical science basis. Contribution of WG 1 to the 4th Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, University Press.

[27] Strauss, S., & Orlove, B. S. (2003). Up in the air: The anthropology of weather and climate. In Strauss, S.; Orlove, B. S. (eds) *Weather, Climate, Culture*. Oxford, Berg Publishers, 3-16.

[28] Ustaoglu, B. (2012). *Trend analysis of annual mean temperature data using mann-kedall rank correlation test in catalca – Kocaeli Peninsula, North West of Turkey for the period of 1970 – 2011*. IBAC, 2, 276 – 287.

[29] Watkins, R., & Kolokotroni, M. (2012). The London urban heat island upwind vegetation effects on local temperatures. *28th Conference, Opportunities, Limits and Needs towards Environmentally Responsible architecture*. Lima.

[30] Yue, S., & Pilon, P. (2004). A comparison of the power of the t test, mann kendall and bootrap tests for trend detection. *Hydrological Sciences Journal*, *49* (1), 21-37.