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Settlement Growth and Its Impact on Land Surface Temperature in Ado-Ekiti, Ekiti State, Nigeria

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Abstract: This study employed the use of Geographic Information System (GIS) technique to investigate the pattern of changes in Land Use/Land Cover (LU/LC) and its impact on Land Surface Temperature (LST) in Ado-Ekiti, Ekiti State, Nigeria. The objectives were to investigate the size of Vegetation, Open Surface and Built-Up land use types in Ado-Ekiti, the State Capital City of Ekiti State in Nigeria from 1988 to 2018 and to know the percentage of changes in the Land Use/Land Cover for 1988, 1999, 2013 and 2018. Four Landsat images of Ado-Ekiti were used in this study. Land Use/Land Cover analysis was carried using ERDAS IMAGINE 9.2 in order to ascertain the areas covered by Vegetation, Open Surface and Built-Up land use types in the study area. Land Surface Temperature values for each of the land use types were extracted from Landsat images of the study area. The results indicated that there was decrease in the size of Vegetation and Open Surface land use types between 1988 and 2018 and there was an increase in the size of Built-Up land use type between 1988 and 2018. The result of the study also revealed that as the size of the Built-Up land use type was increasing, the value of Land Surface Temperature in Ado-Ekiti was also increasing. The study recommended that Government should bring into practice the concept Sustainable City through what is called 'Green Urbanism' so as to mitigate the problem of Urban Thermal Discomfort in Ado-Ekiti the Capital City of Ekiti State in Nigeria.

Keywords: Land Surface Temperature, Settlement Growth, Land Use/Land Cover, Green Urbanism

1. Introduction

Settlement growth is recognized as a crucial phenomenon of economic growth, social and political changes as it offers increased opportunities for employment and production of goods and services. This has initiated a large number of people to migrate from rural areas to urban areas. As a result, cities are growing faster than ever in physical dimension, being centre for residence, industry, trade, communication, administration and social services. However, this growth also triggers numerous environmental problems such as temperature increase, pollution, flooding, loss of fertile agricultural lands, insufficient sanitation and water supply and poor housing conditions [23]. All these are some of the most prominent negative effects of rapid settlement growth. If not managed properly, these may intimidate the sustainable development of cities in the long run [8].

Urbanization has been considered as one of the most important drivers of climate change [12]. The continuous growth of settlement has resulted in major changes in land use/land cover pattern over the past decades in the State Capital cities in South-Western Nigeria [1]. The changes in land use/land cover resulting from settlement growth have generated impacts on climate causing imbalance in the interactions between land surface and atmosphere. There are often some changes in meteorological elements such as temperature and humidity, resulting in different microclimates and the formation of heat islands [12]. The replacement of the natural landscape by buildings and paved surfaces may alter microclimates of the cities. The reduction of green areas and modifications of the land surface in Ado-Ekiti, the State Capital City of Ekiti State in Nigeria can cause an increase in the land surface temperature.

Land Surface Temperature (LST) is the temperature of the skin surface of a land. It is the surface radiometric temperature emitted by the land surfaces which can be derived from a satellite information or direct measurement and observed by a sensor at instant viewing angle [18]. The LST has significant scientific importance in urban Climatology, because its estimation is of great utility in monitoring study of urban climate and may contribute to the identification of changes in climatic elements in the urban environment [6]. Land Surface Temperature provides an accurate measure for indicating energy exchange balance between the Earth and the atmosphere [27]. The degree of LST is affected by land surface attributes, which are significantly influenced by elevation, slope and aspect which exert a direct control on the incoming solar radiation [7].

The use of remote sensing techniques in retrieving land surface temperature of a region are becoming an emerging development in public health and environmental epidemiology as this technology provides a valuable evidence to assist both emergency response planners and public health specialists in identifying areas of high vulnerability to heat and using these scientific findings to improve the health of the populations living within the affected areas [16, 15]. A study in Philadelphia used remote sensing technique to indicate the spatial relationship between vulnerable populations, urban heat island intensities and death during an extreme heat event [11].

2. Literature Review

It is a well-known fact that settlement growth can have significant effects on local weather and climate. One of the common effects of settlement growth is the increase in temperature, which is the direct representation of environmental degradation [10]. Settlement growth has changed city environment greatly owing to the conversion of vegetation land use to built-up land use and Ado-Ekiti, the State Capital City of Ekiti State in South-Western Nigeria is not an exception. Olofin and Adebayo [14] reported that, the growth of settlement as a result of increase in population in Gbonyin Local Government Area of Ekiti State, South-Western Nigeria may result to severe pressure on forest lands. Forest lands were cleared for the sitting of Tissue Paper manufacturing industry and Ply-wood manufacturing industry. Vast hectares of forest lands were cleared for the sitting of these manufacturing industries. Forest lands were also cleared for residential land use. All these processes of conversion of vegetation land use to built-up land use may result to increase in land surface temperature in Ado-Ekiti.

The replacement of vegetation land use by built-up land use can change the land surface temperature characteristics in the State Capital City. Researchers have assessed the link between the urban land surface materials and the urban temperature characteristics. For example, Ayanlade [4] noted that land surface temperature was on the highest in urban residential where there are low vegetal cover while the lowest land surface temperature occurred in farmland where there were high vegetative cover. Rimal [19] observed that settlement growth reduces vegetative cover, thus, adds heat absorbing surfaces such as rooftops, asphalts and other concrete surfaces. Besides, greenhouse gas emissions from industries and automobile systems make the land surface temperature in residential and industrial land uses higher than that of vegetation and agricultural land uses [4].

Zemba, Adebayo and Musa [26] reported an investigation into the application of the integration of Remote Sensing and Geographic Information Systems (GIS) for detecting urban growth and assessing its impact on surface temperature in Jimeta, Nigeria. Remote sensing techniques were utilized to carry out land use/cover change detection by using multi-temporal Landsat Thematic Mapper data. Urban growth patterns were analyzed by using a GIS-based modeling approach. The integration of remote sensing and GIS was further applied to examine the impact of urban growth on surface temperatures. The results revealed a notable and uneven urban growth in the study area. This urban development had raised surface radiant temperature by 90°C from 1986 to 2008 in the urbanized area. The integration of remote sensing and GIS was found to be effective in monitoring and analyzing urban growth patterns, and in evaluating urbanization impact on surface temperature.

Oluwadare et al. [15] estimated the spatial distribution of land surface temperature and thermal radiation from remote sensing data, these data were used to study the effect of urban heat island on human health. Remote sensed data obtained from Thematic Mapper (LANDSAT 7) and the Operational Land Imager and Thermal Infrared Sensor (LANDSAT 8) images between 2002 and 2018 were used to estimate the spatial distribution of Land surface temperature and thermal radiation of Akure, Ondo State, Nigeria. A rapid growing urbanization and alteration of the vegetation cover and other natural surfaces in Akure contributed to increased land surface temperature and surface thermal radiation. It was noticed that the areas with higher surface temperature corresponded with areas that had low vegetation cover. Also, areas with lower surface temperature correspond with areas that have high vegetation. It was also observed that the spatial distribution of the thermal radiation followed the same pattern with that of the spatial distribution of land surface temperature. Regions with higher land surface temperature emitted more thermal radiation than the regions with lower land surface temperature. It was observed in the study that development in the urban area contributed to the increased of land surface temperature in the study area by 3.3°C within the years considered. The study shows the usefulness of remote sensing data and GIS approach in evaluating LST and thermal radiation in a developing region.

Audrey [3] used integrated Remote Sensing and Geographic Information Systems (GIS) for detecting urban growth and assessing its impact on surface temperature in Travis County, Texas by using Landsat Thematic Mapper data and National Land Cover Data from 2001 and 2011. Detecting land surface change over time required relativizing temperature of the study area by the temperature of persistently cold areas on the days considered in this analysis.

This study showed that the Travis County has increased by an average of 2.4°C between 2001 and 2011. Land classified as urban in 2011 increased in temperature by an average of 2.4°C and agricultural land (hay/pasture, herbaceous, and cultivated crops) in 2011 increased in temperature by 4.3°C. The methods used to assess surface temperature change over time were successful and are worthy of continued application to derive more historical trends in temperature change over time. Ruthirako [20] examined the relationships between LST and the characteristics of urban land use indices and population density in Hat Yai City, Thailand. Landsat 5TM images were used for interpretation of land use characteristics and derivation of LST, normalized difference built-up index (NDBI) and Normalized Difference Vegetation Index (NDVI). The characteristics of land use were classified into 4 types: commercial/high density residential, medium density residential, minimum density residential and vegetation cover/park. The average maximum and minimum LST derived from Landsat 5TM were 25.9°C, 33.7°C and 15.8°C, respectively. The areas with high LST were located principally in central built-up areas, slightly northwest-southeast of the study area, including the commercial centre and the newly expanded residential areas. The LST pattern was well related to land use types and population density. The relationship between LST and NDVI however portrayed negative correlation, while that between LST and NDBI highlighted a positive correlation. It is concluded that NDVI and NDBI can be used to evaluate the risk of Urban Heat Island (UHI) and may help city managers better prepare for possible impacts of climate change.

2.1. Causes of Settlements Growth

The following are some of the factors responsible for settlements growth as revealed by Bhatta [5] and Jacob [10].

2.1.1. Population Growth

The first and foremost factor responsible for settlements growth is increase in urban population. Natural increase in population and rural-urban migration are the two major factors responsible for rapid settlements growth. Natural population growth results from excess of births over deaths. Migration is defined as the long- term relocation of an individual, household or group to a new location outside the community of origin. In the recent time, the movement of people from rural to urban areas is significant.

2.1.2. Economic Growth

Expansion of economic base such as increase in number of working persons creates demand for new housing or more housing unit for individuals. This also encourages many developers for rapid construction of new houses and other urban infrastructure. The development of infrastructure and higher living standard in cities often attract people to move into cities. As long as the income gap between rural and urban areas is wide, people will tend to move into the city. Economic factor is one of the main reasons for settlements growth.

2.1.3. Industrialization

Establishment of new industry requires provision of housing facilities to accommodate the workers in a large area that generally becomes larger than the industry itself.

2.1.4. Transportation

Transportation routes open the access of city to the countryside and responsible for linear branch development. The construction of expressways and highways cause both congestion in the city and rapid outgrowth.

2.1.5. Demand of More Living Space

In many developing countries, residents of the core city lack sufficient living space. In a bid to get living space, people can buy new land properties in the peripheries of the city and build new houses there.

2.2. Sustainable City

The concept of the sustainable city first emerged and evolved as Western countries were striving to tackle increasing urban sprawl and environmental issues in the 1970s. The concept gained even greater prevalence in recent years, as the world has begun to place increasing emphasis on the importance of controlling the effects of rapid settlement growth and global warming. Sustainable city is commonly understood as an approach that stresses sustainability as its main feature, embracing social and economic structures that do not compromise environmental aspects. Sustainable city is underpinned by mechanisms aimed at producing city with co-benefits like inclusive economic growth, social fairness and safe and comfortable environment [24]. Sustainable city need to be achieved if we are going to leave urban environment in such a way the future generations will be able to meet their need in all ramifications.

The effect of increased in diurnal land surface temperature due to settlement growth in State Capital Cities of South-Western Nigeria on human comfort or health has become an issue of increased significance among climatologists. Increased in temperature can potentially increase the magnitude and duration of thermal discomfort within cities. During thermal discomfort death rate can be increased and much higher in cities than outlying rural environs. Thermal discomfort from heat waves results to dehydration and health problems such as heat stroke, respiratory and cardiovascular problems. It can increase the risk of still births and shortened gestation [22].

Ado-Ekiti, the State Capital City of Ekiti State in South-Western Nigeria has witnessed settlement growth during the past three decades. The observed economic development in the city involved in the conversion of vegetation and open surfaces land uses to built-up land use. The built-up land use is capable of creating an urban canopy layer and changes the radiation and thermal characteristics of the underlying surfaces. The City has urban features such as asphalt roads, concrete surfaces, metal and stone buildings which absorb sunlight and re-radiate energy as heat. In most cases if not all, the streets in this city typically have fewer trees and other vegetation to shade buildings and cool the air by evapotranspiration, the implication of this is increased in temperature which is capable of posing the threat of urban thermal discomfort.

2.3. The History of Settlement Growth in Ado-Ekiti

In the defunct Western State, Ado-Ekiti was one of the Provincial Headquarters. The town retained this status under a different name (Local Government Headquarters) when Ondo State was created in 1976. When Ekiti State was carved out of the "old" Ondo State in 1996, Ado-Ekiti became the State Capital City. This development resulted to influx of people from rural areas in Ekiti Sate to the State Capital City. Many civil servants of Ekiti State origin that were working and resident in the former Ondo State were transferred to Ekiti State and most of them reported in State Government Secretariat in Ado-Ekiti. This irreversible flow of people to Ado-Ekiti swelled up the population of Ado-Ekiti in a very short period of time. Consequently, the existing infrastructural facilities became grossly inadequate to meet the yarning needs of the dense population. This then set the stage for the eventual unprecedented expansion of Ado-Ekiti [17].

3. Methodology

3.1. Data Required and Sources of Data

The variables that were investigated in this study include; Land Use/Land Cover (LU/LC) and Land Surface Temperature (LST) of Ado-Ekiti from 1988 to 2018 specifically. The main source of data for Land Use/Land Cover and Land Surface Temperature were remotely sensed imageries of the settlement for 1988, 1999, 2013 and 2018. All these Landsat images were collected from the website of the U.S. Geological Survey (USGS) of the National Centre for Earth Resources Observation and Science (EROS) (see Table 1). The Land Use/Land Cover and Land Surface Temperature in the Study area for thirty (30) years were investigated from 1988 to 1999, 1999 to 2013 and 2013 to 2018.

Table 1. *The Description of Satellite Imageries used in the Study.*

Acquisition Date	Source	Path/Role	Resolution	Landsat Series
04 Dec. 1988	USGS	190/55	30M.	L5
17 Dec. 1988	USGS	191/55	30M.	L5
21 Jan. 1999	USGS	190/55	30M.	L5
18 Dec. 1999	USGS	191/55	30M.	L5
14 Dec. 2013	USGS	190/55	30M.	L7
27 Dec. 2013	USGS	191/55	30M.	L7
16 Jan. 2018	USGS	190/55	30M.	L8
03 Jan. 2018	USGS	191/55	30M.	L8

Source: USGS, 2018.

In order to estimate Land Use/Land Cover of the study area, three classes of land use which include Vegetation, Open Surfaces and Built-Up land uses were selected from the Landsat imageries of the study area (see Table 2). Geographic link of ERDAS IMAGING 9.2 were used to investigate the Land Surface Temperature values for vegetation, Open Surfaces and Built-Up land use types. The percentage of changes in the size of each class of land uses with its corresponding Land Surface Temperature values from 1988 to 2018 in Ado-Ekiti were compiled and tabulated in order to understand the rate of settlement growth and its impact on Land Surface Temperature in the study area.

Table 2. *Description of Land Use/Land Cover.*

Land Use Types	Description
Built-Up	Residential, Commercial, Roads and other Urban Features
Vegetation	Forest, Cash Crops and Urban Green Belts
Open Surfaces	Exposed Soil and Rock surfaces

Source: Researcher's Field Work, 2018.

3.2. Methods of Data Analysis

3.2.1. Image Pre-processing

Landsat images of Ado-Ekiti between 1988 and 2018 were used in this study. All the images were retrieved from the U.S. Geological Survey (USGS) of the National Centre for Earth Resources Observation and Science (EROS). All the bands were utilized at a spatial resolution of 30m. These spectral bands were layer stacked to produce a composite image of the study area for each year (1988, 1999, 2013 and 2018) for the purpose of land use/land cover classification and image analysis. Thermal band for Landsat images were used to extract the diurnal land surface temperature from all the periods under consideration. The composite images and thermal bands were clipped with a rectangular area of interest in ERDAS IMAGING 9.2.

3.2.2. Supervised Image Classification

A land use/land cover classification is necessary in order to detect land use/land cover changes as a result of settlement growth from 1988 to 2018 for Ado-Ekiti. The classes of land use/land cover that were considered are vegetation, open surfaces and Built-up land uses. A supervised classification with the maximum likelihood algorithm was conducted to classify the Landsat images using bands 2 (green), 3 (red) and 4 (blue). Visual image interpretation was done with reference to Landsat images of the study area.

3.2.3. Accuracy Assessment

Land use/land cover use maps derived from classification of images usually contain some sort of errors due to several factors that range from classification techniques to methods of satellite data capture. Therefore, assessment of classification results is an important process in the classification procedure to avoid these errors. The accuracy assessment was done by generating equal random points for the classified images, using the accuracy assessment tool in ERDAS IMAGING by comparing the randomly selected pixels with corresponding referenced data.

3.2.4. Land Use/Land Cover Change Detection Analysis

The change detection algorithm employed for detecting land use/land cover change was image differencing. Image differencing is one of the widely used change detection approaches and is based on the subtraction of images acquired in two different times. In the process, the Digital number (DN) value of one date for a given band is subtracted from the DN value of the same band of another date [21]. Change detection analysis was carried out to evaluate the changes in land use/land cover from 1988 to 2018 for Ado-Ekiti.

3.3.5. Estimation of Land Use/Land Cover and Land Surface Temperature

In order to estimate land use/land cover of the study area, three classes of land use which include vegetation, open surfaces and built-up land uses were selected purposefully from the Landsat imageries of the study area. Geographic link and enquire tools of ERDAS IMAGING 9.2 were used to investigate the diurnal land surface temperature value for each of the land use type that was selected. The percentage of changes in size of each class of land use from 1988 to 2018 with its corresponding Land Surface Temperature values were compiled and tabulated in order to understand the rate of Land Surface Temperature response to settlement growth in the study area.

4. Results and Discussion

4.1. Land Surface Temperature Associated with Different Land Use Types

The Land Surface Temperature values obtained in the difference Land Use types in Ado-Ekiti, the State Capital City of Ekiti State, South-Western Nigeria from 1988 to 2018 were clearly presented in Table 3.

Table 3. *Mean and Standard Deviation of Land Surface Temperature in Difference Land Use types in Ado-Ekiti, from 1988 to 2018.*

Land use	LST (1988)		LST (1999)		LST (2013)		LST (2018)	
	Temp.(°C)	S.D.	Temp.(°C)	S.D.	Temp.(°C)	S.D.	Temp.(°C)	S.D.
Built-up	22.9	1.08	25.1	1.69	29.6	1.51	30.6	0.40
Open Surfaces	20.4	1.08	24.7	1.96	27.3	0.94	30.4	0.37
Vegetation	19.9	1.06	23.2	1.95	26.0	1.24	26.8	0.49

Source: Obtained from Landsat Images, 1988, 1999, 2013 and 2018.

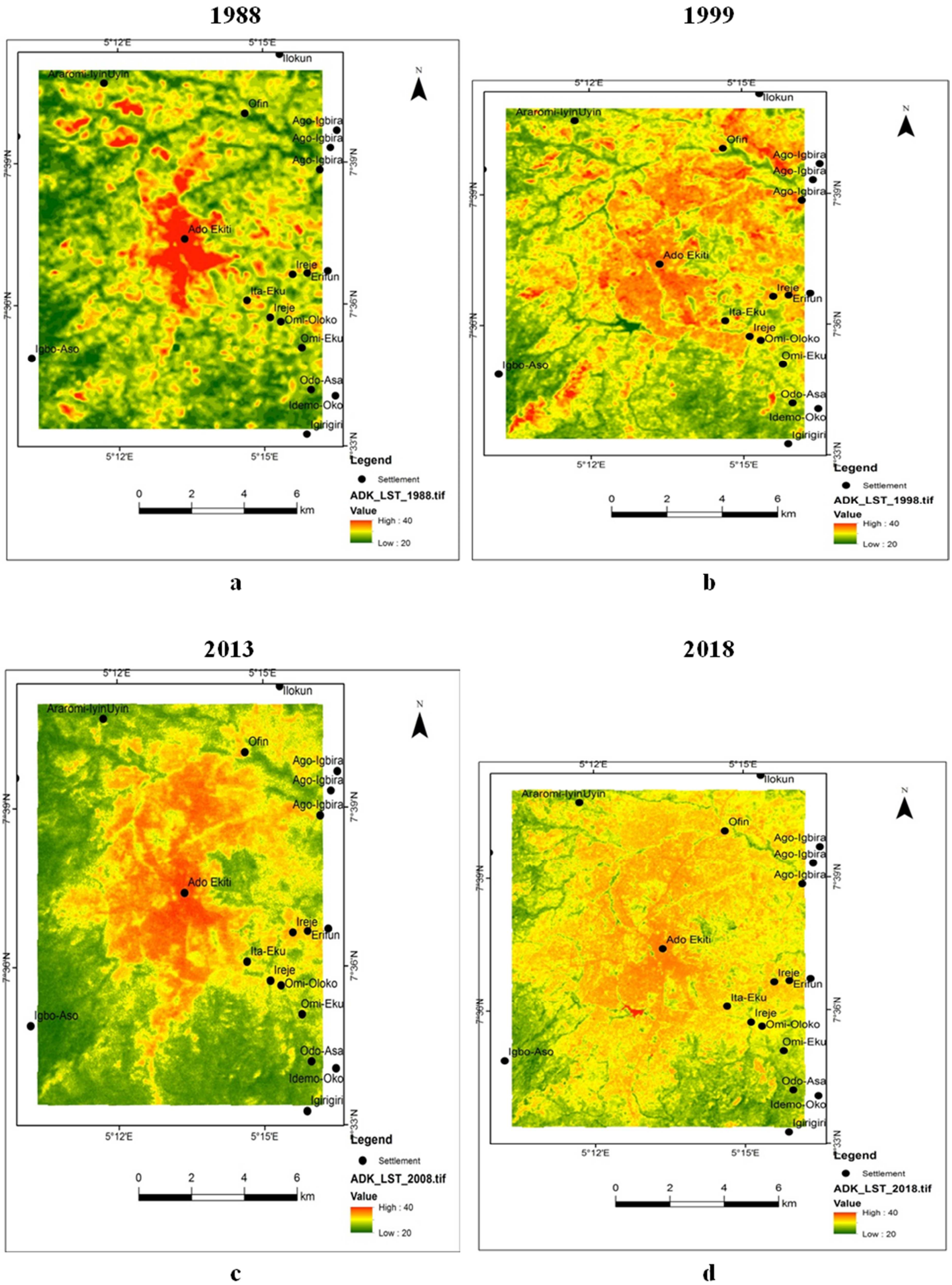
The results of Land Surface Temperature analysis as shown in Table 3 indicated that the mean values of LST from 1988 to 2018 varies in the various land use type. The results of the built-up areas analysis from 1988 to 2018 exhibited the highest LST mean values of 22.9°C with a standard deviation of 1.08 in 1988, 25.1°C with a standard deviation of 1.69 in 1999, 29.6°C with a standard deviation of 1.51 in 2013 and 30.6°C with a standard deviation of 0.40 in 2018, followed by the open surfaces land use with the mean LST values of 20.4°C and a standard deviation of 1.08 in 1988, 24.7°C and a standard deviation of 1.96 in 1999, 27.3°C and a standard deviation of 0.94 in 2013 and 30.4°C with a standard deviation of 0.37 in 2018. Vegetation land use had the lowest mean LST values of 19.9°C with a standard deviation of 1.06 in 1988, 23.2°C with a standard deviation of 1.95 in 1999, 26.0°C with a standard deviation of 1.24 in 2013 and 26.8°C with a standard deviation of 0.49 in 2018. From the analysis, it was clear that the built-up land use type was warmer than vegetation land use type. The Standard Deviation of the land surface temperature Mean values in all the land use type were not the same. The variation in land surface temperature in the land use types in Ado-Ekiti, South-Western Nigeria from 1988 to 2018 may be linked to the conversion of vegetation land use type to built-up and open surfaces land use types so as to give room for road networks, residential and commercial buildings.

The results indicate a trend of increasing mean Land Surface Temperature in all the land use types in Ado-Ekiti, South-Western Nigeria from 1988 to 2018. This might probably due to an increase in built-up land use type as a result of conversion of open surfaces and vegetation land use types to built-up land use type. For instance, the LST in built-up land use type rose from 22.7°C in 1988 to 30.6°C in 2018. The reason for this significant increase of 7.9°C in Land Surface Temperature is not far from settlement growth in Ado-Ekiti, South-Western Nigeria. The reason why there was a growth in the settlement of Ado-Ekiti can be linked to the fact that in 1996, Ado-Ekiti became the State Capital City when Ekiti State was carved out from the old Ondo State, this development lead to the inflow of people especially, the Civil Servants who are the indigene of Ekiti State from Ondo State to Ado-Ekiti.

It is evident from the findings of this study that land surface temperature is considerably low in vegetation land use type (see Table 3). The low surface temperature exhibited by the vegetation land use type is due to the fact that, vegetation can lower the LST through the process of evapotranspiration [9]. It also obvious from the findings this study that LST is considerably high in built-up land use type (see Table 3). The reason for this is that built-up land use type contains large areas of artificial and impervious surfaces such as asphalt roads, concrete surfaces and building roofs with high albedo implications [25]. Jacob [10] in his work on Effects of Urban Growth on Temporal Variation of Surface Temperature in Katsina Metropolis, Nigeria reveals similar facts that LST value is low in Vegetation land use type while it is high in built-up land use type. Likewise Oluwadare et al. [15] noticed that the areas with higher surface temperature corresponded with areas that had low vegetation cover. Also, areas with lower surface temperature correspond with areas that have high vegetation. It was observed in their study that development in the urban area contributed to the increased of land surface temperature in Akure, Ondo State, Nigeria.

4.2. Land Surface Temperature of Land Use Types in Ado-Ekiti

The Land Surface Temperature maps for Ado-Ekiti from 1988 to 2018 were generated and presented in Figures 1a, 1b, 1c and 1d. The Land Surface Temperature values in built-up, open surfaces and vegetation land uses for Ado-Ekiti were obtained and presented in Table 4.



Source: GIS, 2018

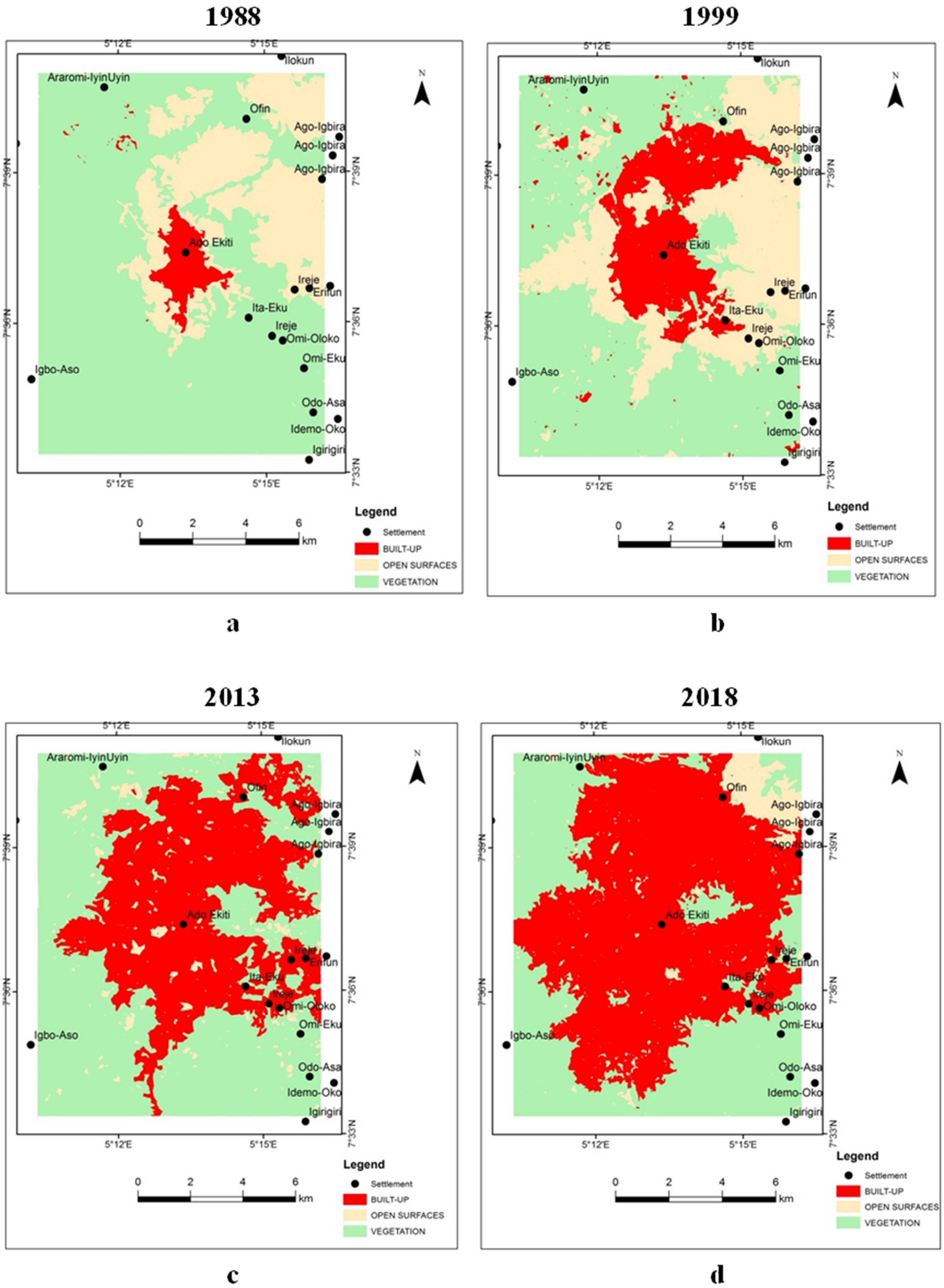
***Figure 1.** Land Surface Temperature dynamics in Ado-Ekiti from 1988 to 2018.*

4.3. Investigation of Settlements Growth (Land Use Change)

In this study, built-up areas which includes all impervious surfaces such as concrete land cover, asphalt roads, residential and commercial buildings and all other urban features are referred to as settlement while dense forest, tree crop- lands and urban green belts are referred to as vegetation and also open surfaces are used to represent exposed soil and rock surfaces.

4.4. Land Use Types and Area Coverage from 1988 to 2018 in Ado-Ekiti

The areas covered by each land use types in Ado-Ekiti from 1988 to 2018 are clearly shown in Table 4. Also Landsat maps showing the built-up, open surfaces and vegetation land uses in Ado-Ekiti were produced and presented in Figures 2a, 2b, 2c and 2d respectively.



Source: GIS, 2018

Figure 2. *Landsat maps of 1988, 1999, 2013 and 2018 indicating area covered by land uses in Ado-Ekiti.*

Table 4. Areas Covered by Land Use types from 1988 to 2018 in Ado-Ekiti.

Land Uses	Areas in 1988 (km^2)	Areas in 1999 (km^2)	Areas in 2013 (km^2)	Areas in 2018 (km^2)
Built-Up	5.33	25.04	60.08	84.85
Open Surfaces	36.78	45.47	38.09	26.69
Vegetation	108.87	80.40	52.81	39.19
Total	150.98	150.91	150.98	150.73

Source: Obtained from Landsat Images of 1988, 1999, 2013 and 2018.

Land use and land cover maps of Ado-Ekiti for 1988, 1999, 2013 and 2018 are shown in Figure 2. The total area of built-up, open surfaces and vegetation land use types from 1988 to 2018 were calculated and are clearly presented in Table 4. During the last 30 years in Ado-Ekiti, the built-up land use type covered a total area of 5.33km^2 in 1988, 25.04km^2 in 1999, 60.08km^2 in 2013 and 84.85km^2 in 2018. Open surfaces land use type covered a total area of 36.78km^2 in 1988, 45.47km^2 in 1999, 38.09km^2 in 2013 and 26.69km^2 in 2018. Vegetation land use type covered a total area of 108.87km^2 in 1988, 80.40km^2 in 1999, 52.81km^2 in 2013 and 39.19km^2 in 2018. From Table 4, it can be observed that there was a drastic increase in built-up land use type from 5.33km^2 in 1988 to 25.04km^2 in 1999 and from 25.04km^2 in 1999 to 60.08km^2 in 2013 and from 60.08km^2 in 2013 to 84.85km^2 in 2018. Table 4 indicates that built-up land use type has increased from 5.33km^2 in 1988 to 84.85km^2 in 2018 indicating an increase of 79.52km^2 over the last 30 years. The reason for the increase in the built-up land use type is not unconnected with the conversion of forest and farmlands to built-up area in Ado-Ekiti in order to meet the demand for residential, commercial, public offices and academic facilities. Open surfaces has a drastic increase from 36.78km^2 in 1988 to 45.47km^2 in 1999 showing a decadal increase of 8.69km^2. The reason for this drastic increase is not unconnected with the conversion of tropical forest to farmlands. However, in 2013 the open surfaces land use type declined from 45.47km^2 in 1999 to 38.09km^2 and from 38.09km^2 in 2013 to 26.69km^2 in 2018. The reason for this decrease may be credited to the construction urban features such as residential buildings, roads and commercial buildings on the open surfaces which were formerly used for agricultural purposes as a result of population growth in Ado-Ekiti. Vegetation land use type decline drastically from 108.87km^2 in 1988 to 39.19km^2 in 2018 indicating a decrease of 69.68km^2. The reason for this drastic decrease may be attributed to rapid settlement growth in Ado-Ekiti.

It is apparent from the findings of this study that area covered by the built-up land use type is increasing rapidly while the area covered by the open surfaces and vegetation land use types is reducing at a fast rate in the study area (see Table 4). The movement of people into this City may be because of the presence of employment opportunities, social amenities and being the seat of government, because as the people are migrating into this City, there is a necessity to build more houses, commercial centre, roads, educational and health facilities to accommodate the ever increasing population.

Table 5. Percentage of Changes in Built-up Land Use and their Respective Corresponding LST Values in Ado-Ekiti.

Cities	Years	% of Changes in Built-up Land use	% of Changes in LST
Ado-Ekiti	1988-1999	369.79	12.8
	1999-2013	139.94	12.3
	2013-2018	41.23	1.4
	1988-2018	93.72	22.1

Source: Obtained from Landsat Images of 1988, 1999, 2013 and 2018.

From the results in Table 5, it was evidence that there were significant increase in the percentages of built-up land uses in Ado-Ekiti from 1988 to 2018. For Ado-Ekiti the percentage of increase in built-up land use from 1988 to 1999 was 369.79% with LST percentage of increase of 12.8% then from 1999 to 2013 the percentage of increase in built-up land use was 139.94% with LST percentage of increase of 12.3% while the percentage of increase in built-up land use from 2013 to 2018 was 41.23% with LST percentage of increase of 1.4%. The percentage of increase in built-up land use from 1988 to 2018 in Ado-Ekiti was 93.72% with LST percentage of increase of 22.1%.

5. Conclusion

Conversion of vegetation land use type to open surfaces and built-up land use types has generally resulted in a decline in the areas covered by the vegetation land use type in the Ado-Ekiti, the State Capital City of Ekiti State in Nigeria. The increase in population size in this city may be the reason why the areas covered by vegetation were being converted into open surfaces and built-up land use types in this city. The reduction in the areas covered by vegetation in the State Capital City has resulted into the increase in Land Surface Temperature in this city. However, adoption of the concept of Green Urbanism (GU) by planting Green Belts (GB) within the city will go a long way in sustaining our cities by reducing the amount of Land Surface Temperature (LST) within the city.

Vegetation makes use of solar radiation for transpiration and release water vapour that helps in reducing the amount of air temperature and potentially decrease the amount of land surface temperature [2]. It should be noted that the more the presence of vegetation covers the more its cooling effects on land surface. In addition to evaporative cooling effects of vegetation, the shade provided by the trees can act to cool the land surface by intercepting solar radiation and preventing the increase in Land Surface Temperature [13]. The increment in the amount of Land Surface Temperature recorded in Ado-Ekiti can be attributed to the reduction in the areas covered by vegetation in the city.

Based on the current findings, it was presumed that increase in LST in the State Capital City of Ekiti State, South-Western Nigeria was in response to increase in built-up land use type (settlement growth). This result points to the need to have focused policies on sustainable city such as introduction of urban green belts within the cities and implementation of the concept of green urbanism by the Government of Ekiti State.

6. Recommendations

The findings of this study revealed that land surface temperature value in the vegetation land use type was lower than the land surface temperature in the built-up land use type (see Tables 4 and 5). However, as the build-up areas in Ado-Ekiti city continue to grow, if measures are not put in place to increase the vegetation in the urban area, then the build-up area will get warmer than the surrounding rural area due to increase in the land surface temperature within the urban area, and these impacts are almost certain to get worse, from higher temperature to heat waves, which can cause disease outbreaks and can lead to health threat among the populations residing in Ado-Ekiti. It is therefore, recommended that whenever there is construction of any building either residential building, commercial building or office building by government or individual, they should endavour to plant trees, flowers and grasses around the buildings instead of concrete in order to reduce land surface temperature within the city. If it is possible, flowers and grasses should be planted around the existing buildings in Ado-Ekiti, the State Capital City of Ekiti State so as to reduce the land surface temperature and therefore mitigate the problem of thermal discomfort caused by excessive high temperature within the City.

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