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Mapping Urban Heat Stress in the Niger Delta Region of Nigeria

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Abstract- ***Mapping temperature zones in urban centers is an important reference for urban planning and construction but has received limited attention in the Niger Delta Region of Nigeria. This study investigates and maps temperature zones within selected cities in the region. Ambient and land surface temperature (LST) measurements were taken during wet and dry seasons across seven states using Landsat 8 satellite imagery and weather stations installed in the study areas. For Yenagoa, Bayelsa State, dry-season LST readings were highest at Point 9 near the FGN Medical Centre (31.12 °C) and lowest at Point 4 near the State Entrance Gate in Igbogene (28.32 °C), with other areas ranging from 28.24 °C to 30.65 °C. Wet-season LST varied from 24.87 °C to 35.15 °C, with Emiringi Road, Okutukutu, Amasoma Road, Okaka, and Oxbow Lake identified as high-temperature zones. Additional hotspots included Ekeki Motor Park, Swali Market, Opolo, and Okutukutu. In Calabar, Cross River State, the wet-season peak was recorded at Point 3 (Mbukpa, a densely populated residential area) at 30.57 °C higher than in the dry season, while the lowest reading occurred at Point 8 on Target Road (28.10 °C). In Asaba, LST ranged from 25.56 °C to 29.88 °C. Ambient temperatures in the dry season ranged from 26.40 °C to 37.20 °C, with relative humidity between 51.78% and 77.52% and north-easterly winds at 1.01–3.25 m/s. In the wet season, temperatures ranged from 24.33 °C to 32.00 °C, relative humidity from 58.50% to 92.16%, and southerly winds at 0.63–2.51 m/s. Several sites, including Asaba Bridge Head and Inebisi Junction, recorded comparatively lower LST and ambient temperatures during the wet season.***

Keywords: Land surface temperature (LST), Ambient Temperature, Combined Heat Stress Map, Niger Delta.

I. INTRODUCTION

Heat stress maps are specialised charts that use colour variations to represent data values in tables or physical maps, often in diagram form. Their quality largely depends on the GIS software used for mapping. Despite their name, heat stress maps do not necessarily depict temperature directly; instead, they display the amount or concentration of certain temperature-related measurements. These maps are especially useful for visualising large, complex datasets, such as those used in Earth science, allowing researchers to view entire datasets at once (NASA, 2022). Heat maps may take the form of a rectangular chart with numerical values in each cell, or more commonly in Earth science applications colour overlays on a geographic map. In such overlays, the colors represent variations in data values, as indicated in the map legend. These legends can use either a continuous color gradient or discrete color categories. For example, NASA uses heat maps to study changes such as land surface temperature, fire and carbon monoxide emission rates, chlorophyll concentration, and sea surface temperature (NASA, 2022).

Land surface temperature (LST) indicates how warm the Earth's surface appears from a satellite's perspective. "Surface" in this context refers to whatever the satellite detects through the atmosphere, whether it is snow, ice, grass, a building's roof, or forest canopy. While LST and ambient temperature are not identical, they are related and can influence one another. The LST maps in this study were generated using Landsat 8 data collected during both the dry and wet seasons for the study period. Map temperatures ranged from 4.74 °C (deep blue) to 53.42 °C (brownish red). In equatorial regions, LST typically remains consistently warm. Elevation also affects temperature, with higher terrain generally cooler than surrounding lowlands at the same latitude. Monitoring LST is crucial because heat emitted from Earth's surface both affects and is affected by weather and climate patterns. Scientists track these changes to study the effects of increasing greenhouse gas concentrations and to assess how rising LST impacts vegetation and ecosystems. Beyond research, LST mapping has practical applications for instance, commercial farmers can use

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it to determine crop water needs during the dry season, when plants are prone to heat stress. LST also influences human comfort, especially during power outages, when high surface temperatures can significantly affect living conditions.

II. METHODOLOGY

The Niger Delta Region of Nigeria, located at approximately latitude 5°19′20.40″ N and longitude 6°28′8.99″ E, is a geopolitical zone comprising the nine states of Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Abia, Imo, Ondo, and Rivers. It is bordered by Anambra State to the southeast, the Atlantic Ocean to the south, and Ekiti and Osun States to the southwest. As Nigeria's major oil and gas producing region, it holds a central role in the country's economy. This study employed a quantitative research approach. Sampling stations were purposively selected within urban centers in the seven states forming the study area. Data collection utilized specialized meteorological instruments, including a pole-mountable or standing RF433 MHz Meteorometer with a 100 m coverage range, equipped with weather history and alarm monitoring capabilities, and a BTMETER model 866AP handheld weather station as backup. These two instruments were used for ground-based data collection across the study sites.

Weather monitors were mounted at a height of 6 m above ground level in open spaces to prevent interference from surface heat sources. Data were recorded on the same day that the Landsat 8 satellite passed over the study area. The RF433 MHz Meteorometer measured air temperature, wind speed and direction, and relative humidity. A Garmin 72H GPS device was used to geo-reference sampling points. Land surface temperature (LST) data were obtained from Landsat 8 imagery, which is critical for studies in areas such as climate change, hydrology, geophysical and biophysical processes, and urban land-use/land-cover analysis. LST for any Landsat 8 image can be retrieved by first processing Band 10. In this study, LST was computed following the method proposed by Avdan and Jovanovska (2016), which was applied to all imagery collected during the research period:

I. Computation TOA (Top of Atmospheric) spectral radiance
II. Conversion of TOA to Brightness Temperature conversion
III. Calculation of the NDVI
IV. Calculation of the proportion of vegetation
V. Calculation of Emissivity
VI. Calculation of the Land Surface Temperature

LST = (Brightness Temperature T / (1 + (0.00115 BT / 1.4388) Ln (Emissivity)

III. RESULTS AND DISCUSSION OF FINDINGS

Land surface temperature (LST) is a key environmental parameter for assessing the exchange of energy and matter between the Earth's surface and the lower atmosphere (Aniekan & Akwaowo, 2017). The Landsat maps of the study stations within Yenagoa metropolis for both wet and dry seasons (Tables 1 and 2) reveal significant seasonal differences. In the dry season, LST values ranged from a minimum of 22.30 °C to a maximum of 53.42 °C, while in the wet season, values ranged from 13.54 °C to 28.69 °C. These variations suggest possible deviations or deficiencies in the satellite-derived results, or the presence of positive temperature anomalies where temperatures were higher than reference points particularly in the dry season.

Satellite sensor readings can be influenced by several factors. Because the sensor receives signals from space, atmospheric conditions (e.g., air pollution, weather) and surface emissivity the ratio of radiation emitted by a surface to that of a blackbody at the same temperature, indicating how efficiently a surface emits or reflects solar energy can affect sensitivity. Additionally, elevation, atmospheric circulation patterns, and ocean currents, which redistribute heat globally, also influence LST distribution (Mohammad, Amir, & Hamid, 2021). The combined heat stress map (Figure 1) shows LST patterns that parallel the shape of Yenagoa as viewed from satellite imagery. From the entrance gate at Igbogene to Famgbe at the city's far end, green areas along both sides of the approach road indicate land cover beyond the urban core. Outside the city, LST values appear in patches on the heat stress map. Areas with significant vegetation cover recorded average LST values around 17.57 °C, whereas the city center averaged 30.72 °C. The zones with the highest heat stress extended through Famgbe, Akaba, Okutukutu, Edepie, Opolo, and Ekenfa.

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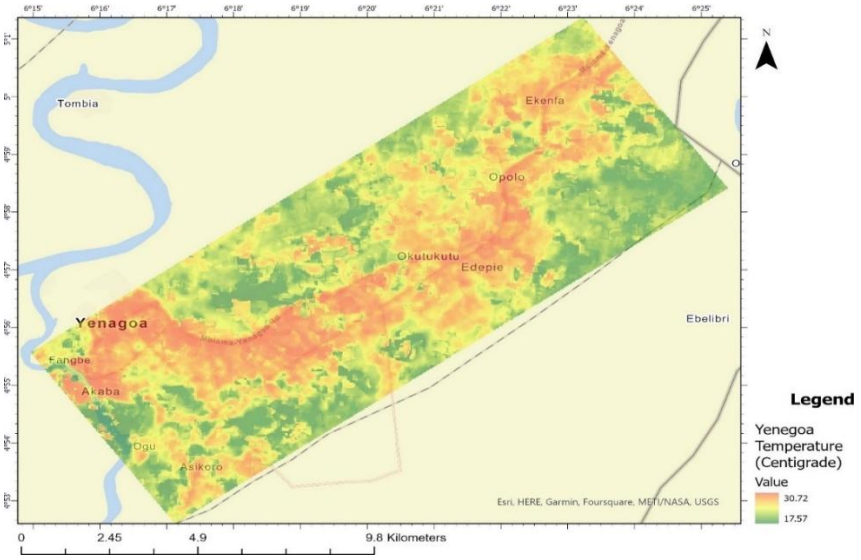

Figure 1: Combined Heat Stress Map for Yenagoa City, Bayelsa State Niger Delta Region

Table 1: Temperature Variations Observed by Landsat8 within Yenagoa Metropolis,Yenagoa. Bayelsa State in the Dry Season.

State	Location	Points	Latitude (y)	Longitude (x)	Temp. Readings	LST (Celsius)
Bayelsa	Tombia Round about	P1	4.953444	6.357722	26.6	24.87
Bayelsa	New Road Emiringi	P2	4.926389	6.356389	29.73	32.42
Bayelsa	Amasoma Road	P3	4.969639	6.341778	32.2	33.10
Bayelsa	State Entrance Gate	P4	5.047528	6.415667	31.5	33.63
Bayelsa	Etegwe Market	P5	4.955972	6.356833	36.43	34.86
Bayelsa	Opolo	P6	4.949528	6.335722	33.73	25.36
Bayelsa	Igbogene	P7	5.036528	6.403222	31.6	24.76
Bayelsa	Ekeki Motor Park	P8	4.929028	6.295	34.95	26.18
Bayelsa	FGN Medical Centre	P9	4.933917	6.268917	34.75	27.28
Bayelsa	St. Peter's Anglican Church	P10	4.924611	6.263389	34.2	26.69
Bayelsa	Swali Market	P11	4.885278	6.267056	34.78	32.10
Bayelsa	Ox-bow Lake	P12	4.90675	6.280944	34.88	34.16
Bayelsa	Okaka by Airforce Base	P13	4.917861	6.307722	36.43	35.15
Bayelsa	NUPRC/Office Okutukutu	P14	4.94867	6.349306	36.41	34.38

Source: Landsat 8 results

Table 2: Landsat8 Temperature Variations of Bayelsa State in the Wet Season

State	Location	Points	Latitude (y)	Longitude (x)	Temp. Readings	LST (Celsius)
Bayelsa	Tombia Round about	P1	4.953444	6.357722	26.6	24.87
Bayelsa	New Road Emiringi	P2	4.926389	6.356389	29.73	32.42
Bayelsa	Amasoma Road	P3	4.969639	6.341778	32.2	33.10
Bayelsa	State Entrance Gate	P4	5.047528	6.415667	31.5	33.63
Bayelsa	Etegwe Market	P5	4.955972	6.356833	36.43	34.86
Bayelsa	Opolo	P6	4.949528	6.335722	33.73	25.36
Bayelsa	Igbogene	P7	5.036528	6.403222	31.6	24.76
Bayelsa	Ekeki Motor Park	P8	4.929028	6.295	34.95	26.18

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Bayelsa	FGN Medical Centre	P9	4.933917	6.268917	34.75	27.28
Bayelsa	St. Peter's Anglican Church	P10	4.924611	6.263389	34.2	26.69
Bayelsa	Swali Market	P11	4.885278	6.267056	34.78	32.10
Bayelsa	Ox-bow Lake	P12	4.90675	6.280944	34.88	34.16
Bayelsa	Okaka by Airforce Base	P13	4.917861	6.307722	36.43	35.15
Bayelsa	NUPRC/Office Okutukutu	P14	4.94867	6.349306	36.41	34.38

Source: Landsat 8 results

Calabar, Cross River State

The adaptive capacity of an urban area depends on its ability to adjust to heat waves, with green infrastructure playing a key role in mitigating high urban temperatures (Maragno, Denis, Fontana, Michele, Musco, & Francesco, 2020). Landsat-derived temperature maps for Calabar metropolis (Tables 3 and 4) identified five distinct temperature zones. In the wet season, Land Surface Temperature (LST) values ranged from 7.87–14.02 °C in Zone 1, 14.03–20.18 °C in Zone 2, 20.19–26.34 °C in Zone 3, 26.35–32.50 °C in Zone 4, and above 32.51 °C in Zone 5, representing the highest wet-season LST. These results align with global observations of increasing heat stress indices and rising temperatures (Knutson & Ploshay, 2016). In the dry season, the LST map (Figure 2) revealed both increases and decreases in temperature across zones, with values of 0–16.99 °C in Zone 1, 17.00–23.92 °C in Zone 2, 23.93–30.84 °C in Zone 3, 30.85–37.77 °C in Zone 4, and 37.78–44.70 °C in Zone 5, the maximum dry-season LST for 2022.

Heat stress was extensive across Calabar and surrounding developed towns, with large, consistent areas of elevated LST. Although the city has aesthetic vegetation that shades paved roads from direct solar heating, green areas are sparsely distributed and mostly located far from the city center. The heat stress map (Figure 2) shows that the southern part of the city experiences the highest LST, while the urban core also faces persistent heat stress. Specific hotspots include Ikot Omin and Esuk Utan, with additional heat stress observed around Adiabo Ikot Mbo. In contrast, areas toward Ikot Omin show lower stress levels, and Akpabuyo, located in a rural zone, exhibits lower LST and reduced heat stress. A notable LST difference of 8.74 °C was observed between rural and urban areas, with legend values of 29.50 °C for the city center and 20.76 °C for the rural zone.

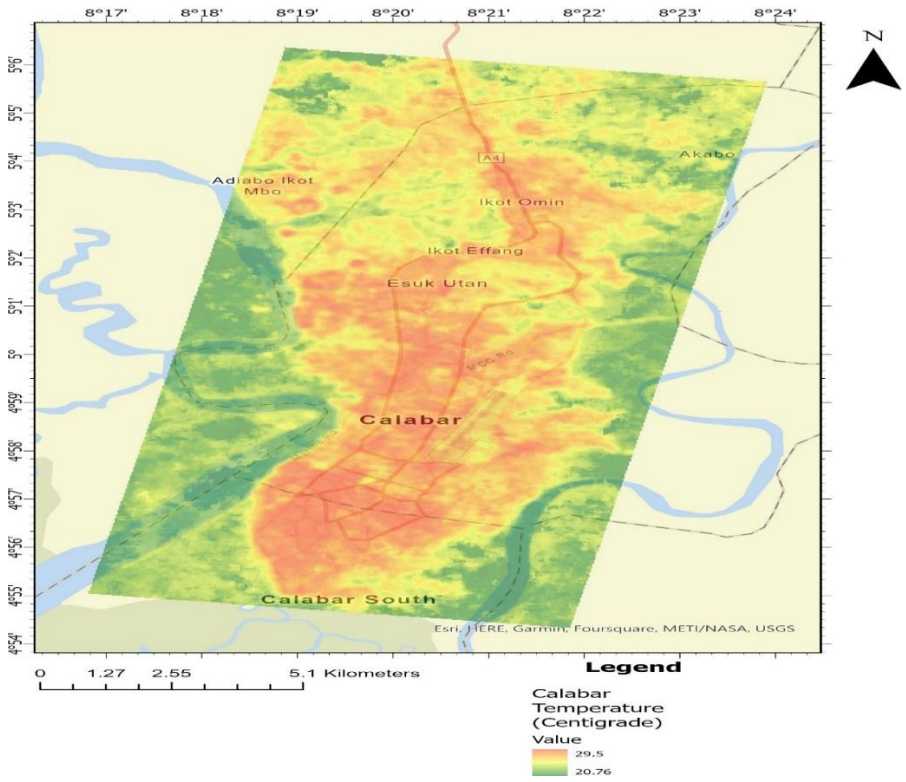

Figure 2: Combined Heat Stress Map for Calabar City in Cross State Niger Delta Region

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Table 3: Landsat 8 Temperature Variations Observed in the Wet Season within Calabar Metropolis, Cross River State.

State	Location	Points	Latitudes (y)	Longitudes (x)	Temperature Readings	LST (Celsius)
Cross River	Okuku RD	P1	6.714936111	8.776861111	29.95	29.96
Cross River	Mayne Avenue	P2	4.944908333	8.325708333	31.28	29.78
Cross River	Mbukpa	P3	4.940205556	8.316994444	32.16	30.57
Cross River	Edibe	P4	4.950183333	8.316508333	30.15	29.80
Cross River	Calabar Stadium	P5	4.968091667	8.328025	34.26	28.66
Cross River	Odukpani	P6	5.08633	8.34551	29.88	29.51
Cross River	MH Way	P7	5.02922	8.3377	29.8	29.69
Cross River	Target Road	P8	4.956144	8.33122	28.75	28.10
Cross River	Lemna Junction	P9	5.039255	8.357025	28.43	29.20

Source: Landsat 8

Table 4: Landsat 8 Temperature Variations Observed in the Dry Season within Calabar Metropolis, Cross River State.

Study Points	Location	Latitudes (y)	Longitudes (x)	Temperature	LST (Celsius)
P1	Okuku RD	6º42'53.77"	8º46'36.70"	29.92	27.78
P2	Mayne Avenue	4º56'41.67"	8º19'32.55"	30.19	28.77
P3	Mbukpa	4°56'24.74"	8°19'1.18"	31.53	28.56
P4	Edibe	4°57'0.66"	8°18'59.43"	31.74	28.70
P5	Calabar Stadium	4°58'5.13"	8°19'40.89"	33.18	29.02
P6	Odukpani	5.08633	8.34551	35.29	28.15
P7	MH Way	5.02922	8.3377	35.79	29.07
P8	Target Road	4.956144	8.33122	36.41	27.49
P9	Lemna Junction	5.039255	8.357025	37.51	28.77

Source: Landsat 8

Asaba, Delta State

Various models, operating on different scales, can be used to assess the urban climate depending on the study's objectives and the size of the study area. Accurate descriptions of the urban land surface are essential, as modeled temperatures and urban energy balance components are highly sensitive to urban canopy parameters (Marie, Matthias, Hans, Christoph, Josef, Alexandra, Robert, & Frieke, 2018). In the wet season of 2022, temperature values for Delta State ranged from 4.73–11.80 °C in the lowest zone, 11.81–18.89 °C in the next, and 18.90–25.98 °C in other areas shown on the legend (Figure 3). Higher temperature zones ranged from 25.99–33.06 °C, with the maximum LST exceeding 33.07 °C. In the dry season (Figure 4.3), LST values were 0–19.28 °C in the coolest zone, 19.29–25.19 °C in the next, followed by 25.20–31.11 °C and 31.12–37.02 °C, with a maximum of 37.03–42.94 °C.

Detection of LST in urban environments, in addition to defining the isotherms of the Superficial Urban Heat Island (SUHI), enables targeted mitigation measures such as reforestation to enhance evapotranspiration, improved land-use distribution, and balancing the physical–thermal properties

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(emittance and albedo) of building materials (Grajeda, Ruth, Alonso, Elia, Esparza, Carlos, Martinez, Wilfrido, Hugo, Yedra, & Eduardo, 2020). The LST map (Figure 3) reveals scattered temperature patterns from the urban center to rural areas. The stretch of tarred expressway from the bridgehead through Inebis Road to the airport area shows persistent high LST year-round. Oshimili South records little to no heat stress, with the Anwai area experiencing lower stress levels (Figure 3). The urban center records an LST of 32.55 °C, while surrounding green areas average 20.01 °C.

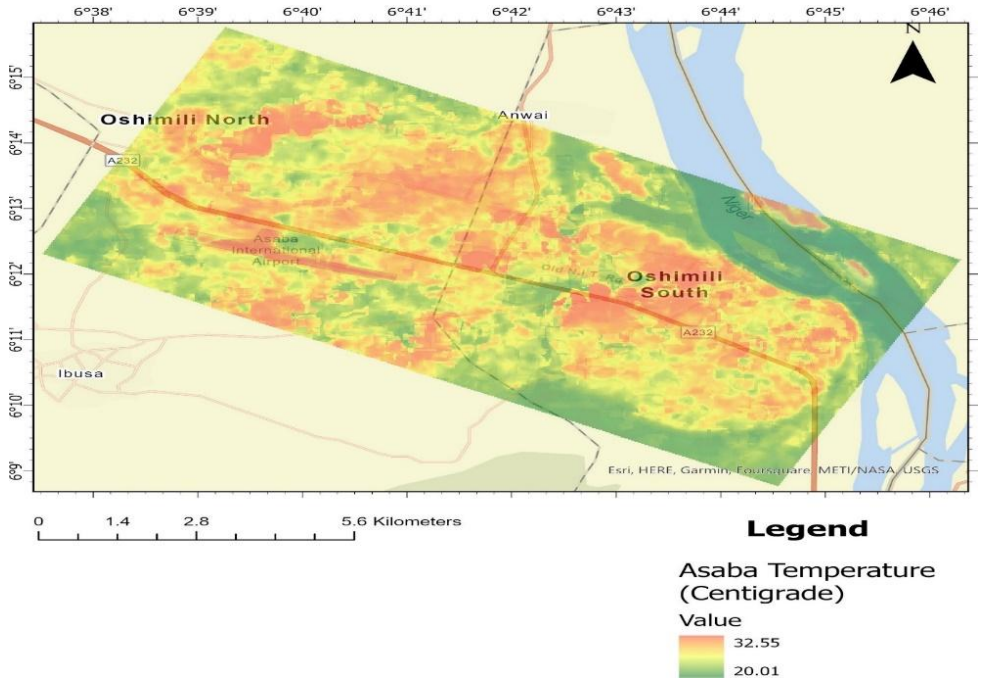

Figure 3: Combined Heat Stress Map for Asaba City, Delta State, Niger Delta Region

Benin, Edo State

Urbanisation is inevitable in a developing region like the Niger Delta. One of its major adverse effects is the expansion of impervious surfaces, which leads to an increase in land surface temperature (LST). Thermal imagery and LST analyses have been used to create detailed temperature maps, and the results consistently show that densely built-up areas experience higher LST, while open lands and vegetated zones record lower values (Vigneshwaran et al., 2022). The LST map (Figure 4) for Benin City displays scattered temperature patterns extending from the urban core to surrounding rural areas, which appear in green on the map.

A continuous stretch of tarred expressway, from the Benin bypass in the south to the midpoint in the northern sector, shows significant heat stress. In contrast, the far northern section of the expressway features green zones with reduced urban heat stress. Urban locations recording high LST around 33.64 °C include Egor (eastern part of the city), Oredo (same sector), the Benin–Warri Expressway in the south, Ikpoba Okha in southern Benin, Ekodei in the west, Ring Road at the city center, and Ikiadolo in the north. These sites represent key heat stress hotspots within the metropolis. Areas with lower LST, classified as “green zones,” are found around Akure Benin Road in the west, the far east of Ikiadolo, Oredo’s eastern edge near the Benin bypass toward Agbor Road, and Ago Osakwe. These zones recorded temperatures of 22.94 °C, significantly lower than the stressed urban core area (Figure 4).

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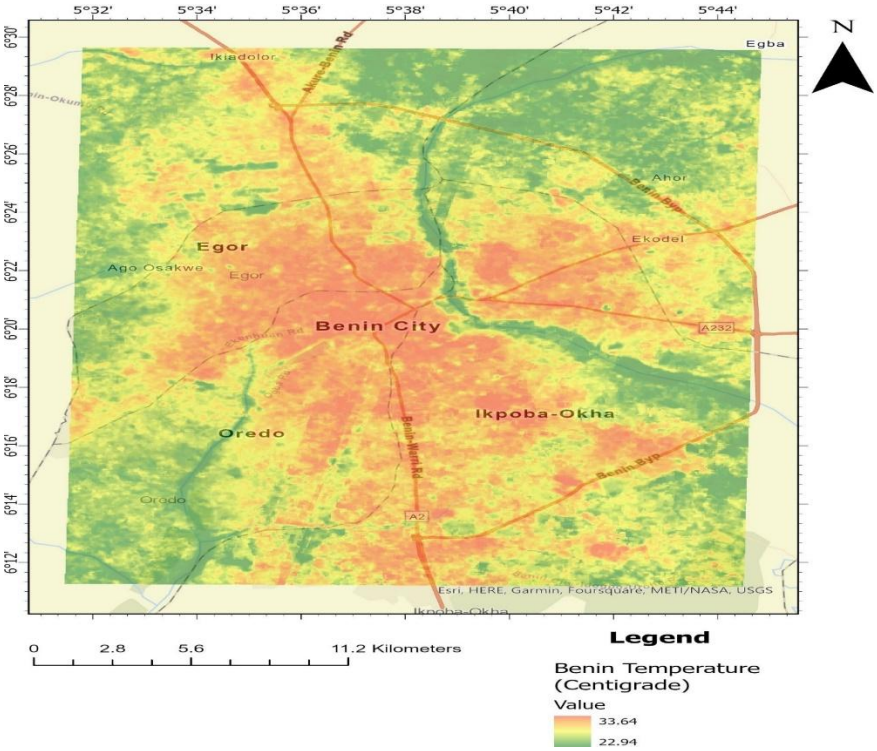

Figure 4: Combined Heat Stress Map for Benin City, Edo State Niger Delta Region

Table 7: Landsat 8 Temperature Variations Observed in the Wet Season within the Study Areas in Edo State

State	Location	Points	Latitude (y)	Longitude (x)	Temperature Readings	LST (Celsius)
Edo	Auchi Town	P1	7.072333333	6.273122222	26.26	33.50
Edo	Auchi STN 2 By Public School Road	P2	7.070736111	6.268294444	24.2	33.36
Edo	Warake Road	P3	7.070736111	6.254597222	26.64	34.84
Edo	Justice Momoh Road	P4	7.066413889	6.26215	26.25	33.75
Edo	Igara Road New Market	P5	7.270291667	6.47445	26.76	35.31
Edo	Benin/ oregbeni Road	P6	6.347819444	5.671308333	32.76	27.58
Edo	Agbor Road Benin	P7	6.346811111	5.678655556	34.5	27.31
Edo	Akpakpava	P8	6.342802778	5.634344444	36.8	28.56
Edo	Ring Road Benin	P9	6.332001667	5.622447222	37.41	29.95
Edo	JBS Estate GRA	P10	6.307416667	5.623763889	24.58	26.78
Edo	Igbesanwan	P11	6.336477778	5.627741667	25.75	28.75
Edo	Igun Street	P12	6.341361111	5.633433333	26.56	28.95`
Edo	Ikpoba Slope	P13	6.346319444	5.639466667	29.9	27.79
Edo	New Benin Market	P14	6.349486111	5.631052778	32.87	29.72
Edo	Uselu	P15	6.370641667	5.616791667	33.97	28.09

Source: Landsat 8

Table 8: Landsat 8 Temperature Variations Observed in the Dry Season within the Study Areas in Edo State.

Study Points	Location	Latitude (x)	Longitude (y)	Temp. Readings	LST (Celsius)
P1	Auchi Town	7º4'20.40"	6º16'23.24"	26.71	35.67
P2	Auchi STN 2 By Public Sch. Rd	7º4'14.65"	6º16'5.86"	27.50	35.22
P3	Warake Road	7º4'14.65"	6º15'16.55"	30.39	36.12

P4	Justice Momoh Road	7°3'59.09"	6°15'43.74"	31.06	34.94
P5	Igara Road New Market	7°16'13.05"	6°28'28.02"	31.72	33.30
P6	Benin/ oregbeni Road	6°20'52.15"	5°40'16.71"	33.56	32.40
P7	Agbor Road Benin	6°20'48.52"	5°40'43.16"	32.39	32.72
P8	Akpakpava	6°20'34.09"	5°38'3.64"	35.78	34.43
P9	Ring Road Benin	6°19'55.206"	5°37'20.81"	36.69	32.28
P10	JBS Estate GRA	6°18'26.70"	5°37'25.55"	35.48	33.05
P11	Igbesanwan	6°20'11.32"	5°37'39.87"	35.28	33.53
P12	Igun Street	6°20'28.90"	5°38'0.36"	34.46	34.61
P13	Ikpoba Slope	6°20'46.75"	5°38'22.08"	33.24	33.58
P14	New Benin Market	6°20'58.15"	5°37'51.79"	33.39	34.81
P15	Uselu	6°22'14.31"	5°37'0.45"	33.14	34.21

Source: Landsat 8

Owerri, Imo State

The LST map (Figure 5) reveals extensive heat stress across Owerri, with green zones located approximately 3.5–6.5 km from the city center. Higher heat stress is concentrated around key locations such as the Owerri Divisional Police Headquarters in the north, Port Harcourt Road, the Imo State House of Assembly, Douglas Road, and the Control area in central Owerri. Surface temperatures in these hotspots reached approximately 30.73 °C (Tables 9 and 10), while areas with lower heat stress recorded values around 22.58 °C.

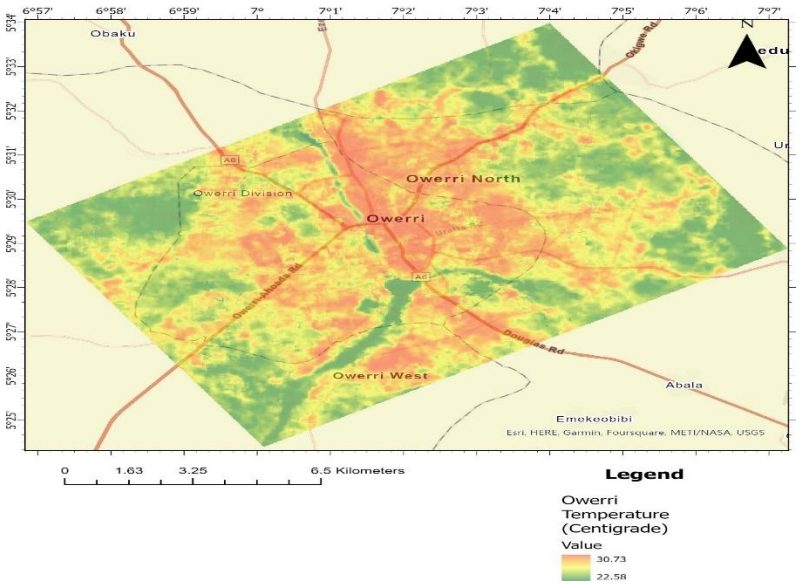

Figure 5: Combined Heat Stress Map for Owerri City Imo State Niger Delta Region

Table 9: Landsat Temperature Variations Observed in the Wet Season within the Study Areas in Delta State.

State	Location	Points	Latitudes (y)	Longitudes (x)	Temperature Readings	LST (Celsius)
Delta	Abraka	P1	5.783261	6.098438889	32	27.16
Delta	Agbor	P2	6.253588	6.197708333	31.76	30.23
Delta	Asaba	P3	6.18729	6.733355	25.88	25.56
Delta	Trafic Inebisi Road	P4	6.20472	6.7267	28.78	26.19
Delta	Asaba Bridge Head	P5	6.181588	6.735621667	30.15	25.40
Delta	Effurun	P6	5.5489	5.780131667	26.42	28.47
Delta	Warri Town	P7	5.549553	5.729443333	25.35	27.16

Delta	Oghara	P8	5.94226	5.687641667	27.5	28.02
Delta	Oghara Green Area	P9	5.929813	5.69267	30.35	26.13
Delta	Amokpe Sapele	P10	5.854522	5.721543333	31.51	28.25
Delta	Sapele RD KM 8	P11	5.576962	5.783901667	26.32	27.06
Delta	KM2 Mami Market 5 Warri	P12	5.590427	5.78115	24.33	25.84
Delta	Okpe RD Sapele	P13	5.886585	5.686495278	28.92	29.88

Source: Landsat 8

Table 10: Landsat 8 Temperature Variations Observed in the Dry Season within the Study Areas in Delta State.

Study Points	Location	Latitudes (y)	Longitudes (x)	Temp	LST (Celsius)
P1	Abraka	5°46'59.74"	6°5'54.38"	26.40	31.14
P2	Agbor	6°15'12.918"	6°11'51.750"	32.39	32.88
P3	Asaba	6°11'14.244"	6°44'0.078"	35.85	32.76
P4	Trafic Inebisi Road	6°12'16.992"	6°43'36.120"	34.40	33.39
P5	Asaba Bridge Head	6°10'53.718"	6°44'8.238	36.22	32.90
P6	Effurun	5°32'56.040"	5°46'48.474"	34.24	30.83
P7	Warri Town	5°32'58.392"	5°43'45.996"	33.57	25.09
P8	Oghara	5°56'32.136"	5°41'15.510"	28.82	32.17
P9	Oghara Green Area	5°55'47.328"	5°41'33.612"	33.10	30.91
P10	Amokpe Sapele	5°51'16.278"	5°43'17.556"	34.33	32.82
P11	Sapele RD KM 8	5°34'37.062"	5°47'2.046"	37.20	30.33
P12	KM2 Mami Market 5 Warri	5°35'25.536"	5°46'52.140"	35.88	29.77
P13	Okpe RD Sapele	5°53'11.706"	5°41'11.383"	33.35	31.31

Source: Landsat 8

Port Harcourt, River State

The heat stress map (Figure 6) reveals extensive coverage of scattered LST patterns stretching from the urban center to the outskirts of Port Harcourt. In the dry season, LST values in the urban core reached 31.83 °C, compared to 19.84 °C in rural "green" areas, representing a notable temperature difference of 11.99 °C. High heat stress zones were concentrated along the East–West Road, from Choba in the west to Eleme Junction in the east, as well as the Port Harcourt–Aba Expressway from Oyigbo into the city center. Additional elevated LST areas include Ikwerre Road from Iguruta to the Education area in Mile 1, Eagle Island, and the Trans Amadi Industrial Layout. These locations consistently record high temperatures year-round. The pattern indicates that built-up areas with dense infrastructure absorb and retain more heat, while vegetated zones on the outskirts remain significantly cooler.

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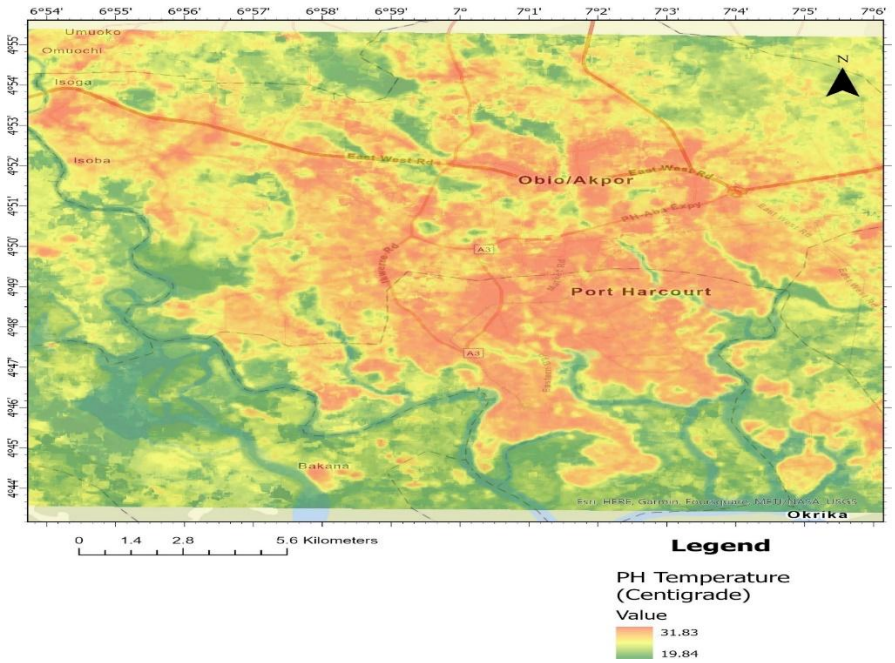

Figure 6: Combined Heat Stress Map for Port Harcourt City Rivers State Niger Delta

Table 13: Landsat 8 Temperature Variations Observed in the Wet Season within Port Harcourt Metropolis Rivers State

State	Location	Points	Latitudes (y)	Longitudes (x)	Temperature Readings	LST (Celsius)
Rivers	Ikwerre Road	P1	4.801944444	6.990333333	28.05	28.41
Rivers	Mile 3	P2	4.801277778	6.990527778	27.68	28.60
Rivers	Station road	P3	4.777694444	7.017194444	28.56	26.28
Rivers	Aba Road	P4	4.850813	7.058934	29.47	26.60
Rivers	Rumuomasi	P5	4.835777778	7.021722222	26.42	27.54
Rivers	Trans Amadi	P6	4.806138889	7.026777778	29.05	28.14
Rivers	Aggrey Road	P7	4.761694444	7.023583333	31.71	27.90
Rivers	Eagle Island	P8	4.783336111	6.9806	32.61	26.34
Rivers	Abuloma	P9	4.795794444	7.030444444	30.93	27.66
Rivers	Trans Amadi 2	P10	4.817741667	7.031438889	30.71	26.69
Rivers	Elelenwo	P11	4.828208333	7.074466667	29.3	26.83
Rivers	Rumuola	P12	4.837752778	7.006141667	30.72	26.32
Rivers	Diobu	P13	4.787480556	7.000177778	35.53	35.01
Rivers	Moscow Road	P14	4.767416667	7.019361111	37.2	37.93
Rivers	Borokiri	P15	4.743958333	7.044069444	37.5	36.19

Source: Land sat 8 data

Table 14: Landsat 8 Temperature Variations Observed in the Dry Season within Port Harcourt Metropolis Rivers State

Study Points	Location	Latitudes(y)	Longitudes(x)	Temp Readings	LST (Celsius)
P1	Ikwerre Road	4°48'07.0"	6°59'25.2"	27.92	28.50
P2	Mile 3	4°48'04.6"	6°59'25.9"	28.71	28.42
P3	Station road	4°46'39.7"	7°01'01.9"	29.96	26.25
P4	Aba Road	4.850813	7.058934	30.10	25.98

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P5	Rumuomasi	4°50'08.8"	7°01'18.2"	31.13	28.80
P6	Trans Amadi	4°48'22.1"	7°01'36.4"	31.71	27.47
P7	Aggrey Road	4°45'42.1"	7°01'24.9"	33.31	27.04
P8	Eagle Island	4.783336111	6.9806	36.40	36.76
P9	Abuloma	4°47'44.86"	7°1'49.60"	37.45	36.76
P10	Trans Amadi 2	4°49'3.87"	7°1'53.18"	37.57	37.33
P11	Elelenwo	4°49'41.55"	7°4'28.08"	35.01	35.91
P12	Rumuola	4°50'15.91"	7°0'22.11"	34.56	36.57
P13	Diobu	4°47'14.93"	7°0'0.64"	33.65	27.21
P14	Moscow Road	4°46'2.70"	7°1'9.70"	33.40	27.33
P15	Borokiri	4°44'38.25"	7°2'38.65"	30.87	30.71

Source: Land sat 8 data

Uyo, Akwa Ibom State

The heat stress map (Figure 7) shows extensive coverage across the urban core of Uyo, extending from Oron Road in the west toward Etoi, Ikot Ekpe Mbiribit, Ikot Okon, and Ibiabong in the south. Notably, areas such as Ikot Akpan Abia, although located near the outskirts of the city, also exhibit significant heat stress. In the dry season, the urban center recorded LST values of approximately 29.92 °C, while surrounding green areas such as those at the end of Abak–Itu Road, Uruan, and Mbak showed much lower LST values, averaging 22.24 °C. This difference highlights the cooling effect of vegetated zones in contrast to the heat retention within densely built-up urban areas.

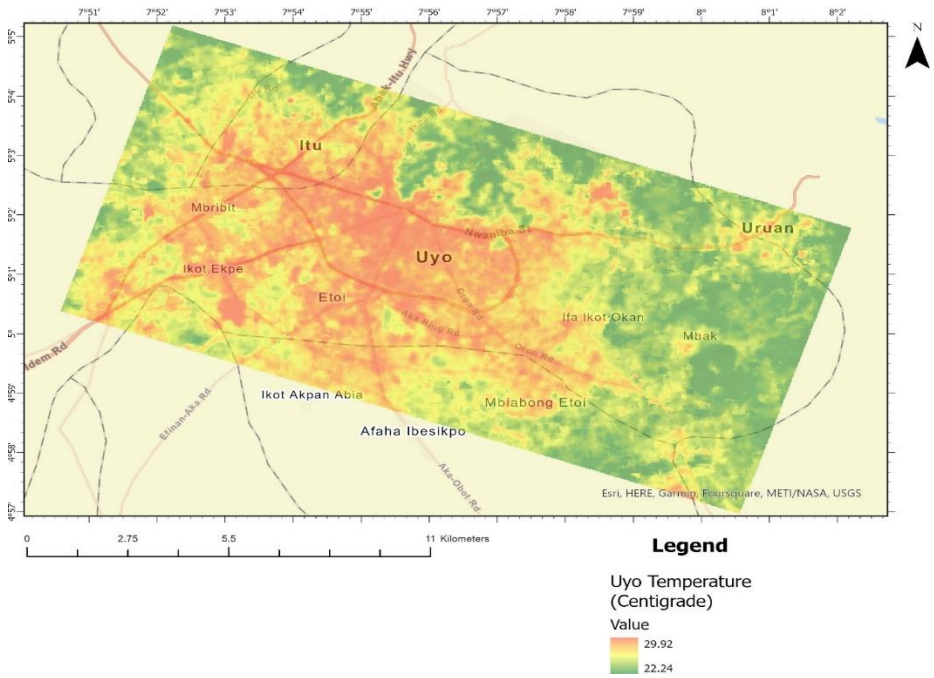

Figure 7: Combined Heat Stress Map for Uyo City Akwa Ibom State Niger Delta Region

Table 15: Landsat 8 Temperature Variations Observed in the Wet Season within Uyo Metropolis, Akwa Ibom State.

State	Location	Points	Latitudes (y)	Longitudes (x)	Temperature Readings	LST (Celsius)
Akwa_Ibom	Oron Road	P1	5.008208333	7.942183333	27.48	30.88
Akwa_Ibom	Aka Etinan	P2	5.008836111	7.916472222	29.08	30.77
Akwa_Ibom	Ewet Estate	P3	4.991063889	7.966916667	29.88	30.57
Akwa_Ibom	Mbak 4 Nsukara	P4	5.02528	7.9942	28.81	28.64

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Akwa_Ibom	Idoro Road	P5	5.04276	7.89179	29.85	29.44
Akwa_Ibom	Ediene Ikot obio	P6	5.0415	7.89146	28.6	28.69
Akwa_Ibom	Eket Essa Ekpa Inum	P7	4.66341	7.98404	28.78	23.17
Akwa_Ibom	Oron RD Residential	P8	5.006066667	7.929711111	26.53	30.60
Akwa_Ibom	Atai Obio Offot	P9	5.01182	7.85566	29.68	28.09

Source: Landsat 8 data

Table 16: Landsat 8 Temperature Variations Observed in the Dry Season within Uyo Metropolis, Akwa Ibom State.

Study Points	Location	Latitudes (y)	Longitudes(x)	Temp. Readings	LST (Celsius)
P1	Oron Road	5°0'29.55"	7°56'31.86"	29.77	29.13
P2	Aka Etinan	5°0'31.81"	7°54'59.30"	29.98	29.25
P3	Ewet Estate	4°59'27.83"	7°58'0.90"	33.61	28.45
P4	Mbak 4 Nsukara	5.02528°	7.99420°	33.08	28.21
P5	Idoro Road	5.04276	7.89179	35.18	29.21
P6	Ediene Ikot obio	5.04150	7.89146	35.21	28.24
P7	Eket Essa Ekpa Inum	4.66341	7.98404	37.60	30.62
P8	Oron RD Residential	5°0'21.84"	7°55'46.96"	35.36	26.51
P9	Atai Obio Offot	5.01182	7.85566	35.94	25.59

Source: Landsat 8 data

Regional Trends and Implications

Across all the Niger Delta cities studied, the dry season temperatures were consistently higher than wet season values, reflecting seasonal variations in solar radiation and evapotranspiration. The most heat-stressed zones corresponded to areas with high building density, impervious surfaces, and limited vegetation. Conversely, cooler temperatures were found in rural and vegetated areas, underscoring the mitigating influence of green infrastructure. The consistent temperature gaps ranging from 7 °C to nearly 12 °C between rural and urban areas indicate a pronounced Urban Heat Island (UHI) effect across the Niger Delta Urban Centres.

IV. CONCLUSION

The urban centres in the Niger Delta Region of Nigeria have different temperature zones within them, also temperature correlation for two seasons was observed only for two states during the study, while other states have varying temperatures with the seasons. Also, at some of the study area temperature wet and dry seasons results showed similarity while at other study location proximity to coastal line played a major role in temperature distributions and dispersion patterns. The cities under study exhibited different temperature characteristics as the heavily developed and industrialised tend to have temperature class 4 and 5 in most of the sampled area, The high temperature zones lie within the major centres inside the metropolis. In order to contribute to the sustainability of the urban environment, there is need to expand some of the cities to decongest them and create more greener cities for comfortable habitation. Ambient and land surface temperature data for the purpose of urban development should be created by meteorological agencies and made available as guidelines for urban planners and infrastructural developers in the Niger delta.

V. RECOMMENDATIONS

Based on the research findings, several targeted interventions are recommended to address heat stress and strengthen climate resilience in the Niger Delta Region. Expanding urban green infrastructure is critical, with the establishment of parks, green belts,

and roadside vegetation corridors in high-LST zones such as Yenagoa's city center, Calabar's southern district, and Port Harcourt's industrial layouts. This should be complemented by large-scale tree planting along major transport corridors, including the Benin–Warri Expressway, Port Harcourt–Aba Expressway, and Oron Road in Uyo. Building codes should be updated to promote reflective and permeable materials such as cool roofing, permeable pavements, and light-colored surfaces—while offering subsidies or tax incentives for retrofitting public buildings with heat-reflective materials.

Protecting and restoring peri-urban vegetation is equally vital, including halting the conversion of green belts into impervious developments, particularly in cooler zones like Akpabuyo (Calabar), Anwai (Asaba), and Uruan (Uyo), and advancing community-driven afforestation and mangrove restoration projects to enhance evapotranspiration. Land surface temperature data should be fully integrated into urban planning, guiding zoning, ventilation corridor design, and shaded public space allocation, while requiring Environmental Impact Assessments (EIAs) for major projects to include heat impact projections. Public awareness and climate literacy programs are also essential to educate residents and planners about the Urban Heat Island effect and its health risks, encouraging household-level greening initiatives like rooftop gardens and courtyard vegetation. Finally, seasonal heat stress management programs should be adopted during peak dry-season months, including shaded rest stops, increased watering of urban trees, and the provision of public cooling centers to safeguard vulnerable populations.

REFERENCES

[1] Aniekan, E. & Akwaowo, E. (2017). *Temporal appraisal of land surface temperature dynamics across the nine states of Niger Delta region of Nigeria from 2004-2016 using remote sensing dataset of Modis.

[2] Araya, Y. N., et al. (2012). Potential: Climate change adaptation strategies in agricultural communities).

[3] Audu, M. O., et al. (2012). Potential: Environmental pollution and health risks in oil-producing regions)

[4] Avdan, U., & Jovanovska, G. (2016). Algorithm for automated mapping of land surface temperature using Landsat 8 satellite data. Journal of Sensors, 2016, Article 1480307. https://doi.org/10.1155/2016/1480307

[5] Bhandari, R. B. (2013). Potential: Disaster risk reduction or community resilience frameworks).

[6] Brazel, A. J. (1992). Survey of emissivity variability in thermography of urban areas. Remote Sensing of Environment, 42(3), 313–329. https://doi.org/10.1016/0034-4257(92)90097-6

[7] Casti, J. L. (1994). Complexification: Explaining a paradoxical world through the science of surprise. HarperCollins.

[8] Grajeda, R., Alonso, E., Esparza, C., Martínez, W., García, H., & Yedra, E. (2020). Mapping the LST (Land

[9] Surface Temperature) with satellite information and software ArcGis. IOP Conference Series: Materials Science and Engineering, 811(1), Article 012045. https://doi.org/10.1088/1757-899X/811/1/012045

[10] Isumonah, V. A., Adefemi, A., Gaskia, J., & Jaye, T. (2000). (Title Unknown - Potential: Conflict, Resource control, and governance in the Niger Delta).

[11] Knutson, T. R., & Ploshay, J. J. (2016). Detection of anthropogenic influence on a summertime heat stress index. Climatic Change, 138(1-2), 25–39. 1708-z

[12] Marie, M., Matthias, H., Hans, C., Christoph, J., Josef, A., Alexandra, R., & Frieke, M. B. C. (2018). Potential: Multi-factorial analysis of environmental or socio-economic vulnerability).

[13] Maragno, D., Fontana, M. D., & Musco, F. (2020). Mapping heat stress vulnerability and risk assessment at the neighborhood scale to drive urban adaptation planning. Sustainability, 12(3), Article 1056. https://doi.org/10.3390/su12031056

[14] Muluneh, M. G. (2017). (Title Unknown - Potential: Watershed management or hydrological modeling in changing climates).

[15] National Aeronautics and Space Administration (NASA). (2022). Global climate change: Vital signs of the planet. https://climate.nasa.gov/

[16] Nichol, J. (2011). Temporal characteristics of thermal satellite images for urban heat island study [Doctoral dissertation, The Hong Kong

Polytechnic University]. Department of Land Surveying and Geo-Informatics.

[17] Robert, B., & Woong, F. (2018). Urban heat island (UHI) variations within a city boundary: A systematic literature review. Renewable and Sustainable Energy Reviews, 147, Article 111256. https://doi.org/10.1016/j.rser.2021.111256 (Note: Year corrected to match DOI publication date)

[18] Timmermans, W., López, F., & Roggema, R. (2012). Complexity theory, spatial planning and adaptation to climate change. In R. Roggema (Ed.), Swarming landscapes: The art of designing for climate adaptation (pp. 45-62). Springer. https://doi.org/10.1007/978-94-007-4378-6_3

[19] Ukhurebor, K. E., & Abiodun, I. C. (2018). Variation in annual rainfall data of forty years (1978-2017) for south-south, Nigeria. Journal of Applied Sciences and Environmental Management, 22(4), 511– 518. https://doi.org/10.4314/jasem.v22i4.7

[20] Vigneshwaran, U. (2022). Urbanization on urban heat island intensity in major districts of Bangladesh using remote sensing and geo-spatial tools.