ANALYSIS OF URBAN AND RURAL CLIMATIC VARIATIONS: EXAMPLES FROM BENIN CITY AND NIFOR, EDO STATE, NIGERIA

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ABSTRACT

This paper examined the trends and variations of some climatic parameters between rural and urban using data for 60 years (1952-2012) collected from the archives of the Nigerian Institute for Oil Palm Research (NIFOR) and Nigerian Meteorological Agency respectively. The annual trends of the climatic parameters were analyzed using regression while the variations of the climatic variables between rural (NIFOR) and urban (Benin City) settlements were analyzed using simple percentages and compared using t-test. The monthly values of each of the climatic parameters were computed for the period under investigation and this formed the basis for comparison. The results show that rainfall and number of rain-days is increasing in Benin City but decreasing in NIFOR. However, temperatures (minimum, maximum and mean) are observed to be on the rise in both Benin and NIFOR though a steeper rise is noticed Benin City. Minimum, maximum and mean temperatures varied between Benin and NIFOR at 0.84 ^{0}C (3.68%), 0.02 ^{0}C (0.06%) and 0.41 ^{0}C (1.51%) respectively while rainfall and rain-days varied between Benin and NIFOR at 267.68 mm (12.04%) and 9.58 (6.6%) respectively. With the exception of maximum temperature, the variation of the climatic parameters is significant at 0.05 confidence level. The paper recommends intensification of urban greenery and functional drainage system to enhance physiological comfort and reduce urban flooding respectively.

Keywords: Climate, rural, urban, trends, rainforest, Nigeria

INTRODUCTION

Climate is an important environmental factor which influences both the physical and socio-economic landscapes. Thus, environmental threats such as gully erosion and flooding which are highly prevalent in the Benin region have weather and climate undertones. Climate exercises both direct and indirect controls on socio-economic activities which include agriculture, transport, manufacturing and recreation. The environmental and socio-economic role of atmospheric processes is reinforced by global climate change which is expected to intensify in the 21st Century.

The climate of the Benin region is tropical given its latitudinal location. The wet season lasts from March to October as in other parts of the rainforest belts of Nigeria (Odekunle, 2004). As in other parts of Nigeria, and by extension the West African Sub-region, the pattern of rainfall in the region is explained by mechanisms such as the inter-tropical discontinuity (ITD), El Nino/Southern Oscillation (ENSO) and sea surface temperature anomalies (SSTA). During the rainy season, the region is usually under the dominant influence of the rain-bearing tropical maritime (mT) air mass while in the dry season, the tropical continental air mass which is dust laden and characterized by dryness is prevalent (Olaniran, 2002). The seasonal variation of rainfall in the region has therefore been mainly ascribed to the northward excursion and retreat of the ITD (Anyadike, 1985; Adejuwon, 1991; Umar, 2012). The ITD is a moisture boundary which separates the tropical

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continental air mass and the tropical maritime air mass (Anyadike, 1985; Adejuwon, 1991). By virtue of the location of the Benin region within the Tropics, it experiences high insolation which results in convectional heating of the surface. Associated with the intense heating of the surface coupled with high cloud cover, is high temperatures. Although mean temperatures are high throughout the year in the region, which is analogous to areas in the humid rainforest belt of Nigeria, there are observed seasonal variations.

Thermal and rainfall disparities between urban and rural areas highlight the dichotomies between their fabrics both in terms of surface modifications and atmospheric chemistry. A clear analysis of these disparities could form a basis for regulating human activities, particularly in the urban areas for a more livable environment especially in the face of global warming and climate change. This paper, therefore, examines the climatic variations between Benin City (urban) and NIFOR (rural).



Figure 1: Edo State and the Synoptic Weather Stations for the Study

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Materials and Method

Monthly rainfall and temperatures (minimum and maximum) data (1952-2012) as well as rain-days (1961-2012) for NIFOR (rural) and Benin City (urban), were collected from the archives of NIFOR and the Nigerian Meteorological Agency, Lagos. The annual rainfall, rain-days and temperature (minimum, maximum and mean) were computed from the monthly data. The annual trends of the climatic data were examined using simple linear regression. The simple percentage, mean and t-test were used to analyze the variations of the climatic parameters between NIFOR and Benin City. The annual variations of the climatic parameters between NIFOR and Benin City were plotted into bar charts.

Results and Discussion

The annual trends of mean temperatures in Benin City and NIFOR are presented in Figures 2a while the annual variations between the two locations are presented in Figures 2b. Mean temperature appears to show increasing trends during the 1952-2012 period (Figure 2a) in Benin City and NIFOR with regression parameters of 0.023 and 0.0206 respectively. This implies a slightly warmer temperature in Benin City than in NIFOR. The sharper annual trend of mean temperature in Benin City may be attributed to high population density which leads to intensification of 'urban heat island phenomenon' (UHI). The concept of UHI is based on the hypothesis that higher temperatures are observed in urban areas compared to their surrounding rural environments. The disparity of mean temperature between Benin City and NIFOR is also highlighted in Figure 2b. The variation of mean temperature between Benin City and NIFOR corroborated Odjugo and Iweka, (2006) who reported increasing temperature gradient between the core of Benin City and the suburbs. Generally, the increasing trends of annual mean temperatures in rural and urban communities in Benin region may portray

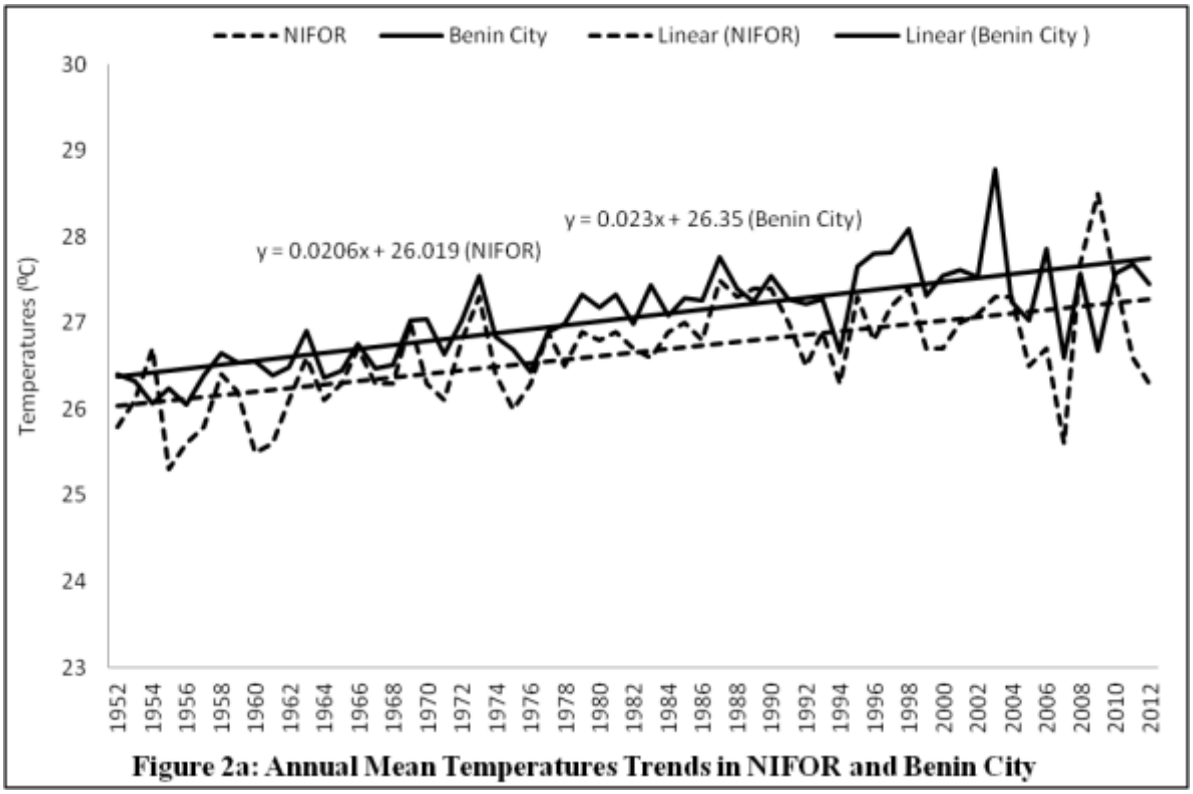


Figure 2a: Annual Mean Temperatures Trends in NIFOR and Benin City

warming which in the global context is termed global warming. Though temperatures are generally lower in the wet season, the seasonal variation of mean temperatures between Benin City and NIFOR is observed to be higher in the wet season (Figure 2c) than in the dry season. The increasing trends of mean temperatures couple with high humidity, particularly in Benin City could pose adverse effects on humans. This could cause human discomfort and may increase morbidity and mortality (Fisher *et al.,* 2012). Sithole and Odindi (2015), noted that the transformation from natural landscape to impermeable surfaces due to urbanization and its associated urban heat island phenomenon could significantly undermine urban environmental quality.

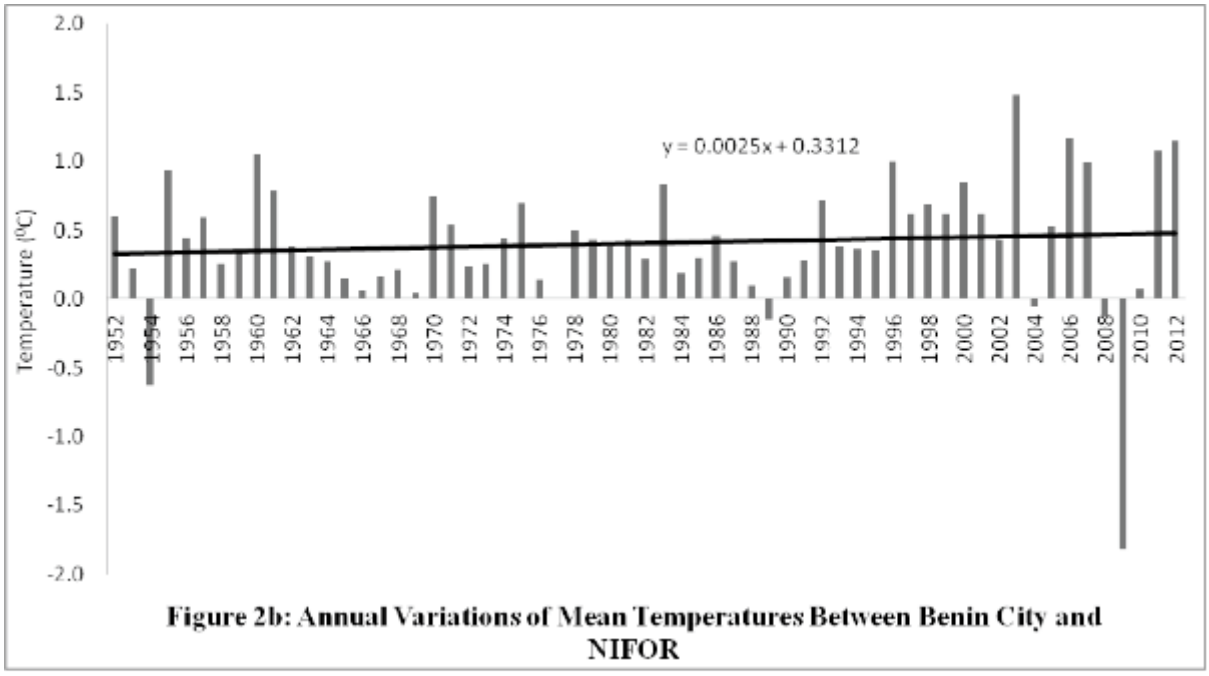


Figure 2b: Annual Variations of Mean Temperatures Between Benin City and NIFOR

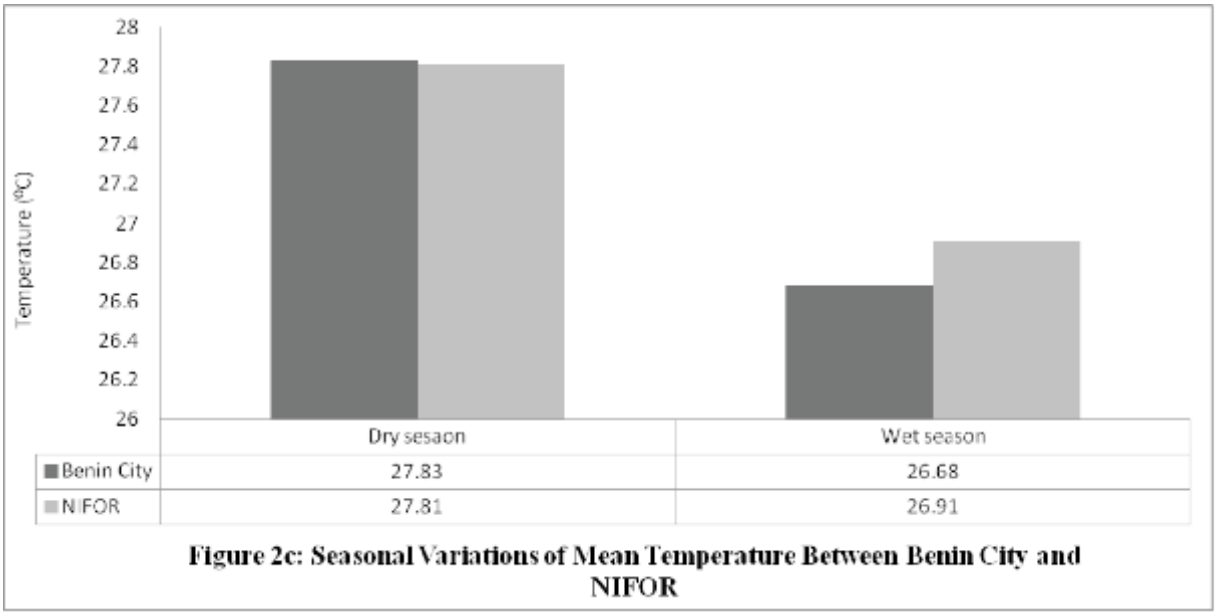


Figure 2c: Seasonal Variations of Mean Temperature Between Benin City and NIFOR

The trends and variations of annual rainfall between Benin City and NIFOR are presented in Figures 3a and 3b. While annual rainfall witnessed increasing trend in Benin City with a regression parameter of 4.19, the trend in NIFOR was downward with a regression parameter of -2.50. There appears to be widening variation of annual rainfall between Benin City and NIFOR with a regression parameter of 6.70. The increasing trend of annual rainfall in Benin City compared to NIFOR could be attributed to the higher concentration of atmospheric particulates which act as condensation nuclei. Studies have shown that the concentration of particulates tend to be higher in the urban areas compared to their surrounding rural areas. The increasing trends of annual rainfall in Benin City and the widening variation of

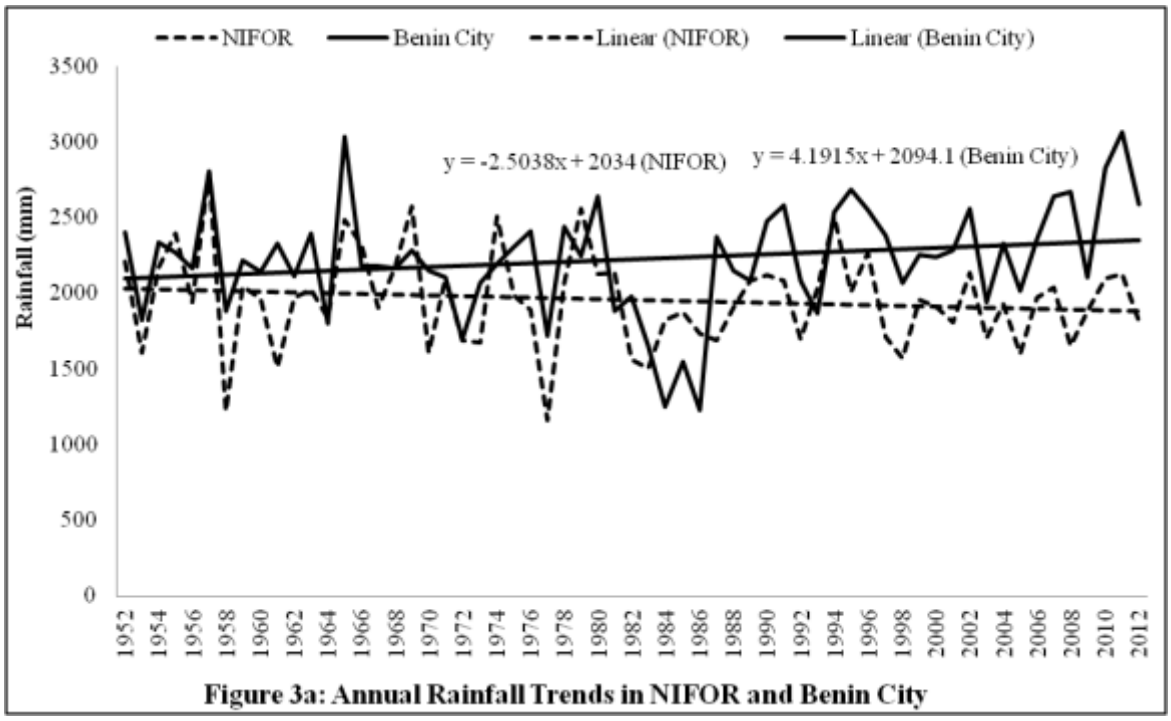


Figure 3a: Annual Rainfall Trends in NIFOR and Benin City

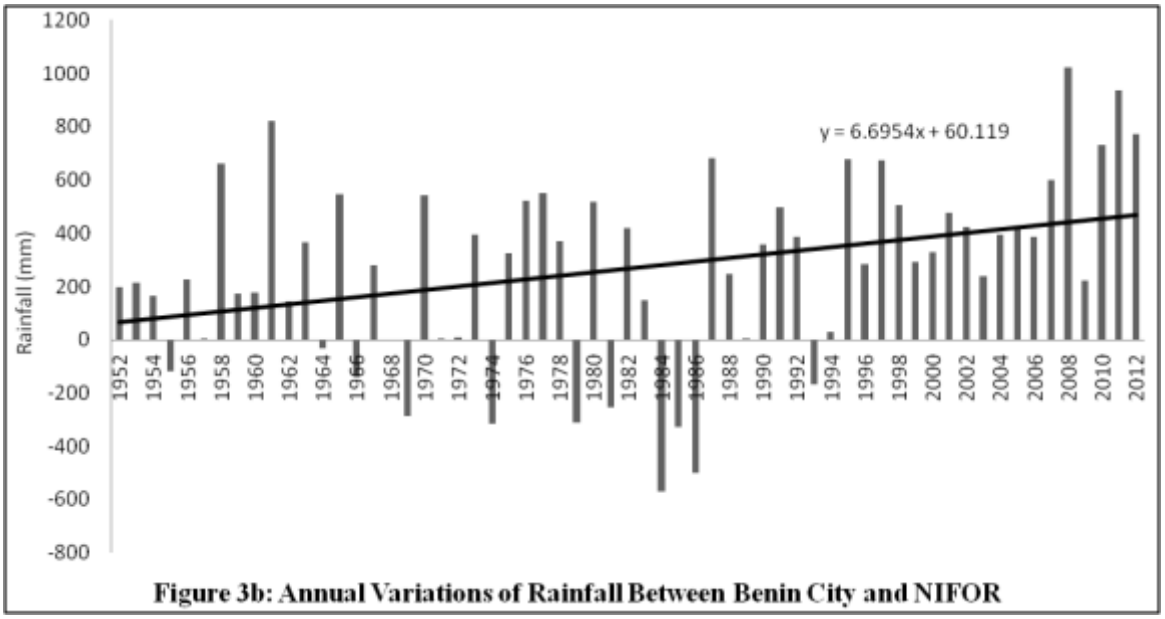


Figure 3b: Annual Variations of Rainfall Between Benin City and NIFOR

annual rainfall between Benin City and NIFOR may partly explain the increasing flood incidence in Benin City which was reported in Atedhor *et al.* (2011). However, the decreasing trend of annual rainfall in NIFOR could pose adverse effects on crop production.

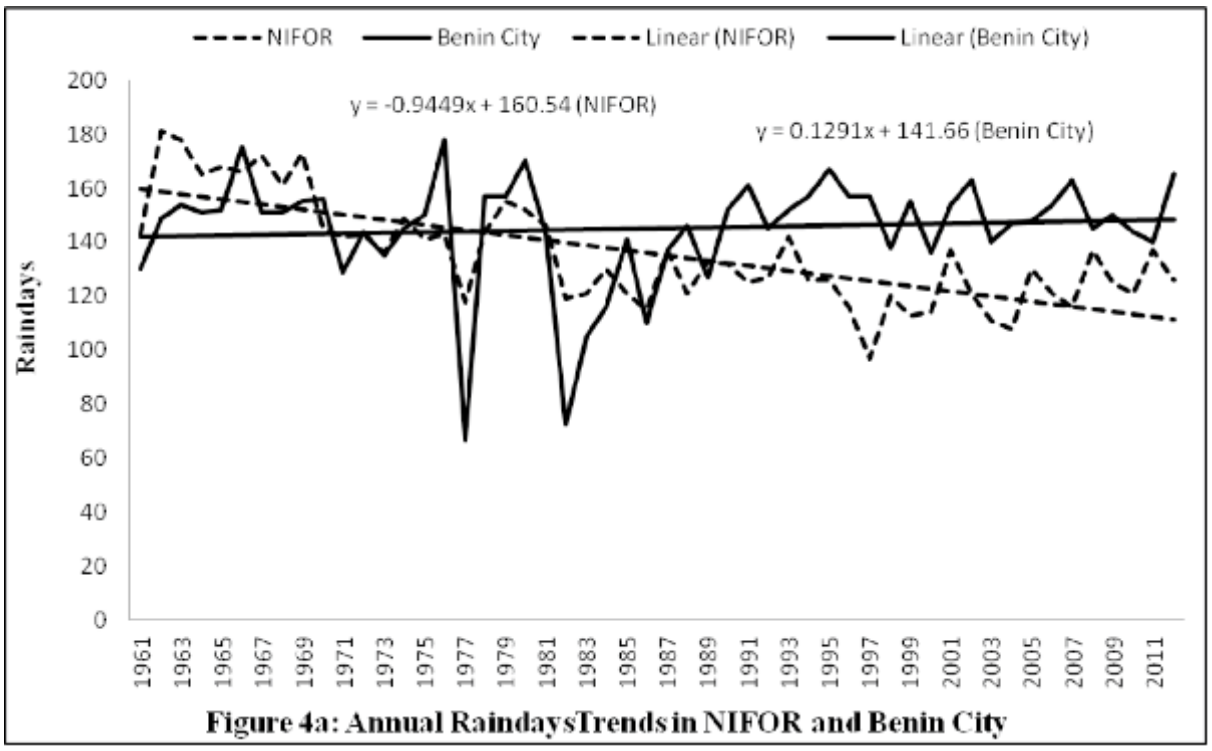


Figure 4a: Annual RaindaysTrends in NIFOR and Benin City

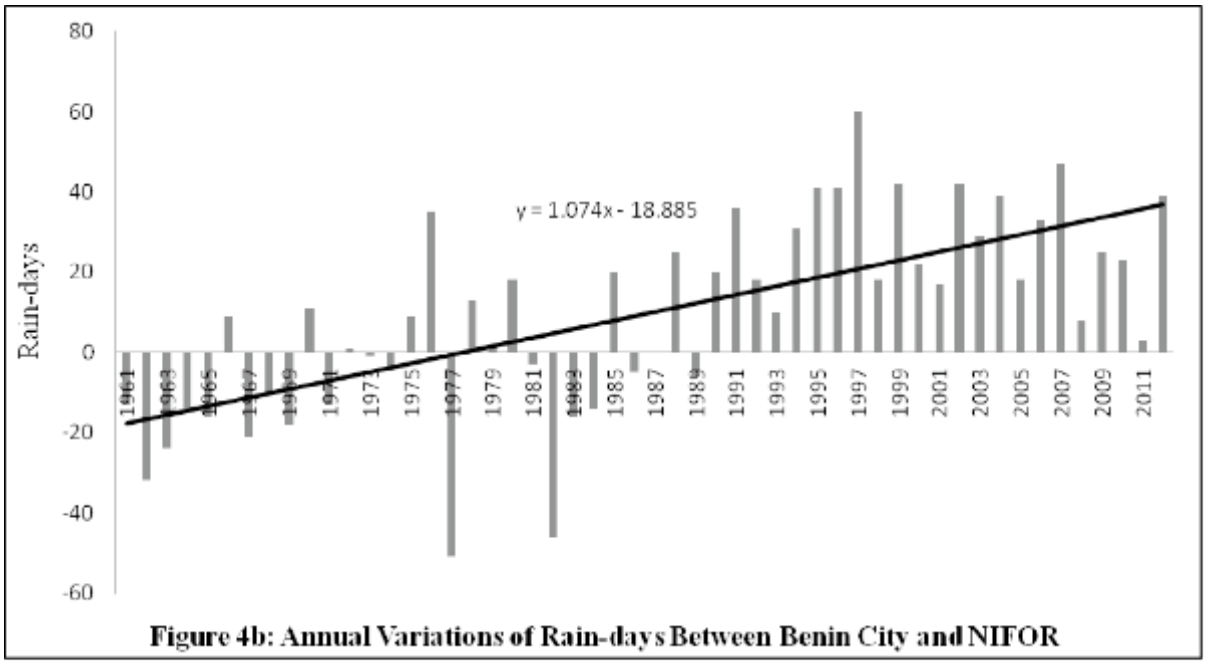


Figure 4b: Annual Variations of Rain-days Between Benin City and NIFOR

The mean monthly variations of the climatic parameters are presented in Table 1. While mean minimum temperatures are highest in March at 23.75 ^{0}C and 22.92 ^{0}C in Benin City and NIFOR respectively, they are lowest in August and January at 22.09 ^{0}C and 21.07 ^{0}C respectively. Mean monthly maximum temperatures in Benin City and NIFOR were highest in February and December at 34.04 ^{0}C and 37.41 ^{0}C respectively and lowest in the months of August at 28.42 ^{0}C and 28.27 ^{0}C respectively. Mean monthly temperatures in Benin City and NIFOR were highest in the month of February and December at 28.72 ^{0}C and 29.28 ^{0}C respectively while the lowest occurred in August at 25.10 ^{0}C and 25.03 ^{0}C respectively. Rainfall reduces temperature through the process of evapo-transpiration which intensifies latent heat at the expense of sensible heat (Odekunle et al 2008 cited in Odekunle, 2011). Thus, the highest and lowest mean temperature occurs in the dry and wet seasons respectively. The heat waves associated with the elevated mean temperature in the months of February and March coupled with the high relative humidity usually induce heat stress.

Mean monthly rainfall is highest in July in Benin City and NIFOR at 359.28 mm and 327.12 mm respectively and lowest in the months of January and December at 13.95 mm and 10.29 mm respectively. Similarly, mean monthly rain-days in Benin City and NIFOR are highest in July at 21.23 and 20.88 respectively and lowest in the months of January and December at 1.48 and 0.88 respectively. Rainfall in the region exhibits seasonality with the wet season as in other rainforest belts of Nigeria lasting from the month of March to October (Odekunle, 2004) while the dry season lasts from November till February. As Adejuwon (1991) noted, the ITD oscillates between latitude 6^0 and 8^{0}N when normally most stations south of these latitudes would have received their onset rainfalls in April. The gradual commencement of the rainy season in March reflects northward advancement of the ITD in fits before it is sustained (Ayoade, 2002). Rainfall in the region is bimodal with highest monthly rainfall often occurring in the months of July and September. The 'little dry spell' usually occurs in the month of August. This rainfall anomaly is also sometimes referred to as 'August Break'. Although

Table 1: Mean Monthly Values of Climatic Parameters in Benin and NIFOR

Parameters	Stations	January	February	March	April	May	June	July	August	Septembe
Minimum temperature (^{0}C)	NIFOR	21.07	22.68	22.92	22.76	22.11	21.77	21.61	21.78	21.95
	Benin City	22.17	23.40	23.75	23.59	23.20	22.61	22.18	22.09	22.41
Maximum temperature (^{0}C)	NIFOR	32.44	33.6	33.54	32.68	31.98	30.6	33.13	28.27	29.19
	Benin City	32.72	34.04	33.52	32.69	31.79	30.28	28.40	28.12	29.04
Mean temperature (^{0}C)	NIFOR	26.76	28.14	28.23	27.72	27.05	26.19	27.37	25.03	25.57
	Benin City	27.44	28.72	28.63	28.14	27.49	26.45	25.29	25.10	25.73
Rainfall (mm)	NIFOR	14.32	42.96	94.16	162.07	211.12	256.06	327.12	301.63	313.47
	Benin City	13.95	52.32	111.84	181.11	224.69	274.96	359.28	292.14	358.97
Rain-days	NIFOR	1.23	3.67	7.1	10.02	13.21	17.38	20.88	20.37	20.12
	Benin City	1.48	4.35	7.83	11.13	14.56	17.81	21.23	20.50	20.44

The variation in the climatic parameters between Benin City and NIFOR are presented in Table 2. Out of the three temperature parameters examined, minimum temperature reveals the highest variation between Benin City and NIFOR at 0.84 ^{0}C (3.6%) while maximum temperatures show the least variation at 0.02 ^{0}C (0.06%). The variation for mean temperature is 0.41 ^{0}C (1.51%). While rainfall varies between Benin City and NIFOR at 267.68 mm (12.04%), rain-days vary at 9.58 (6.6%). Table 3 reveals that all the climatic parameters examined in this paper varied significantly between Benin City and NIFOR. The disparities between the climate of urban and rural environments have been partly linked to surface and atmospheric properties of environments such as roughness, smoke, elevation difference and wind intensity (Bulut *et al*., 2008). For instance, land cover modifications influence local surface energy balances by altering the quantity of solar energy emitted, the degree and period over which absorbed energy is released as heat and the diversion of energy to non-heating fluxes via evaporation (Vargo *et al.*, 2013).

Table 2: Percentage Variations of Climatic Parameters Between Benin and NIFOR

Parameter	Benin	NIFOR	Difference	% difference
Minimum temperature	22.79	21.95	0.84	3.68
Maximum temperature	31.34	31.31	0.02	0.06
Mean temperature	27.07	26.66	0.41	1.51
Rainfall	2224.04	1956.37	267.68	12.04
Rain-days	145.08	135.50	9.58	6.6

Table 3: Statistical Analysis of the Variations of Climatic Parameters Between NIFOR and Benin

Pairs	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Minimum temperature in NIFOR - Minimum temperature in Benin	-0.84098	0.92515	0.11854	-1.07869	-0.60327	-7.077	60	0.00
Maximum temperature in NIFOR - Maximum temperature in Benin	-0.02295	0.62005	0.07939	-0.18175	0.13585	-0.289	60	0.774
Mean temperature in NIFOR - Mean temperature in Benin	-0.41311	0.46514	0.05994	-0.53301	-0.29322	-6.892	60	0.00
Rainfall in NIFOR - Rainfall in Benin	-267.6854	347.05771	44.43619	-356.56102	-178.7898	-6.024	60	0.00
Rain-days in NIFOR – Rain-days in Benin	-9.57692	24.32327	3.37303	-16.34856	-2.80528	-2.839	51	0.006

CONCLUSION

This paper examined the trends and variations of some climatic parameters between rural and urban using data for 60 years (1952-2012) collected from the archives of the National Institute for Oil Palm Research (NIFOR) and Nigerian Meteorological Agency respectively. The annual trends of the climatic parameters were analyzed using regression while the variations of the climatic between rural (NIFOR) and urban (Benin) were analyzed using simple percentages and t-test. The monthly values of each of the climatic parameters were computed for the period under investigation and also formed bases for comparison. Rainfall and rain-days revealed increasing trends in Benin while the trends in NIFOR show decrease. Temperatures (minimum, maximum and mean) show increasing trends in both Benin and NIFOR with Benin revealing sharper increasing trends of minimum and mean temperatures while the increasing trend of maximum temperature is more pronounced in NIFOR. Minimum, maximum and mean temperatures varied between Benin and NIFOR at 0.84 ^{0}C (3.68%), 0.02 ^{0}C (0.06%) and 0.41 ^{0}C (1.51%) respectively while rainfall and rain-days varied between Benin and NIFOR at 267.68 mm (12.04%) and 9.58 (6.6%) respectively. With the exception of maximum temperature, the variations of the climatic parameters are significant at 0.05 confidence level. The paper recommends intensification of urban greenery and functional drainage system for enhanced physiological comfort and reduced urban flooding respectively.

Acknowledgement

The author wishes to thank the Nigerian Meteorological Agency and the Nigerian Institute of Oil Palm Research (NIFOR) for the climatic data used in this study.

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