ENVIRONMENTAL IMPACT ANALYSIS ON THEINCREASE IN TEMPERATURE AND URBAN HEAT ISLAND; A CASE STUDY OF GWAGWALADA, ABUJA

Agu C.C, Ikwuka A, Hudu H.M, Abdullahi N.A, and A.T Ibrahim
Atlantic International Research Centre, National Space Research Development Agency, Nigeria

Abstract: **This research looks at the impact of urban heat island in Gwagwalada urban and it's the rural surrounding area, it was achieved through the following; i) the change detection of Gwagwalada, ii) identifying the relationship between the rise in temperature as well as vegetation, iii) examining the effect of UHI on the inhabitants of Gwagwalada, iv) determining if Gwagwalada urban generates more heat than its rural environs. Lands at 7 and 8 satellite imageries were used to do the classification, NDVI, and land surface temperature analysis. While air temperature data from POWER climate data were applied toward analyzing the UHIindex. Change detection of the study area shows that in 2020 the increase in urbanization affected the area while features like vegetation and water body reduced due to climate change and urban concentration. Land surface temperature also increased in 2020 due to various activities in the study area and the construction of surface imperious structures in the area. From the result of the air temperature with the calculation of the UHIindex, it shows that temperature increased in the study area and some of the adaptation and mitigation measures were considered.**

KeyWords: **Urban Heat Island, Change Detection, NDVI, Land Surface Temperature, and Air Temperature.**

I. BACKGROUND

Urbanization, aneffect of socio-economic growthin certain conditions, has progressively moreturn out to bethemaineffect in many municipal areas (Ji et al., 2006). Growing the immigration of inhabitants tocities and the increase of cities and towns will amplify the rise of temperature increase in the prospect. The heat island incident has a hugeoutcome on air pollution, pollution supervision, provincial temperature, and energy utilization increase in the air conditioner, as well as municipal well being in city areas.The temperature disparity among cities as well asbordering regions was generated from a variation in immersed energy. Within theareas, dark-colored textures similar to asphalt, concrete, plusfurther construction resources were caused lessening with in the albedo coefficient as a result increase in immersed energy. Various processes of lessening the pressure of heat island occurrence are growing vegetation, intensifying the city landscape, and using constructional resources with anelevated albedo rate.Heat Island (HI) happens when built-up areas temperature increases more compare to the extended rural areas, due to anthropogenic activities (Nwaerema, Edokpa 2018). The temperature variation among built-up areas as well as its countryside environs is an outcome of variation in the mass of energy acquired and freedinside the city building resources, like asphalt and concrete. Sunlight is a part of electromagnetic radiation from the Sun through electromagnetic waves (Aremu, 2008). This is seen as Ultraviolet light, Visible, and Infrared.

Nigeria is amonga small number ofnations in Africa where urbanization is not a newoccurrenceasseveralcities are as aged as the primeval cities in Europe. Some of the towns are Kano, Katsina, Ado-Ekiti, Benin City, Ibadan, Oyo, Iwo, Oshogbo, and Ogbomosho, which were pre-colonial cities (Onakerhoraye and Omuta, 1994). The country's urbanization pace was predictablysetat 5% as of 1973 (Olowu, 1985) alsoaround 1980 almost 30% of the entire in habit an its have by now been dwelling in city centers. In 2005, roughly 60% of the population in Africa, in broad, areanticipated to be a city. The nation's metropolitan centers have been rising by twice the general in habitants (expected at 2.5%) withtwice the pace of municipaldata in numerousnations of Europe and America (Olowu, 1985).

Over the years, the rapid growth in population, and industrialization affect the increase of monetary and communalroles in the city areas, and such have altered urban morphology and energy composition. Just like many satellite towns, Gwagwalada town consists of the planned and the unplanned sections. Population, raiseabove the past two decades, and the move of the country's capital from Lagos to Abuja in 1991 (Ejaro, 2013). Other social and economic functions such as theUniversity of Abuja Teaching Hospital (UATH), University of Abuja, the

intended siting of Federal Government seat of power in Gwagwalada town before it was moved out due to intense temperature rise and its clumsiness contributed to the high rate of land-use conversion which altered Gwagwalada land cover, resulting to temperature anomaly (Ejaro, 2013). Gwagwalada city experiences urban heat and the urban and rural regionsconfirma hugevariance.This research aims to estimate the concesences of urban heat islands within Gwagwaladaas well as its rural environs. These can be achieved with the subsequent objectives;

- To establish the change detection of Gwagwalada.
- To identify the relationship between the rise in temperature and vegetation.
- To examine the effect of UHI on the inhabitants of Gwagwalada.
- To determine if Gwagwalada urban generates more heat than its rural environs.

Two majororganizations of study have appeared for measuring UHI (Schwarz et al., 2011). Firstly, the coverlevel UHI is usually calculated by means of air temperature (T_{air}), that is identified through in situ sensors on standard meteorological altitude or through the crossing of a mounted sensors. Secondly, surface UHI is calculated employing Land Surface Temperature (LST) resultingto air-borne or satellite-bornedata remote sensing. T_{air} is a straight UHI dimension plusnearer to that sensed by individuals, but the meteorological system inside a municipalregion is not constantly as absoluteit would be preferred. Hence, remote sensing data mightgive the spatial sharing of temperature around a hugevicinity, but can bemerely not direct approximation of the UHI. Arrangement of mutually ways presents extra assessment in the explanation of UHIs (Schwarz et al., 2012). UHI concentration is resolute asthe spatially-equal temperature disparityamong a municipal area as well as its neighboring rural district (Magee et al., 1999; Kim and Baik, 2005). This conception, nevertheless, envelops a variety of diverse displays, that are notable in conditions of delineation of what is well thought as "urban" as well as "rural" (Stewart and Oke, 2009). The inspection of these signsplus their detailed methods may be seenin Schwarz et al. (2012). Based on an abstract of UHI researches carried out in the previous two years by Mirzaei (2015), it was well-known that UHI amount was calculated only by exact indicators gotten from whichever remote sensing data (LST) or stationary and mobile measurements (T_{air}). Like, Coseo and Larsen (2014) referred to the T_{air} variation among neighborhoods and the Chicago-Midway airport as UHIconcentration to decide how three-dimensional built configurations as well as their nearby heat sources plus sinks consequence UHI in Chicago.Quan et al. (2014) took the variation between the urban plus rural LST based on MODIS Terra as well as Aqua data to signify UHI concentration to examine the spatial-temporal difference of UHI in Beijing, China. Nevertheless, little effort were made to examine the variation involving UHI concentration

calculated using LST and T_{air}. One current research by Schwarz et al. (2012), analytically calculated all signs of UHI concentration for the city of Leipzig employing air borne-based LST and T_{air}over two-time phases (19:30–21:00on 22 September 2010 and 5:00–6:30 on 23 September 2010)and concluded that the assessment of the UHI concentration depended on the chosensign and the data used. Since the variation among LST and $T_{air}$is mostly controlled by the surface energy equilibrium throughout the daytime, and solar radiation throughout the night time has lesscon sequence (Sheng et al., 2015; Vancutsem et al., 2010), it is essentialto additionally investigating the hourly and seasonal variations among thestandards of UHI concentration that are calculated using LST and T_{air}. Landsat thermal-infrared data is an influential means that can be used to learn the urban thermal surroundings (Zhang and Wang, 2008;Weng and Fu, 2014). The long-term evidence since 1984 and the comparatively fine spatial resolution of the Landsat 5 data make this evidencethe foremost basis for UHI investigation (Dihkan et al., 2015; Chen et al., 2016). Hence, this study evaluates the calculated value of UHI concentration using equally Landsat LST and T_{air}as well as can give a meticulous analysis of the long-term temporal difference of UHI. This research used the concept of Environmental determinism which says that individual growth, improvement, and behavior are restricted by the climate and physical environment (Lethwaite, 1966). And Environmental Possibilism says that the environment and climate impose certain constraints or limitations, but human actions determine the way the environment will suit him.

II. METHODOLOGY

Study Area
Theresearch area is Gwagwalada city. It's one of the biggest satellite cities in Abuja (NPC, 1991). It also one of the mainly heavily in habited districts in the federal capital territory (FCT) and the headquarters of one of the oldest councils in the Federal Capital Territory, Abuja (Ejaro, 2013). The city observes a remarkable influx of public servants as well as the structured private division bringing about a sudden increase of the inhabitants into alsowithin the federal capital city (FCC). Gwagwalada also experiences outstanding development and improved land conversion speed leading to temperature increase over time. The continuing loss of vegetal cover for construction as well asconsequent buildings and urbanization normally led to a temperature rise in Gwagwalada urban with time (Ejaro, 2013). Gwagwalada settlement is situated about 55 kilometers far from the federal capital city (FCC) inside the Federal Capital Territory. It lies amid latitude 08055"N also 09000"N and longitude 07000"E and 07005E (Balogun, 2001). Gwagwalada communityarea has a whole landmass of about 6,500 hectares. Gwagwalada city is made up of the older customary and latestdesigned sections. The old is the

pre-1976 part, while the recentoutcome from the development of the Federal Capital Development Authority following its intended responsibility within the spatial growth of the Federal Capital Territory (FCT). Its double parts'inner arrangement is relativelycomparable to the pre-colonial city centers within the western along with northern parts of Nigeria (Balogun, 2001). The city centers are places in Gwagwalada, where the improvement of the metropolis is projected to increase out from thus substituting as increase pole of Gwagwalada city such places are phase1,2,and 3, (FCDA, 2000).
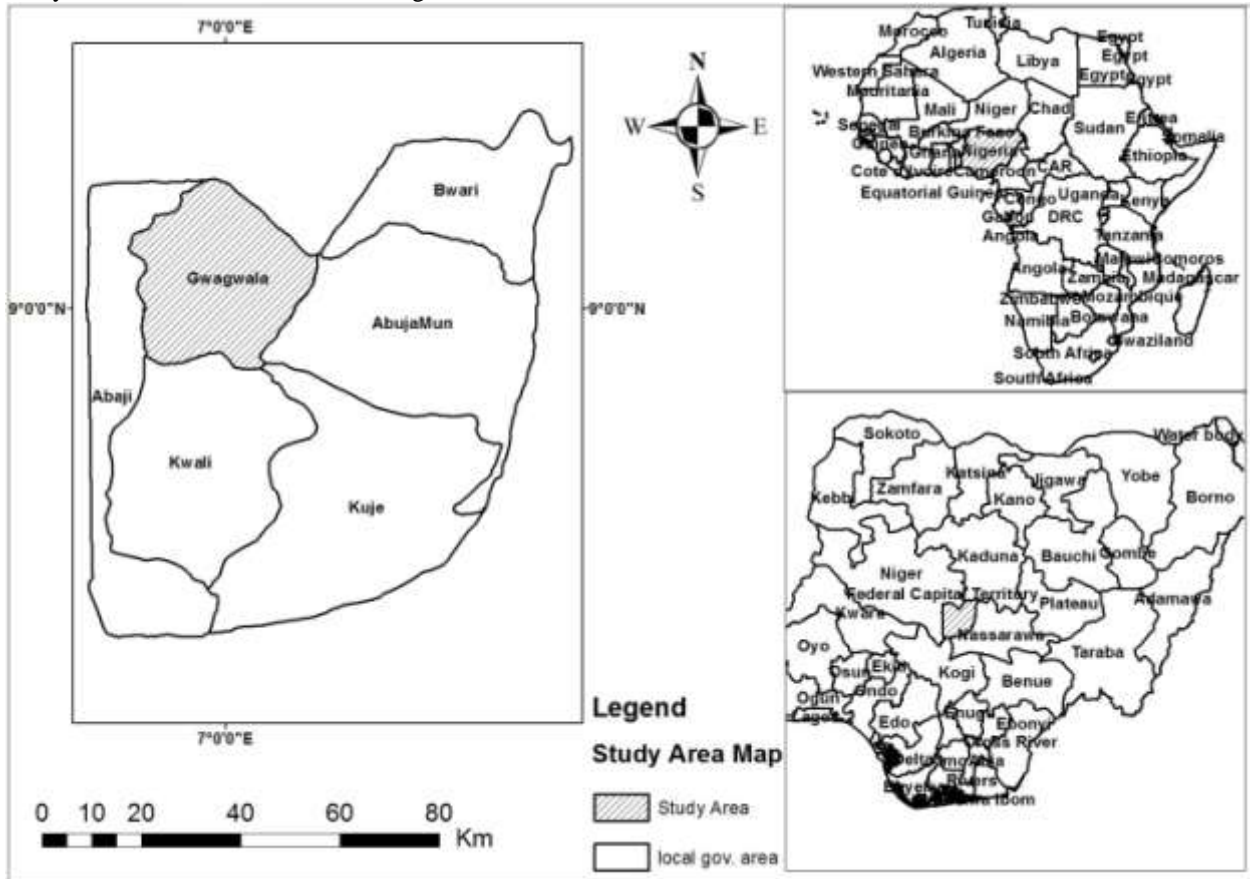
Study area map.

III. DATA AND MATERIALS

The dataapplied for this research were derived data thatholds spatial and atributecharacteristics. The data comprises Landsat 7 Enhanced Thematic Mapper (ETM+)plus Landsat 8 Operational Land Imager (OLI) images, topo graphic maps, Temperature. Software packages consist of; ArcGIS version 10.5, Idrisi.

Datatypes and sources

Data list		Data type	Data	Data source	Resolution
1.	Landsat 7	Secondary	Satellite imagery	Earth explorer	30m
2.	Landsat8	Secondary	Satellite imagery	Earth explorer	30m
3.	Temperature,	secondary	Climate data	Prediction of worldwide energy resources, NASA	

The Landsat imagery was acquired from (URL; http://earthexplorer.usgs.gov). The imageryis, Landsat 7 ETM + image purchased on 27th December 2001as well as Landsat 8 OLI purchased onthe 22nd of January 2020 as shown in Table 3.1. The satellite data has 30m spatial resolutions. ETM data have a spectral collection of 0.45-

2.35 micrometers with bands 1,2,3,4,5,6,7 plus 8 while the OLI reached band 12.

Climate data (Air Temperature) wereobtained fromthe Prediction of Worldwide Energy Resources (POWER) (https://power.larc.nasa.gov/data-access-viewer/) for 2000 and 2019 yearly data.

Software Analysis
The software employed ishighlighted;
ArcGIS 10.5: It's a spatial and statistical analyst tooland was applied in the research to obtain together with the spatial analyses plus the spatial statistical analyses.
Idrisi: Supervised classification was being done by Idrisi, the land change of the Idrisi was applied to observe the land-use/land-cover involving the years of surveillance.
Microsoft Excel: is a spreadsheet software employ to approximate and investigate statistical information. The software was being used to spread out the statistical analysis.
To take out the research area, the topographic map covering the Enugu was georeferenced in the ArcGIS background. The methods approved for this study were grouped into fourphases (a)Land use/ Land cover (LULC). (b) Land Surface Temperature (LST) generated (c) Normalized difference vegetation index (NDVI) generated. (d) Urban Heat Island Index.

A. Normalized Difference Vegetation Index
NDVI is applied to calculatethe vegetation abundanceas well asuseful to understand vegetation density plus assessing fluctuations in vegetal health.

$$NDVI = \frac{NIR-R}{NIR+R}$$

While NIR meansthe near-infrared band
R meansRed band
It is delivered a single-band resultprecisely.

B. Land surface Temperature.
Land surface temperature is the temperature of the earth from sun'semission (Francois Becker and Zhao-LiangLi 2009).ArcGIS 10.5 was employed to recover the earthperceptible Temperature. Firstly the thermal band 6 imagerywas used to calculate LST in Landsat 7 while thermal band 10 imagery was used to calculate Landsat 8. Conversion of the bands to spectral radiance using the calculation **L= LMIN+ (LMAX-LMIN)*DN/255**
L which means spectral radiance at the sensor's aperture in Wm-2sr-1μm-1.
LMIN which means spectral radiance scaled to QCALMIN (3.2 Wm-2sr-1μm-1).
LMAX which meansspectral radiance scaled to QCALMAX (12.65 Wm-2sr-1μm-1).
QCAL which means DN.

QCALMIN which means little sum quantized standardized pixel speed (equivalent to LMIN) in DN (0).
QCALMAX highest quantized standardized pixel rate (comparable to LMAX) in Digital Number (DN =255).
After which, it converted from spectral radiance to radiant surface temperature with the following formula

$$Tk = \frac{K2}{\ln(\frac{K1}{L} + 1)}$$

Tk meansthe radiant surface temperature (in Kelvin).
K2 means calibration constant 2 (1282.71 K).
K1 means calibration constant 1 (666.09 Wm-2sr-1μm-1).
L means the spectral radiance at the sensor in Wm-2sr-1μm-1.

Which proceed with the conversion of radiant surface temperature to Land Surface Temperature with the following formula **LST = TB/ (1 + (λ TB/ ρ) lnε**

LST means the Land Surface Temperature (in Kelvin).
TB meansthe Radiant Surface Temperature (in Kelvin).
λ isthe wavelength of emitted radiance (11.5 μm).
ρ is h×c/σ (1.438×10−2 m K).
h is Planck's constant (6.26×10-34J s).
c is the velocity of light (2.998×108 m/sec).
σ is Stefan Boltzmann's constant (1.38×10-23J K-1).
ε is emissivity.

Then, the Land Surface Temperature will be changed to Celsius (Tc) as highlighted below
Tc=LST-273
Where
LST = Land Surface Temperature (in Kelvin).

C. Land use land cover:
A supervised classification using the Maximum Likelihood Classifier was performed on a false-color composite (RGB 345) of Landsat 8 OLI imagery. The training areas were categorized into built-up areas, roads vegetation, and waterbody. A statistics table was obtained from the percentage of the land cover of the classes obtained. An accuracy assessment was performed using Google Earth for ground-truth verification did you use an error matrix, the overall accuracy was 75%.

D.Urban Heat Island Index.
The mainlyfrequent approach to examine the heat island occurrence is evaluatingcity areas with nearby rural areas. The majority of the researches, in this case, have been prepared by calculating the UHI index. The UHI index is employed to examine the rise of temperature development caused by heat island, evaluated with rural nearby areas. This index outlined below:

$$UHI = T_u - T_r$$

T_u is the Average Temperature of the city center plus T_r is the Average Temperature of the rural regions.

IV.   RESULTS AND DISCUSSION

Landuse/Landcover Analysis
The imagery was classified among five areas; Buildups, Vegetations, Bare surfaces, Waterbody, and Rocks and was been looked at from 2001 and 2020 respectively. The results of the land use classification show that Gwagwalada, Abuja which covers an area of 1,043 km², in 2001 was more dominated with the vegetative cover of 492.33km, followed by buildup which was 228.85km, while the water body was 102.36km and bare surface and rocks account for 62.38km and 78.19km respectively. But in 2020, the case was different, because the vegetation reduced by 211.60km, buildup increased to 660.89km as a result of urbanization. While the water body reduced to 8.68km due to the climate change effect. And rocks, as well as bare surface, reduced to 45.35km and 37.59km respectively.
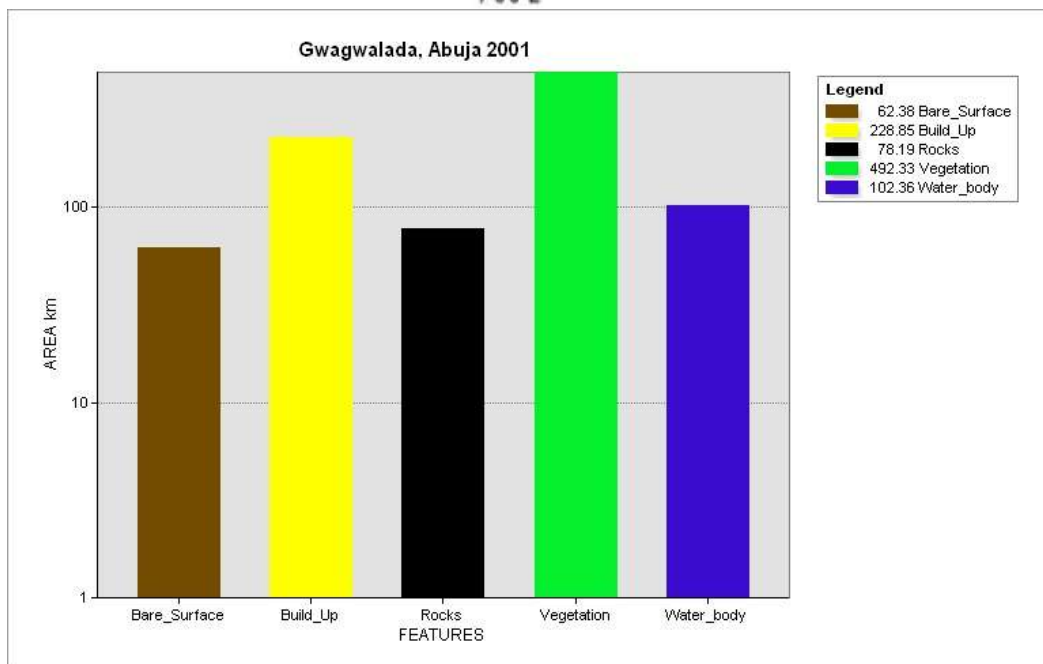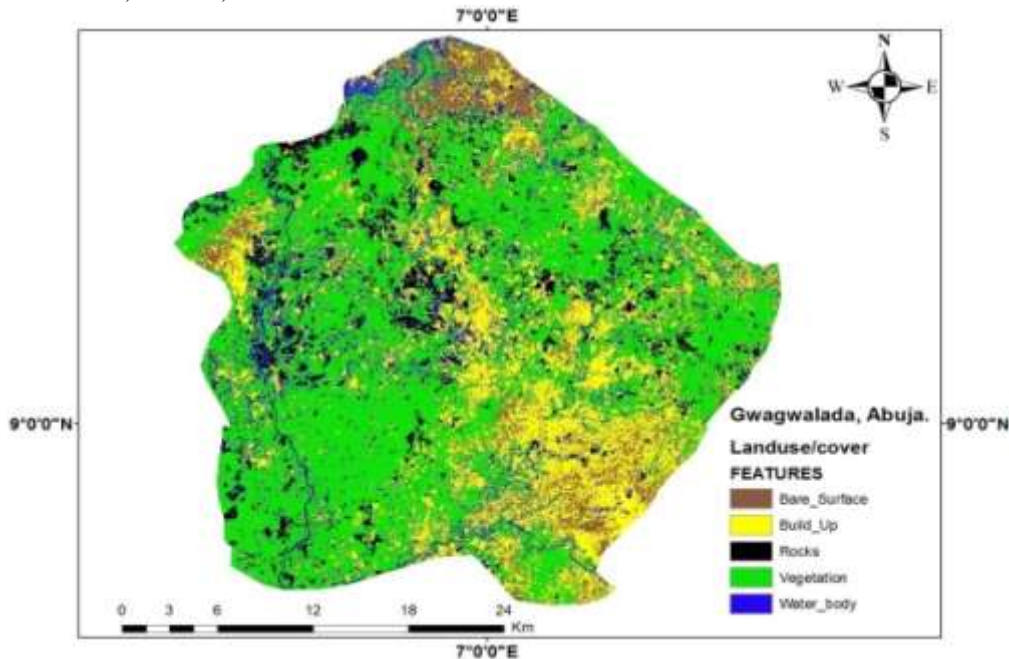
Showing the land use cover map of Gwagwalada and its area coverage in 2001.
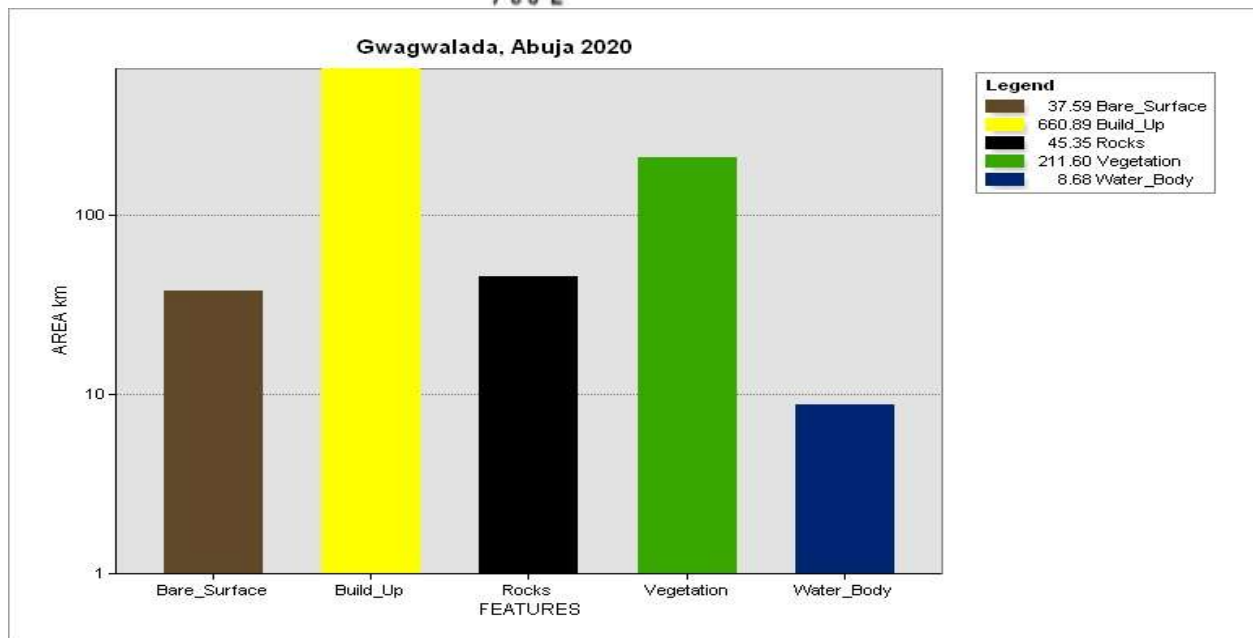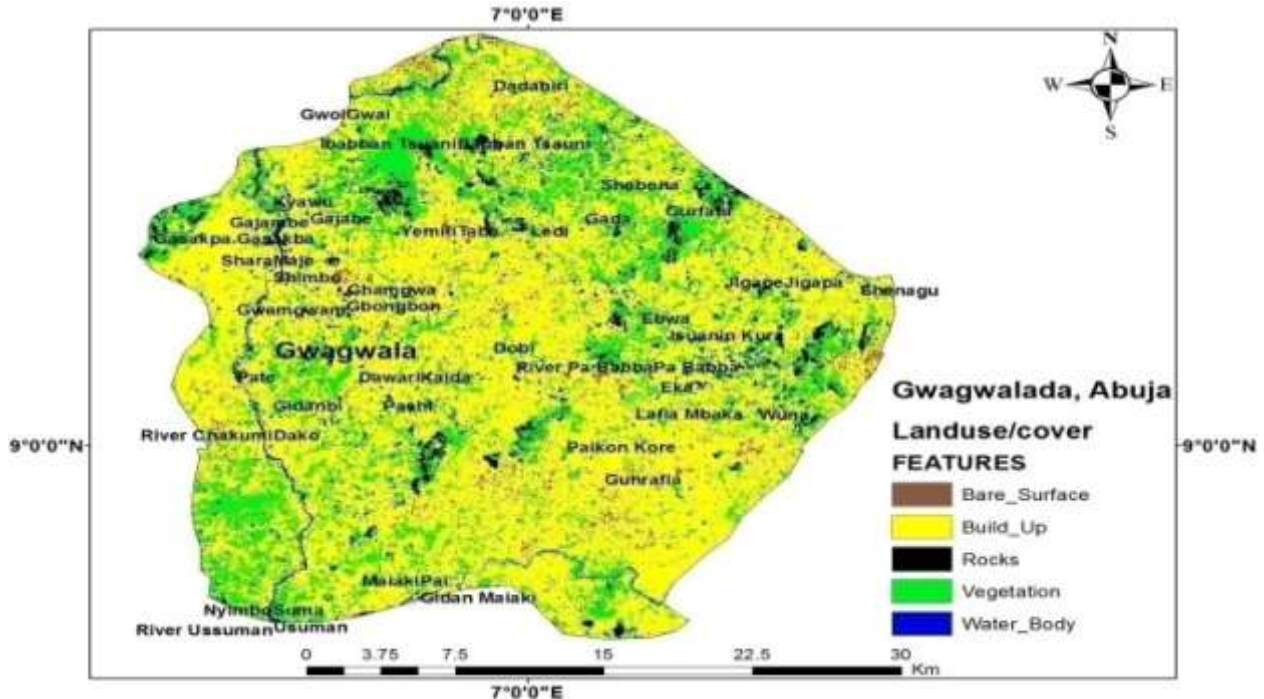
Showing the land use cover map of Gwagwalada and its area coverage in 2020.

Analysis of the spatial pattern of Normalize Differential Vegetation Index (NDVI)

NDVI principles are indicated as a percentage fluctuating in rate from -1 to 1 however in groundwork, largedifficult values show water, values with zero indicate bare soil, and values near one indicate solid green vegetation. In 2001 normalize differential vegetation index ranged from 0.09 to -0.38, with settlements like GwoGwai, Dobi, sharamaje, Pate,and Gunrafia having values from -0.38 - -0.18, while settlements like Maiakipai, River Chakun, Shebona, and Ebwa recorded a value of -0.18 - -0.16. And Pashi, Gasakba, Gajabe, Baban, Wuna, and Gidanbi recorded -0.12 - -0.09.the areas with the higher value show that there is vegetation presence.
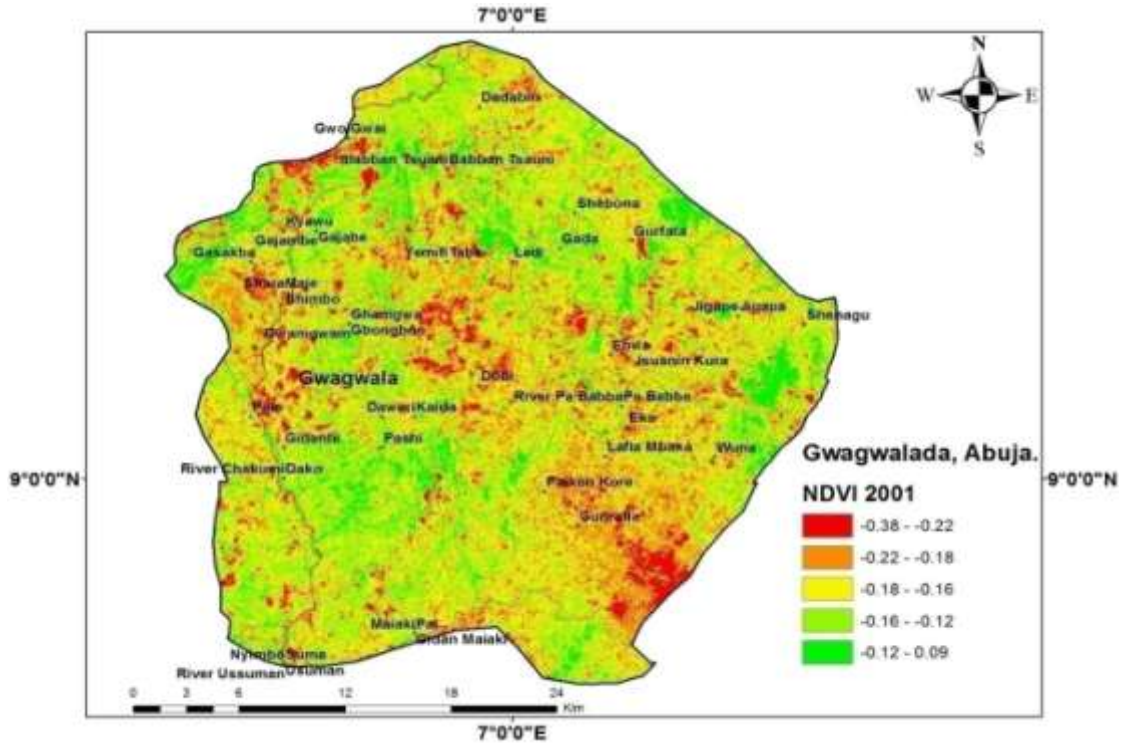
shows the NDVI of Gwagwalada, Abuja 2001.

In 2020 the NDVI values increased from-0.05to0.37. Areas like River Chikun and Dobi had -0.05 - 0.10, while Paikon, Pashi, Tabe, Shebona, Gada, Gurfata, Gajabe, Kyawu, Ledi, and Jigapehad values of 0.13 – 0.15. Finally,Shenagu,

LaifiaMbaka, Dadabiri, GwoGwai, Tsauni, and Nyimbo had values of 0.17 – 0.37. This is attributed to the seasonal changes, plant photosynthetic activity, biomass, plant and soil moisture, plant stress, etc.
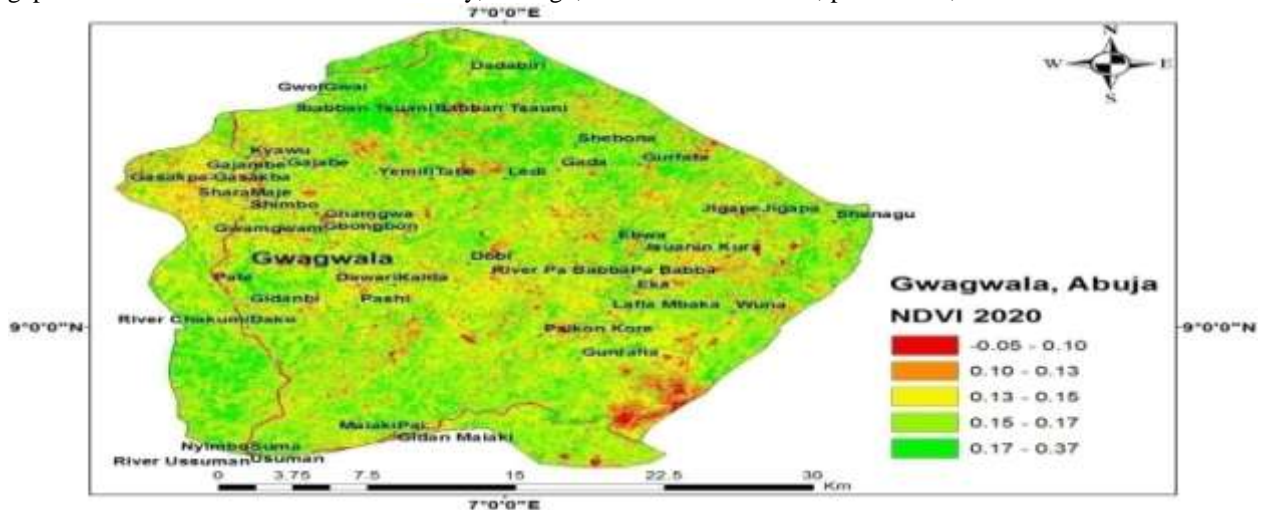
shows the NDVI of Gwagwalada, Abuja 2020.

**Land surface temperature (LST) Analysis**

LST can be defined as an energy molecule on a surface. The hotter they are, the more they move. The LST of Gwagwalada as of 2001 shows the temperature to range from $42.36^{o}C$ to $24.35^{o}C$. While in 2020 it increased from $43.87^{o}C$ to $26.19^{o}C$, this is a result of an increase in

urbanization, deforestation, surface imperviousness, and anthropogenic activities in the environment. In 2001, some areas like Gidanbi, Pashi, Nyimbo Suma, and MaiakiPai experienced a decrease in temperature, but in 2020 these affected areas experienced an increase in temperature. The high increase of people coming into Gwagwalada for
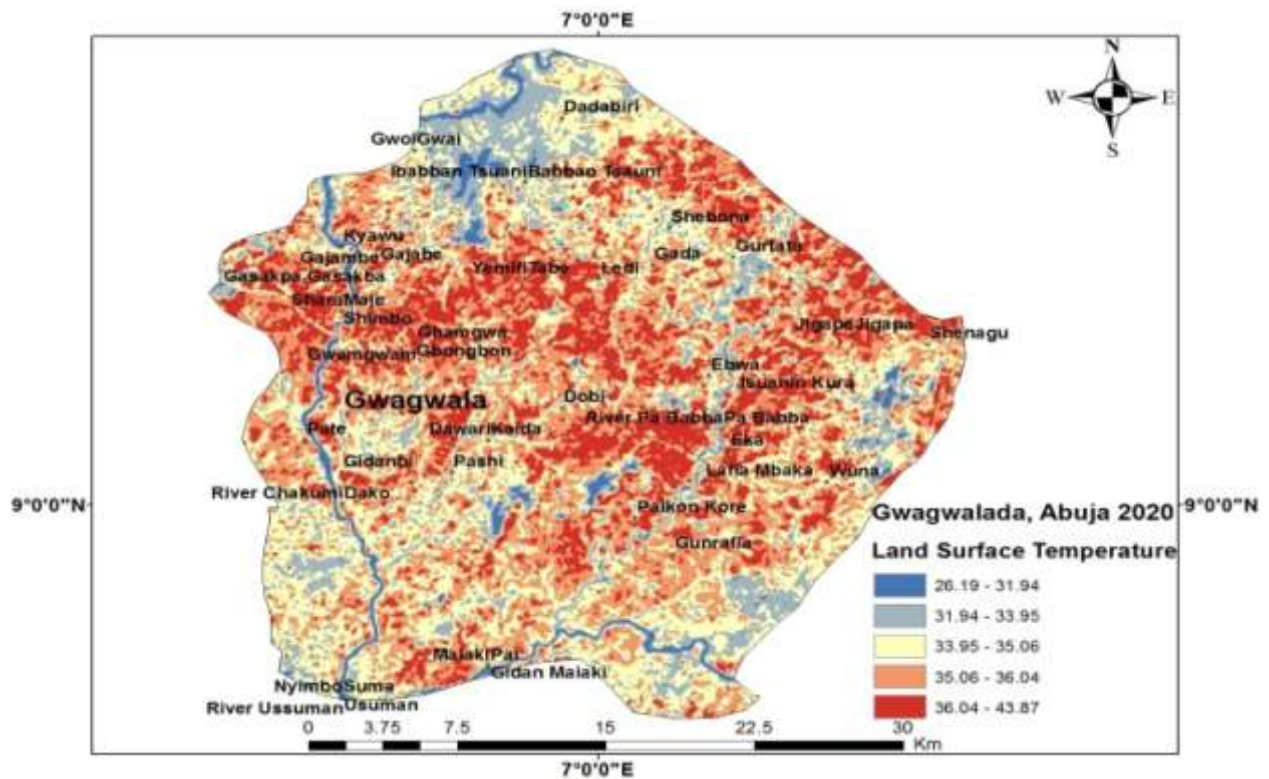
settlement and more deforestation going on in the area and exposing the rocks and bare lands which in turn reflect the solar radiation to the environment as given rise to the increase in land surface temperature.**Fig 4.5**shows the LST of Gwagwalada in 2001.
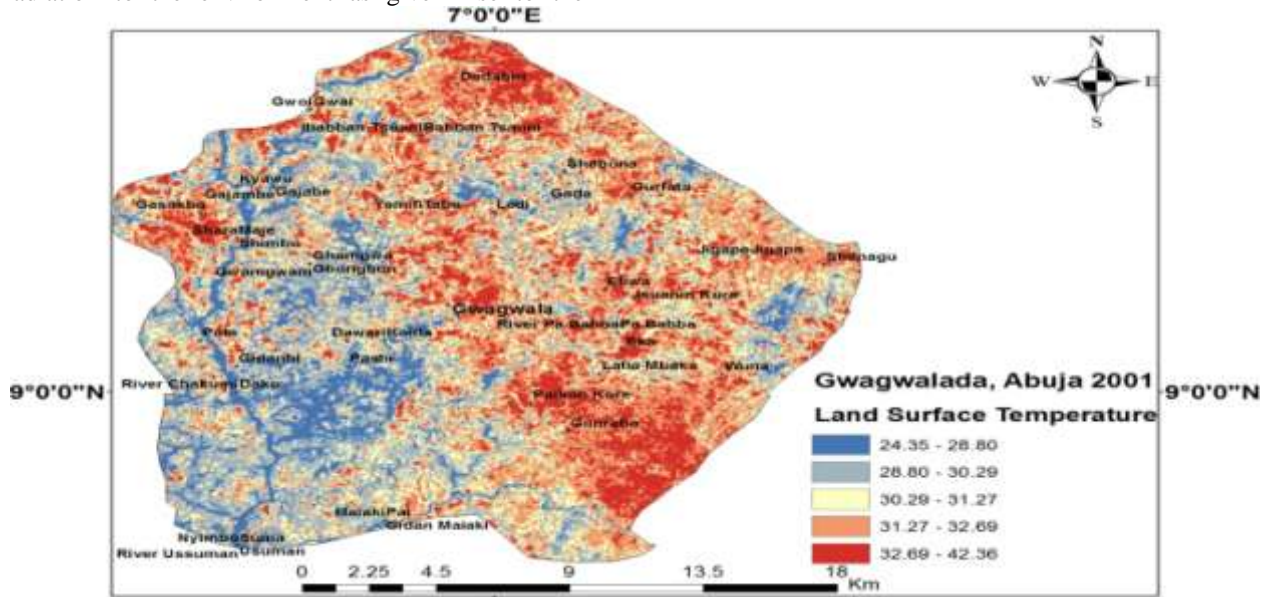
shows the LST of Gwagwalada in 2001

shows the LST of Gwagwalada in 2020

Urban Heat Island Index
This approach looks at the heat island occurrence and evaluatingcity areas with nearby rural areas. In essence,the urban heat is land index is air temperature urban substrate by air temperature rural. Table 4.1 shows the annual air temperature of Gwagwalada city and its rural or suburbanenvirons, between 2000 as well as 2019 respectively.

Towns	Temperature2000	Temperature2019
Gwagwalada urban	26.17	26.86
LaifiaMbaka	25.58	26.02
Pa Babba	25.58	26.02
Paikon Kore	25.88	26.44
Tabe	26.27	26.56
Usuman	26.7	27.22
Wuna	25.58	26.02

Air Temperature of Gwagwalada, Abuja
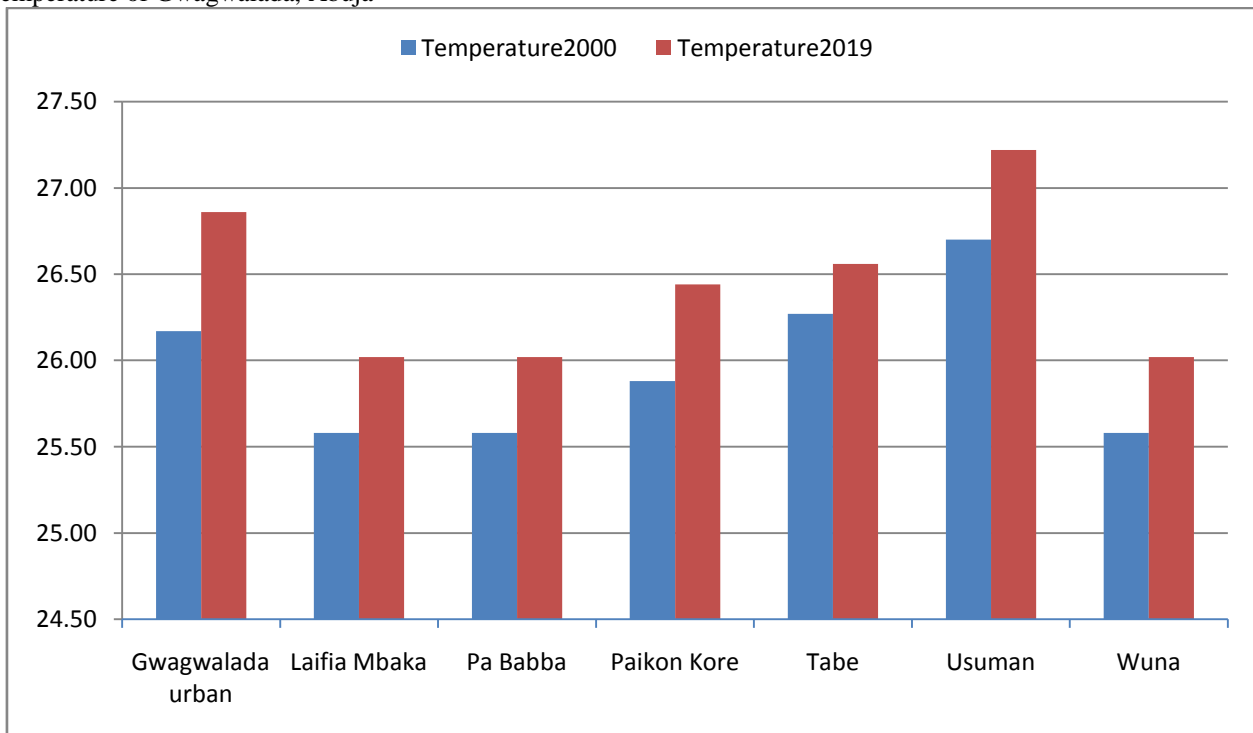
Air Temperature of Gwagwalada, Abuja.

Towns	Temperature2000	Temperature2019	Temperature difference
Gwagwalada urban	26.17	26.86	0.69
LaifiaMbaka	25.58	26.02	0.44
UHI	0.59	0.84	
Gwagwalada urban	26.17	26.86	0.69
Pa Babba	25.58	26.02	0.44

UHI	0.59	0.84	
Gwagwalada urban	26.17	26.86	0.69
Paikon Kore	25.88	26.44	0.56
UHI	0.29	0.42	
Gwagwalada urban	26.17	26.86	0.69
Tabe	26.27	26.56	0.29
UHI	0.1	0.3	
Gwagwalada urban	26.17	26.86	0.69
Usuman	26.7	27.22	0.52
UHI	0.53	0.36	
Gwagwalada urban	26.17	26.86	0.69
Wuna	25.58	26.02	0.44
UHI	0.59	0.84	

Air Temperature difference and UHI index of Gwagwalada, Abuja.

From the table, it can be said that the air temperature of Gwagwalada increased from 2000 to 2019 due to the increased intensity of solar radiation to the exposed environment. Most of the vegetation is lost due to man's activities and construction of surface imperviousness, thereby making the environment to receive direct solar radiation. Greenhouse gas also contributed to the increase in air temperature, most of the carbons emitted to the environment through cars, generators, and so on.

Adaptation and Mitigation strategies.
From the analysis and findings, it is discovered that what gave rise to the increase in the temperature and urban heat island in Gwagwalada, Abuja was mainly increasing in urbanization, which brought congestion of the town and construction of surface impervious structures like tarred roads, buildings, and concrete walkways, thereby encouraging deforestation and greenhouse gas emissions.
The following are recommended for adaptation and mitigation of urban heat island within Gwagwalada, Abuja;
- Afforestation should be encouraged.
- Planting of vegetation like green grasses and trees along the streets and roads should be encouraged.
- Roofing of houses with green color coatings that will absorb the heat in the environment should be encouraged.
- The creation of water springs and fountains should be encouraged.
- The government should develop and encourage the use of bio-fuel to reduce the combustion of hydrocarbon, carbon monoxide, and carbon dioxide, which are greenhouse gasses.

- Awareness and enlightenment should be created on the effect of urban heat island on the environment.

V. CONCLUSION AND RECOMMENDATION

Conclusion
This work studied the effect of an increase in temperature and the urban heat island of Gwagwalada, Abuja. Looking at the change detection of the area between 2001 and 2020, it was discovered that in 2001, vegetation occupied the highest area of the study area while buildup followed it and the water body also was higher, while rocks and bare surface occupied the least area. While in 2020, the buildup was more as a result of an increase in urbanization, followed by vegetation, bare surface, and rocks, while the water body is the least due to climate change effect. On NDVI, in 2001 normalize differential vegetation index ranged from 0.09 to -0.38 while in 2020 to increased to 0.37 to -0.05. This is attributed to the seasonal alterations, plant photosynthetic activity, biomass, plant as well as soil moisture, plant stress, etc. The LST of Gwagwalada as of 2001 shows the temperature to range from $42.36^{o}C$ to $24.35^{o}C$. While in 2020 it increased from $43.87^{o}C$ to $26.19^{o}C$, this is a result of the increase in urbanization, deforestation, surface imperviousness, and anthropogenic activities in the environment. It can be said that the air temperature of Gwagwalada increased from 2000 to 2019 due to the increased intensity of solar radiation to the exposed environment. Most of the vegetation is lost due to man's activities and construction of surface imperviousness, thereby making the environment receive direct solar radiation. Greenhouse gas also contributed to the increase in air temperature, most of the carbons emitted to the environment through cars, generators, and so on.
In conclusion, from the analysis, it is estimated that the temperature of the study area will be increasing every year

and may result in the discomfort of the people living in the study area. Mitigations and adaptations of urban heat island have been outlined in this research to further help in reducing the effect of the urban heat island.

Recommendation
The research reveals the consequence of the urban heat island of Gwagwalada, Abuja, and its surrounding suburbs and possible ways to mitigate and adapt to it. But most of the health implication of urban heat island was not looked at, so it calls for further researches into it.

Abbreviations
ETM^+ = Enhanced Thematic Mapper
IPCC = Intergovernmental Panel on Climate Change
KM^2 = Square Kilometres
LST = Land Surface Temperature
LULC = Land Use / Land Cover
NDVI = Normalized Differential Vegetation Index
OLI = Operational Land Imager
POWER = Prediction of Worldwide Energy Resource
THI = Temperature Humidity Index
RH = Relative humidity
UHI = Urban Heat Island
T_u = average Temperature of the urban center
T_r = average Temperature of the rural areas.

VI. REFERENCE

[1]. Balogun, O. (2001). The Physical Nature and Physiography of Gwagwalada Area Council. Federal Capital Development Authority Journals volume 28, (pg 14-35).

[2]. Coseo, P., and Larsen, L., (2014). How factors of land use/land cover, buildingconfiguration, andadjacent heat sources and sinks explain Urban Heat Islandsin Chicago. Landscape Urban Plann. 125, (pg117–129).

[3]. Ejaro, S.P, (2013), Land Accessibility problems in Nigeria: A case study of Gwagwalada. Research Journal of Social Science and Management, volume 02, (pg 60-72)

[4]. FCDA, (2000). The Master Plan and Zoning of the Federal Capital Territory (FCT), A case study of Gwagwalada Town. Federal Capital Development Authority Journals, volumes 2, (pg1-30).

[5]. Ji, W., Ma, J., Twibell, R.W., and Underhill, K., (2006). Characterizing urban sprawl usingmulti-stage remote sensing images and landscape metrics. Comput. Environ.Urban Syst. 30 (6), (pg861–879).

[6]. Kim, Y., and Baik, J., (2005). Spatial and temporal structure of the urban heat island inSeoul. J. Appl. Meteorol. Climatol. 44, 591–605.

[7]. Magee, N., Curtis, J., and Wendler, G., (1999). The urban heat island effect at Fairbanks,Alaska. Theor. Appl. Climatol. 64, 39–47.

[8]. Nwaerema P., and Edokpa D., (2018). Population Variability and Heat Bias Prediction in a Tropical Country, Nigeria, From 2006 to 2036. Advance Journal of Social Science. ISSN: 2581-3358 Volume 4, Issue 1, pp. 28-38, 2019 DOI: https://doi.org/10.21467/ajss.4.1.28-38

[9]. NPC (1991). The Population and People of Nigeria. National Population Commission Journals 2017 publications

[10]. Onakerhoraye, A.G., and Omuta, G.E., (1994). Urban Planning Systems and Planning for Africa, Benin Social Science Series for Africa, University of Benin, Nigeria.

[11]. Olowu, D., (1985). Local government and urban development in Nigeria. In: Abiodun, J.O. (Ed.),Urban and Regional Planning Problems in Nigeria. University of Ife Press Ltd., Nigeria, (pp. 272–298).

[12]. Schwarz, N., Lautenbach, S., and Seppelt, R., (2011). Exploring indicators for quantifying surface urban heat islands of European cities with MODIS land surfacetemperatures.RemoteSens. Environ. 115, 3175–3186.

[13]. Schwarz, N., Schlink, U., Franck, U., Gro, and beta mann, K., (2012). Relationship of land surface andair temperatures and its implications for quantifying urban heatisland indicators an application for the city of Leipzig (Germany). Ecol. Indic.18, 693–704.

[14]. Stewart, I.D., and Oke, T., (2009). A new classification system for urban climate sites. Bull.Am. Meteorol. Soc. 90, 922–923.

[15]. Mirzaei, P.A., (2015). Recent challenges in modeling of urban heat island. SustainableCities Soc.19, 200–206.

[16]. Quan, J., Chen, Y., Zhan, W., Wang, J., Voogt, J., Wang, M., (2014). Multi-temporaltrajectory of the urban heat island centroid in Beijing: china based on aGaussian volume model. Remote Sens. Environ. 149, 33–46.

[17]. Zhang, J., Wang, Y., (2008). Study of the relationships between the spatial extent ofsurface urban heat islands and urban characteristic factors based on LandsatETM+ data. Sensors8 (11),7453–7468.