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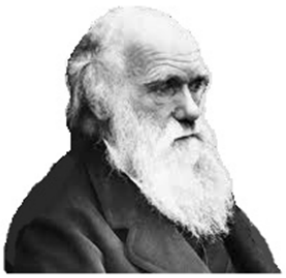

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Urban-Rural Temperature and Diurnal Temperature Range (DTR) in Delta State, Nigeria

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ABSTRACT

The study examined urban-rural temperature and Diurnal Temperature Range (DTR) in Delta State, Nigeria with the aid of the ex-post facto research design. Monthly temperature and DTR data were collected from the 5° × 5° grid point via google earth employing the Cruts 4.06 and Crutem 4-2019-12 grid boxes. One-way analysis of variance (ANOVA), Paired t-test, and Mann-Kendall test were employed to establish the variation and trend in temperature and DTR in urban–rural areas of Delta State. In the same vein, the Tukey HSD Multiple Comparisons were used to determine where the significant variation lies. The study indicates that Delta state has an annual temperature of 26.9 °C and a DTR of 8.4 °C. The results also showed an urban bias of 0.2 °C in temperature and 0.4 °C in DTR in the urban-rural canopies, which confirmed the concept of urban heat islands and their negative impacts on DTR. The study confirmed that that a significant difference exists in annual temperature between urban and rural areas of Delta State. The outcomes of the study indicate that a significant difference exists in annual DTR between the urban and rural areas in Delta State. That the annual mean temperature and DTR between the urban and rural areas differ significantly. Therefore, the study recommends that urban planners adhered to planning regulations and the green roof city approach.

***Keywords*:** Urban Heat Island (UHI), Urban Heat Island Effect (UHIE), Effect, Diurnal Temperature Range (DTR), Temperature

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1. INTRODUCTION

Urban Heat Island (UHI) is the amassing of heat prodigy within the urban canopy owing to human activities and expansions in an urban area, this is most noticeable in the climate of the urban area of the world (Efe, 2005; Eyefia, 2013; Efe, 2013; Efe & Eyefia, 2014b). The rise in land surface temperature comes into being due to UHI that definitely and irrefutably stimulates material and energy flow of ecological systems in the urban area and the modification of their structure and functions. UHI has a great negative effect on rising temperatures and other weather parameters, which in turn affects the local meteorology at the micro-scale. Thus, changing the local wind patterns, rainfall, temperature, clouds, fog, and humidity.

The number one prominent scientific observation on urban climate was carried out by Howard in 1818 in the city of London. In 1820, he observed that temperature in the urban environment is higher than its rural environment. Renou (1868) in his study on the urban area of Paris and its surrounding areas revealed an increase of 1 °C temperature in the urban area over its countryside. Studies carried out on UHI in the 1990s were comparatively few, but 30 of this research between 1990 – 2000 were published annually. In 2010 the figure rose to 100, and by 2015, it has doubled to over 300 (Valéry et al., 2020). Solecki et al. (2005) and the United States Environmental Protection Agency (2008) asserted that the mean root of the UHI surfaces modification is man's activities and the generation of heat waves from energy usage (Li & Zhao, 2012). Also, the urban environment's rising temperature in the urban area was ascribed in the direction of the immense burning of fuel (Lamdsberg, 1981; Efe & Eytefia, 2014b). The UHI has caused the advent of communicable diseases, wide-ranging heat causing injury to the thermoregulatory system of the human body, thermal tiredness, and dryness of the human throat, high rate of heat mortality, injury particularly those working in an outdoor environment and high rate of heart attacks and heat stroke.

Kalnay and Cai (2003) indicated that there is a mounting scientific body pointing out that changes in alterations in the landscape and how it is used owing to anthropogenic activities affect the diurnal temperature range (DTR). Also, Hartmann et al. (2013) and Stjern et al. (2020) asserted that, as the global climate gets hotter, variations are also detected in the mean UHI and daily diurnal temperature range over the world [33-42].

The DTR measures the difference between the minimum and the maximum temperature over a given day. According to Global Warming Science (2010), the DTR can be described as the variance between the daily maximum and minimum temperature. Changes in DTR are caused by possible multiple factors of water vapour, aerosols, heat emissions from urbanization, changes in land use, cloud cover, and greenhouse gases. Bilbao et al. (2019) posited that since the past three decades the earth's surface has displayed an increasingly warmer temperature, with the warmest being the 2000s, with a warming of 0.85 (0.65 to 1.06) °C overland and ocean temperatures from 1880–2012 (Intergovernmental Panel on Climate Change [IPCC], 2013).

Though DTR change arises on a global scale, its effect differs from place to place and, as an upshot, investigating DTR variations and trends is an important aspect of climate change research (Giorgi & Lionello, 2008). UHI and DTR are vital mechanisms in the climate system and any alterations either by man or natural causes in their pattern have adverse effects on vegetation, wildlife, and the health of the people. However, studies on UHI and DTR are not been fully investigated in Nigeria despite the importance of DTR as such, providing scanty information on the subject matter. On the other hand, studies on spatial variations of urban heat islands, rainfall, and temperature in other cities in Nigeria abound. For example, Eyefia (2013)

studied the urban climate of Benin City; Efe and Eyefia (2014b) explored the urban warming in Benin City; Efe and Eyefia (2014a) investigate the urban effects on the precipitation of Benin City; Ndakara and Eyefia (2021) examined the spatial and seasonal variations in rainfall and temperature across Nigeria. These studies are limited to temperature and rainfall to the neglect of DTR. Other studies on UHI and DTR include Pyrgou et al. (2019) which revealed a downward DTR trend of -0.24 °C in the municipal area and -0.36 °C in the countryside of Nicosia, Cyprus. This increase was ascribed to the daily minimum temperature. Bilbao et al. (2019) stressed that DTR in Spain from 1950 – 2011 has a high downward trend of -0.11 °C to -0.29ºC per decade for an area situated in the Mediterranean Sea. Vinnikov et al. (2002) study indicates that a complex pattern exists in temperature trends and there are variations in the diverse times in the seasonal and diurnal cycle, displaying increasing trends in all areas in most times of the day and periods of the year. Also, studies on UHI and DTR are relatively absent in this part of Nigeria except that of Obansola (2015) in the city of Akure. In his study, Obansola (2015) evaluates the consequence of UHI on DTR in Akure, Ondo State, and opined that monthly temperature variations in the semi-urban and metropolitan areas displayed higher temperatures than the fringes. He ascribed this increase to human activities, morphology and geometry of the urban landscapes. Dike et al. (2019) asserted that DTR in Nigeria reduce regionally per decade (−0.34 °C) in the Nigeria Sahel and upward trend per decade (0.01 °C) in the Nigeria Guinea Coast. The annual DTR show a downward trend in the Nigeria Sahel that is ascribed to a rise in the daily maximum temperature per decade (Tmin, 0.51 °C) which surpasses the degree of increase in the daily maximum per decade (Tmax, 0.17 °C). They however call for studies in other cities in Nigeria. Upon the above neglect and calls, this study examined the urban-rural temperature and DTR differential in Delta State, Nigeria.

Study Area

Delta State lies between latitude 5°00' and 6°45'E and longitude 5°00' and 6°30'N. It has a landmass of 16,842 square kilometres (6,503 sq mi), with a low-land area, except in the northern parts with pockets of hills, and valleys with elevation less than 500 feet (150m). The mangrove swamps are most preponderate in the coastal areas of the state and the freshwater swamps to the northern parts of the state. Delta state is drained by River Niger, Ethiope River, Okumeshi and Ase River, these major rivers and their tributaries that are interconnected with the Forcados and Escravos rivers empty its water into the Bight of Benin. The state is characterized by a long-wet season, and rainfall throughout the year (Efe, 2006; Efe & Eyefia, 2015). Relative humidity hardly drops less than 60% and fluctuates between 80% and 100% throughout the year. The southern parts of Delta State possess a humid tropical climate while the northern east parts possess a sub-humid climate (Efe, 2007; Efe and Eyefia, 2015). The temperature in Delta state is high (19.9 °C – 31 °C), especially in the oil-producing regions occasioned by the influence of the gas flaring (Efe, 2011).

The Implication of Urban-Rural Temperature and DTR on the Citizenry of the Area

Researches all over the world have shown that urban heat island (UHI) has two-sided effects which can be impacted negatively on human well-being and the microclimate of the area (Khan et al., 2021). UHI has a great negative effect on temperature and other weather parameters, which in turn affects the local meteorology of an area, that is changing the local wind patterns, rainfall, clouds, fog, and humidity, which has led to climate anomaly that in turn

have negative impacts on food insecurity, physiological comfort of the people, reduction in air quality, pollution of water sources owing to flood, and interruption of the social and economic structure of the people in the state. On human health, it has caused advent communicable diseases, wide-ranging heat causing injury to the thermoregulatory system of the human body, thermal tiredness, and dryness of the human throat, high rate of heat mortality, injury particularly those working in an outdoor environment and high rate of heart attacks and heat stroke. Another negative effect of UHI is the increase in outpatient visits to hospitals which also makes old people susceptible to cardiovascular disease.

2. MATERIAL AND METHOD

The ex-post facto research design was utilized for the study where archival meteorological data from 1901 – 2019 were extracted and used for this study. The meteorological parameters utilised are the mean annual and monthly temperature (T_{mean}) and DTR. The DTR is derived from the variance amongst T_{max} and T_{min} daily reading. These data were obtained from the archive of the Climate Research Unit (CRU) dataset via google earth. The eight (8) existing gridded points of 5° × 5° high-resolution Cruts 4.04 and Crutem 4-2019 grid boxes for temperature and DTR were utilized for this study in line with Harris, Osborn, Jones, and Lister (2020). To determine UHI, the differences between the urban and the rural areas' temperatures (ΔTu-Tr) were adopted. The following existing CRU stations for Delta State were utilized for this study (See Table 1).

Table 1. Climate Research Unit (CRU) Stations Employed with Coordinates

Stations Name	Latitude	Longitude	Elevation (M)	Urbanization Status
Okpai	5.78	6.58	26	Rural
Uwherun	5.33	6.05	13	Rural
Asidani	5.25	6.25	17	Rural
Burutu	5.25	5.75	15	Rural
Asaba	6.19	6.72	44	Urban
Agbor	6.26	6.18	155	Urban
Abraka	5.75	6.13	20	Urban
Warri	5.51	5.75	6	Urban

Source: Authors Compilation (2022)

The mean temperature and DTR were summarized with the aid of descriptive and analytical statistics. One-way analysis of variance (ANOVA) and paired t-test was employed

to determine the degree of variation in annual, and seasonal mean temperature and DTR in Delta State, paired t-test was utilised to test the temperature differential within urban and rural environment in Delta State. These statistical tools have been adopted by (Ndakara & Eyefia, 2021; Efe, 2011; Efe & Eyefia, 2014a; Efe & Eyefia, 2014b) for similar studies. To determine if trends exist in the annual mean temperature and DTR over Delta State, the Mann-Kendall test was employed. to ascertain the urban heat island effect (UHIE) on the DTR in urban and rural areas of the Delta State, the DTR ratio in an urban area was divided by the DTR ratio in the rural area ($DTRR_{urban}/DTRR_{rural}$) which gives the degree of UHIE magnitude in the urban area (Merkin, 2004).

Decision Rule

If the calculated z-statistic is positive it signifies an upward trend, a calculated z-statistic of negative result signifies a downward trend and a calculated zero z-statistic indicates a no trend. If the calculated results are equal, it shows that uniformity occurs amongst the urban and the rural area and UHIE on DTR is not present. On the other hand, if the calculated DTR is less than, it shows that UHIE exists (Merkin, 2004).

3. RESULTS AND DISCUSSION

The various findings of the study were discussed in Fig. 1 and Table 1 – 13 below.

Table 2. Descriptive Statistics of Temperature in Delta State

Statistic	Warri	Abraka	Agbor	Asaba	Uwherun	Burutu	Asidani	Okpai
Numbers of observations	121	121	121	121	121	121	121	121
Minimum	26.308	26.258	25.950	26.192	26.158	26.117	25.825	25.917
Maximum	27.958	27.883	27.467	27.692	27.792	27.667	27.350	27.417
Median	27.083	27.000	26.625	26.850	26.925	26.825	26.533	26.608
Mean	27.133	27.054	26.680	26.911	26.968	26.863	26.568	26.648
Variance (n)	0.111	0.104	0.099	0.093	0.106	0.094	0.088	0.088
Standard deviation (n)	0.334	0.323	0.314	0.305	0.326	0.306	0.296	0.296

Source: Authors Computation (2022)

From Table 2, the descriptive analysis indicates that the minimum temperature of 26.3 °C – 26 °C was observed in Warri and Agbor in urban area of Delta State, while the lowest values of (25.8 °C) were recorded in the rural areas of the state. However maximum temperature span is 28°C -27.4°C in Warri, and 26.2 °C – 25.8 °C in Uwherun and Asidani respectively.

The table shows that the highest median of 27.1 °C was observed in Warri in the urban area with the lowest of 26.5 °C in Asidani a rural area. The highest temperature of 27.1 °C was observed in Warri and Abraka in the urban area of Delta state. Furthermore, the highest variance of 0.1 °C temperature was observed in Warri while the highest standard deviation of 0.3 °C was observed in Warri an urban area indicating a slight variation over the years.

Table 3. Descriptive Statistics of Diurnal Temperature Range (DTR) in Delta State

Statistic	Warri	Abraka	Agbor	Asaba	Uwherun	Burutu	Asidani	Okpai
Numbers of observations	121	121	121	121	121	121	121	121
Minimum	7.375	8.092	8.392	8.742	7.175	7.442	7.783	7.750
Maximum	8.775	9.408	9.742	10.058	8.542	8.783	9.108	9.108
Median	7.900	8.567	8.867	9.217	7.700	7.942	8.275	8.233
Mean	7.935	8.609	8.912	9.261	7.732	7.978	8.315	8.273
Variance (n)	0.044	0.044	0.047	0.045	0.041	0.042	0.042	0.044
Standard deviation (n)	0.210	0.210	0.217	0.212	0.204	0.205	0.204	0.211

Source: Authors Computation (2022)

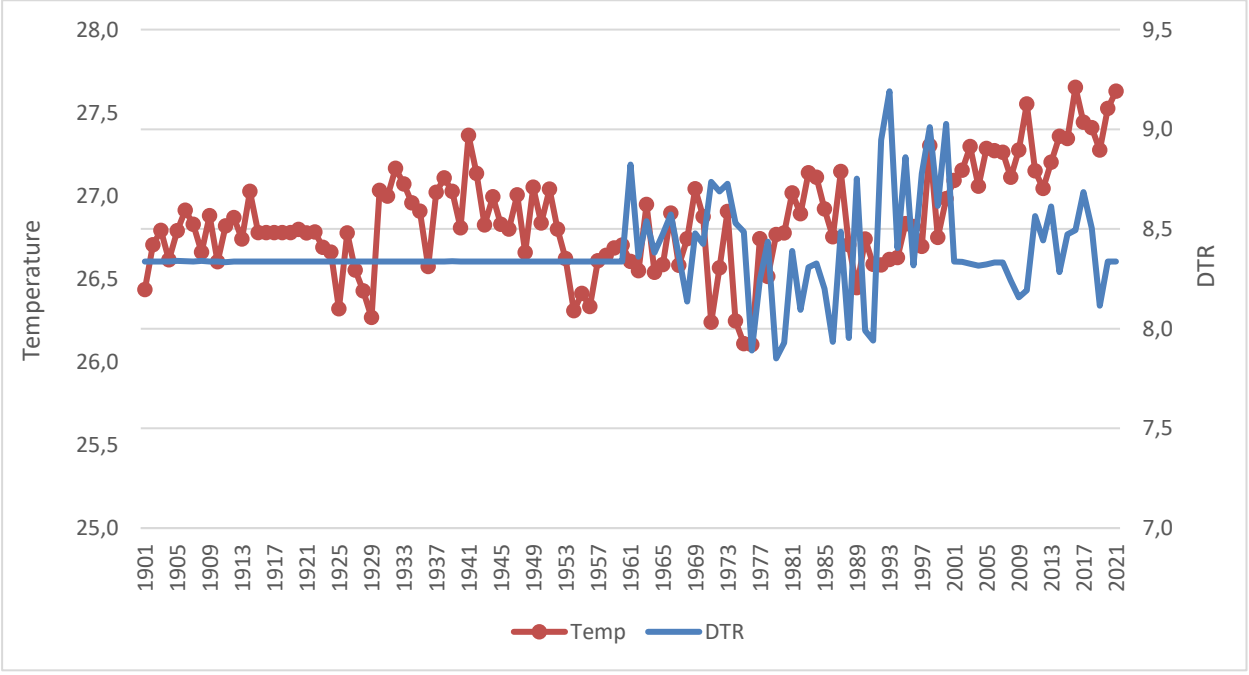

Fig. 1. Mean Temperature and Diurnal Temperature Range in Delta State

Table 3, shows a minimum DTR value of 8.7 °C in an urban area and 7.2 °C in Asaba and Uwherun (a rural area) respectively. However, the maximum DTR of 10.1 °C was observed in Asaba and 9.1 °C was observed in Asidani and Okpai in rural areas respectively. The highest mean DTR of 9.2 °C was observed in Asaba an urban area and the lowest value of 7.7 °C in Uwherun a rural area in Delta state. Additionally, a variance of 0.05 °C was observed in Asaba while the highest standard deviation of 0.2 °C was observed in all the stations in the state, and this shows a minimal variation of DTR in Delta State.

Fig. 1 revealed that Delta State had a mean temperature of 26.9 °C and DTR of 8.4 °C during the periods of study. The highest mean annual temperature in Delta State was recorded in 2016 (27.7 °C) with the lowest mean annual mean temperature in 1975 – 1976 (26.1 °C) respectively and the highest mean annual DTR of 9.2 °C was recorded in 1993, while the lowest mean annual DTR was recorded in 1976, 1979,1980,1986 and 1991 (7.9 °C) respectively. The cause of high temperature observed in some years in Nigeria can be attributed to influence of tropical continental airmass (CT) owing to deforestation, anthropogenic activities like smoke from domestic and industrial generating set and vehicles. While, low temperature can be attributed to the issues of climate change

Table 4. Mean Seasonal Diurnal Temperature Range (DTR) Over Delta State

Months	Warri	Uwherun	Burutu	Asidani	Abraka	Okpai	Agbor	Asaba
Jan	10.1	9.7	10.1	10.7	10.6	11.7	11.7	12.3
Feb	9.9	9.6	9.9	10.4	10.4	11.2	11.3	11.6
Mar	8.9	8.6	8.9	9.3	9.3	10.0	10.0	10.4
Apr	8.3	8.1	8.4	8.6	8.6	9.1	9.1	9.3
May	7.9	7.7	7.8	8.0	8.0	8.4	8.4	8.6
Jun	6.8	6.7	6.9	7.1	7.0	7.4	7.4	7.6
Jul	5.8	5.8	6.0	6.2	6.1	6.5	6.4	6.7
Aug	5.9	5.9	6.0	6.2	6.1	6.5	6.5	6.7
Sept	6.4	6.3	6.5	6.8	6.8	7.4	7.3	7.6
Oct	7.3	7.1	7.3	7.6	7.6	8.1	8.1	8.4
Nov	8.3	8.0	8.3	8.6	8.7	9.5	9.6	10.1
Dec	9.5	9.2	9.5	10.1	10.0	11.1	11.1	11.8

Source: Authors Computation (2022)

Table 4, indicates the mean seasonal temperature and DTR over Delta State, from the analysis it shows that DTR ranges between 5.8 °C – 12.3 °C over Delta State, the highest DTR

of 12.3 °C was Observed in Asaba an urban in January and the lowest of 5.8 °C was observed in Warri an urban area and Uwherun a rural area respectively. It can be observed that high DTR (7.7ºC – 12.3 °C) were recorded in all the stations from January to May, but in June low DTR were observed in Warri, Uwherun and Burutu that ranges between 6.7 °C- 6.9 °C, while Asidani, Abraka, Okpai, Agbor and Asaba had high DTR that ranges between 7.0 °C -7.6 °C. However, in July, August, and September all the stations had low DTR that ranges between 5.8 °C- 6.8 °C, the low DTR observed in these areas can be attributed to the heavy downpour that is associated with the wet season. This study is in agreement with the works of PNAS (2007), Zhou et al. (2009) and Dei et al. (1999) who demonstrated that rainfall has a downward effect on DTR. The low DTR in these areas may also be attributed to the heavy downpour in the area. However, other months had higher DTR values of 7.3 °C – 12.3 °C were observed in Okpai, Agbor, and Asaba

Table 5. Mean Seasonal Temperature Over Delta State

Months	Warri	Uwherun	Burutu	Asidani	Abraka	Okpai	Agbor	Asaba
Jan	27.6	27.4	27.2	26.8	27.4	27.0	26.9	27.0
Feb	28.8	28.5	28.4	28.1	28.7	28.5	28.5	28.7
Mar	28.8	28.5	28.4	28.1	28.8	28.5	28.6	28.9
Apr	28.2	27.9	27.9	27.6	28.2	27.9	27.9	28.2
May	27.4	27.3	27.2	26.9	27.4	27.1	27.0	27.3
Jun	26.4	26.3	26.2	26.0	26.4	26.1	26.0	26.2
Jul	25.6	25.6	25.5	25.3	25.6	25.4	25.5	25.2
Aug	25.4	25.4	25.3	25.1	25.4	25.2	25.1	25.4
Sept	25.9	25.8	25.8	25.5	25.9	25.7	25.5	25.8
Oct	26.5	26.4	26.3	26.0	26.4	26.2	26.1	26.3
Nov	27.7	27.3	27.2	26.8	27.4	27.0	27.0	27.1
Dec	27.5	27.3	27.1	26.7	27.2	26.8	26.6	26.7

Source: Authors Computation (2022)

Table 5, indicates the seasonal temperature over Delta State, adjudicating from the table it can be observed that temperature ranges between 25.1 °C – 28.9 °C, with the highest temperature of 28.9 °C in Asaba and the lowest temperature of 25.1 °C in Asidani and Agbor. Temperature from January to May was high in all the urban and rural areas and this range was 26.9 °C – 28.9 °C. However, a lower temperature (25.1 °C – 26.5 °C) was observed in all the stations from June – October. The low temperature in these stations is attributed to the influence

of the wet rainy season. But, November - December had higher temperatures in the urban and rural areas which ranges between 27.0 °C – 27.7 °C.

Table 6. Mean Temperature and DTR Between Urban and Rural Areas Over Delta State

Stations	Temperature	DTR
Warri	27.1	7.9
Abraka	27.1	8.3
Agbor	26.7	8.9
Asaba	26.9	9.3
Mean	27	8.6
Uwherun	27.0	7.7
Burutu	26.9	8.0
Asidani	26.6	8.3
Okpai	26.8	8.9
Mean	26.8	8.2
Urban and Rural Differences	0.2 °C	0.4 °C

Source: Authors Computation (2022)

Table 6, indicates that the mean urban-rural areas temperature of 27 °C and 26.8 °C show an urban warming of 0.2 °C. DTR spans 8.6 °C to 8.2 °C in the urban to rural areas of Delta state with a variation of 0.4 °C. It was observed that the urban area of Agbor and Asaba which are in Delta North, had lower temperatures of 26.7 °C and 26.9 °C respectively, while Warri and Abraka in Delta South and Central districts had higher temperatures of 27.1^{o}C respectively. The high temperature recorded in Warri and Abraka may be attributed to the high rate of gas flaring that is located around these areas (Efe, 2011). The same is said of the high temperature recorded in Uwherun, Burutu, Asidani and Okpai although they are rural areas (26.8 °C - 27.0 °C). The DTR in the urban area spans 7.9 °C in Warri to 9.3 °C in Asaba. In rural areas, it ranges between 7.7 °C in Uwherun to 8.9 °C in Okpai. The contrast of 0.4 °C in DTR in urban and rural areas is ascribed to urban influence. The high DRT in Okpai, Asidani and Burutu in rural areas is also attributed to excessive gas flaring. While the low DTR in Uwherun, being a rural area is attributed to high rainfall in the area which has a significant influence on the DTR amount. This corroborated the works of PNAS (2007); Zhou et al. (2009); Dai et al. 1999). They demonstrated that rainfall has significant effects on DTR. Also, Dike et al. (2019) confirmed that areas with low DTR signifies area with high rainfall and, areas with low rainfall signifies area with high DTR. But this study is not in tandem with that of Wang et al. (2012) and

Obansola (2015), who demonstrated that DTR in the urban area shows a downward trend owing to the effect of urbanization, with DTR showing an increasing trend in the rural area. The results demonstrated that substantial signal of UHI in Delta State, with a clear pointer of urban-rural difference (0.2 °C) increase in the mean annual temperature and 0.4 °C increase in the DTR. This also manifests in a substantial night-time heat island effect in the state.

Table 7. Paired T-Test Between Urban - Rural Temperature in Delta State

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Urban-Rural	.18492	.23670	.01076	.16378	.20606	17.187	483	.000

Source: Authors Computations (2022)

Table 7 revealed that $t(483) = 17.187$, $p < 0.05$ thus there is a significant difference in annual mean temperature between an urban and rural area of Delta State.

Table 8. Paired T-Test Between Urban - Rural Mean Annual DTR in Delta State

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Urban-Rural	.61901	.28577	.01299	.59348	.64453	47.654	483	.000

Source: Authors Computations (2022)

From Table 8, $t(483) = 47.654$, $p < 0.05$, thus there is a significant difference in annual DTR in the urban-rural area of Delta State at $p < 0.05$.

Table 9. ANOVA Explaining the Mean Temperature Variation in Delta State

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.960	7	4.994	50.021	.000
Within Groups	95.851	960	.100		
Total	130.811	967			

Source: Authors Computation (2022)

In this result, Table 9 shows that the $f(7,960) = 50.021$, p-value is 0.000, which is less than the significance level of 0.05, therefore the annual mean temperature between urban and rural areas differs significantly.

Table 10. Tukey HSD Multiple Comparisons

Stations	N	Subset for alpha = 0.05			
		1	2	3	4
Asidani	121	26.5702			
Okpai	121	26.6521			
Agbor	121	26.6884			
Burutu	121		26.8694		
Asaba	121		26.9099		
Uwherun	121		26.9669	26.9669	
Abraka	121			27.0603	27.0603
Warri	121				27.1397
Sig.		.072	.242	.295	.515
Means for groups in homogeneous subsets are displayed.					
a. Uses Harmonic Mean Sample Size = 121.000.					

Source: Authors Computations (2022)

Table 10 shows that the mean temperatures in Asidani, Okpai, Agbor, Burutu, Asaba and Warri are significantly different. While the temperatures in Uwherun and Abraka are not significantly different.

Table 11. ANOVA Explaining the Mean DTR Variation in Delta State

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	234.571	7	33.510	756.188	.000
Within Groups	42.542	960	.044		
Total	277.113	967			

Source: Authors Computations (2022)

Table 11 indicates that $f(7,960) = 756.188$, p-value is 0.000, below the 0.05 threshold for significance, therefore the annual DTR between urban and rural areas differs significantly.

Table 12. Tukey HSD Multiple Comparisons

Stations	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Uwherun	121	7.7347					
Warri	121		7.9380				
Burutu	121		7.9554				
Okpai	121			8.2537			
Asidani	121			8.3322			
Abraka	121				8.6289		
Agbor	121					8.9331	
Asaba	121						9.2521
Sig.		1.000	.998	.073	1.000	1.000	1.000
Means for groups in homogeneous subsets are displayed.							
a. Uses Harmonic Mean Sample Size = 121.000.							

Source: Authors Computations (2022)

Table 12 shows that the mean DTR in Uwherun, Warri, Burutu, Okpai, Asidani, Abraka, Agbor and Asaba are significantly different.

Table 13. Mann-Kandel Trend Test Temperature in Delta State

Stations	Calculated Z	Upward	Downward	Remarks
Warri	4.01757	0.0000294	0.999971	Upward Trend
Agbor	3.94377	0.0000401	0.999960	Upward Trend
Asaba	4.02874	0.0000280	0.999972	Upward Trend
Abraka	4.11148	0.0000197	0.999980	Upward Trend
Uwherun	4.29312	0.0000088	0.99999	Upward Trend
Burutu	4.52616	0.0000030	1.00000	Upward Trend
Asidani	4.64061	0.0000017	1.00000	Upward Trend
Okpai	4.32002	0.0000078	0.99999	Upward Trend

Source: Authors Computation (2022)

Table 13, revealed the Mann-Kandel test for temperature in Delta state, the analysis indicates that all the stations had an upward trend in the series.

Table 14. Mann Kandel Trend Test Annual DTR in Delta State

Stations	Calculated Z	Upward	Downward	Remarks
Warri	0.884557	0.188198	0.811802	No trend
Abraka	1.59243	0.0556445	0.944355	No trend
Agbor	1.67224	0.0472385	0.952762	Upward trend
Asaba	1.70135	0.0444384	0.955562	Upward trend
Uwherun	1.08702	0.138515	0.861485	No trend
Burutu	1.47838	0.0696534	0.930347	No trend
Asidani	2.03508	0.0209213	0.979079	Upward trend
Okpai	1.44416	0.0743468	0.925653	No trend

Source: Authors Computation (2022)

Table 14, indicates the Mann-Kandel test for DTR in Delta state, the result of the analysis shows that Warri, Abraka, Uwherun, Burutu and Okpai had no trend in the series, while Agbor, Asaba and Asidani had an upward trend in the series.

4. CONCLUSIONS

The study revealed that Warri and Abraka had a higher mean annual temperature of 27.1 °C in the urban area, while the highest DTR of 9.3 °C was observed in Asaba an urban area. The outcomes of the study indicate an urban-rural bias of 0.2 °C in the annual temperature and 0.4°C in the urban-rural canopies. The study revealed that a significant difference exists in annual temperature between urban and rural areas of Delta State. The Mann-Kandel test on annual temperature revealed that a significant upward trend exists in urban and rural areas of Delta State. However, the annual mean DTR indicates that Warri, Abraka, Uwherun, Burutu and Okpai had no trend in the series, while Agbor, Asaba and Asidani had an upward trend in the series. The study, therefore, recommends that there is a need for the reappraisal of the regulations governing gas flaring in Nigeria, designs and planning of cities, especially the oil-producing states in Nigeria, and there is the need to replace pavements and concreted areas with green trees and grasses to lessen the effects of (UHI) and eventually advance the well-being of the people in Delta State.

The study, therefore, recommends that there is a need for the reappraisal of the regulations governing gas flaring in Nigeria, designs and planning of cities especially the oil-producing states in Nigeria. It can be observed from the study that, the temperature from the rural areas of Delta State is higher which may be attributed to gas flaring in most rural areas of the state, which in turn has changed the local climate of the rural areas. It is also evident that the DTR reading generated from the rural areas of Delta State is lower than the urban areas as a result of an increase in rainfall due to their nearness to water bodies.

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