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TEMPERATURE MAPPING AND SUSTAINABLE DEVELOPMENT IN ILORIN METROPOLIS: A GEOSPATIAL APPROACH

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ABSTRACT

Temperature mapping makes up part of every nation's geospatial data infrastructure and a tool for sustainable development. An isothermal map (temperature map) creates an understanding of the variation of temperature of an area and the effect of urban heat island (UHI). This study examines temperature mapping within the context of sustainable development in Ilorin metropolis from a geospatial perspective. The primary data of minimum and maximum temperature from the digital and the minimum and maximum thermometer for the period of four months (April, May, June and July, 2015) were collected, the duration covered both the dry and wet seasons. On the other hand, satellite imagery and other maps were used as part of the secondary data for the purpose of mapping the temperature of Ilorin metropolis. For this study, the ordinary kriging method was used. The classification scheme used was Equal Interval in order to showcase the natural distribution of values as bulk of values will fall under different colour zone, and this in turn highlight extreme values into characteristic colours for ease of identification. Seven classes were used to illuminate the difference in values. The study shows the spatio-temporal variation of temperature in the study area, the core areas are characterized with increased temperature. However, the isothermal map serve as a tool and a pointer to the government, geographers, and the general public so as attain the city growth and sustainable development.

Keywords: Isothermal Map, Sustainable Development, Kriging, Spatial Interpolation, Core, Urban Heat Island And Peripheries.

INTRODUCTION

A nation's geographic map is an important tool in the life of the nation sustainable development. Research shows that increased temperatures, coupled with the urban heat island effect, can have a crippling effect on both biological and infrastructure systems (Wang, 2000). Thus, production and regular revision of maps is necessary because it keeps users in the knowledge of economic, social and other development activities in the environment within a specified time (Ufuah, 2005). According to Olomo, Ufuah and Akpan (1998), maps are essential and indispensable tools in any development and planning programme both at the national and regional levels. Ufuah (2003) went further to suggest that for any state or (locality) to attain sustainable development of both the physical and human features especially socio-economic growth, mapping and the use of maps must be embraced. Therefore, the relevance of maps in sustainable development and nation building cannot be over-emphasized (Uloucha and Nsofor, 2001; Ufuah, 2005).

Temperature mapping (isothermal map) of an area is of intrisic concern to many nations, map users, geographers and cartographers. Topographic Maps (isothermal map, relief map, drainage map) can be of great use to a country's developmental efforts and programmes towards sustainable development (Balogun, 2006).

Today, mapping has taken the advantage of computer speed, accuracy and high storage capacity, hence manual map making is no longer fashionable (Eniolorunda, 2010). This possibility is brought about by the adoption of geospatial techniques. Such a technique involves the application of either satellite imagery or aerial photograph with innumerable mapping and Geographic Information System (GIS) software to integrate multisource and multi-date data for the generation of land use changes involving such information as trend, rate, nature, location and magnitude of changes (Peter, 1999). It has the advantages of cost-effectiveness, timeliness, practically unlimited synoptic view, high rate of data acquisition and feasibility of gathering data from inaccessible areas, increased labour efficiency etc. (Ufuah, 2006a). These inherent characteristics of geospatial techniques can be recognized as advantages in relation to, or over conventional methods of developing or designing an isothermal map.

Many research works have examined the application of remote sensing and geographical information system powerfully and effectively in deriving multispectral, multi-resolutional, multi-temporal data on land use, land cover climatic parameters that are related to the effects of the urban heat island (Ifatimehin, 2007; Ujoh and Kwabe, 2010). The use of Geo-information technology in the mapping of temperature variations as related to the effect of urban heat island is increasing day by day because of the areal coverage of satellite images, data image processing and analysis and its mapping capabilities as in situ data only cannot be fully represented.

It was noted in many studies that Urban Heat Island (UHI) varies based on the city structure and the range of temperatures within the island vary as well (Zhen, 2000) as parks, green belts reduces the temperature of the area, while central business districts (C.B.D), built up areas have warmer temperatures (Zhen, 2000 and Mcktrick, 2002). Similarly, Olanrewaju (2009) discovered an increase in the temperature of the city of Ilorin. This rising air temperature of the city has its own fair share from the danger and threat posed by increases temperature on the environment and on man especially due to the rapid population growth. On this note there will be need for the development of an isothermal map

(temperature mapping) which will serve as an essential tool for a sustainable development, environmental monitoring, and measure for combating urban heat island effect of the area.

STUDY AREA

The study area is Ilorin metropolis, which is the capital city of Kwara state, Nigeria. Ilorin metropolis consists of three local government areas namely; Ilorin east, Ilorin west and Ilorin south. Ilorin is located approximately on latitude 8º30' and 8º50' north of the equator and longitude 4º20' and 4º35'east of the Greenwich meridian (Figure 2.1). Ilorin is the gateway city between the southern and northern Nigeria with an approximate land area of 100kilometres square, (Kwara state diary, 2012).

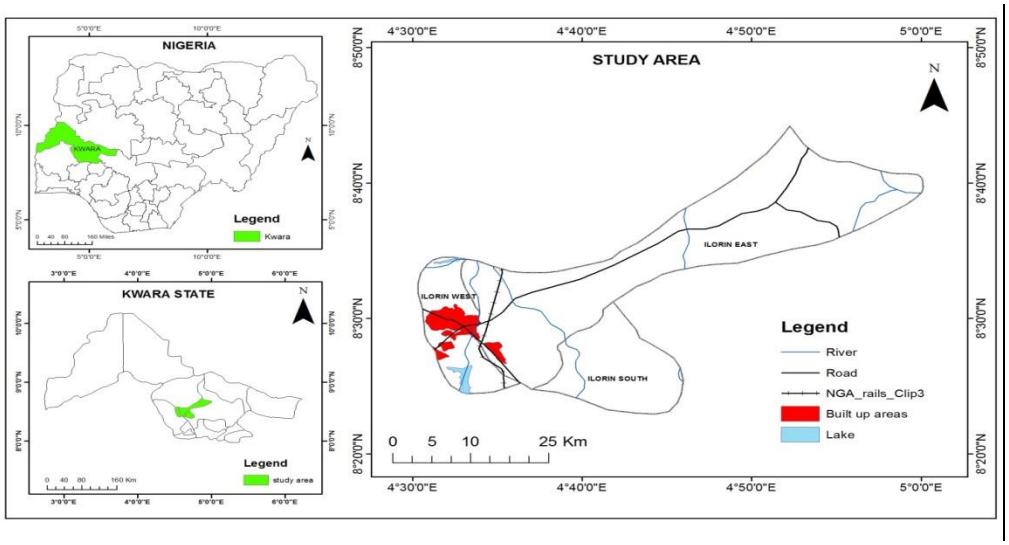

Figure 2.1. Map of Ilorin, the Study Area.

Source: Office of the Surveyor General of the Federation (OSGOF), Abuja. (2015)

The climate of the city is humid tropical under the influence of the two trade winds prevailing over the country, characterized with high temperature throughout the year (Ajibade, 2002). Ilorin enjoys wet and dry seasons. The daily average temperatures are in January with 25ºC, May 27.5 ºC and September 22.5 ºC. The wet season is between May and October with two peak periods in June and September while the dry season spans between November and April. The mean annual rainfall is 1,200mm (Olanrewaju, 2012). The mean annual total rainfall is 1200m (Olaniran, 2002). The temperature in Ilorin is uniformly high throughout the year.

RESEARCH METHODOLOGY

The primary data of minimum and maximum temperature from the digital and the minimum and maximum thermometer for the period of four months (April, May, June and July, 2015) were collected, the duration covered both the dry and wet seasons. On the other hand, satellite imagery and other maps were used as part of the secondary data for the purpose of mapping the temperature of Ilorin metropolis.

The isothermal map was developed by employing GIS technique. Via the process of data importation such as (maps, the temperature records for the stipulated time, satellite imageries of Ilorin and the coordinates points) on 10.2 Arc GIS environment.

i. Digitization operation was carried out so as to simplify and select the features needed for the study area map from the street guide map of Ilorin.

ii. Spatial interpolation Operation was carried out on ArcGIS 10.2 Geostatistical analyst tool and it was used for interpolating the temperature data. For this study, kriging method of interpolation was used. Kriging is a geostatistical method for spatial interpolation, it differs from other local interpolation methods because kriging can assess the quality of prediction with estimated errors. Kriging has since been adopted in wide variety of discipline. There are different types of kriging methods; universal kriging, simple kriging, ordinary kriging, block kriging etc. However, the ordinary kriging method was used because it is reliable (Lloyd,2005; Chang,2014;) The classification scheme that was used is the equal Interval in order to showcase the natural distribution of values as bulk of values will fall under different colour zone, and this in turn will highlight extreme values into characteristic colours for ease of identification. Seven classes was used to illuminate the differences in value.

To generate the isothermal map, the sample points were exported to raster and then masked with the Digital Elevation Model (DEM) of the area.

iii. Overlay operation was carried out also, so as to overlay different layers to generate the isothermal map.

RESULTS AND DISCUSSIONS

Presentation of Temperature Data from the Selected Stations in Ilorin Metropolis.

Table 4:1: Temperature Readings from the selected stations in Ilorin for the Selected Month (April, May, June and July 2015).

STATIONS	X	Y	April AV	May AV	June AV	July AV	AVE_AVE
PERI 1	671798.98	946508.4504	30.63548	30.05	30.05305	30.06559	30.20103
PERI 2	671807.08	944508.7135	30.95806	30.13222	30.35878	30.08172	30.3827
CORE 3	671815.17	942508.9766	33.33118	32.27444	32.47742	32.42043	32.62587
CORE 4	671823.24	940509.2395	33.65484	32.53667	32.59068	32.53333	32.82888
CORE 5	671839.32	936509.7649	33.68817	32.71556	32.75663	32.61828	32.94466
CORE 6	671836.46	934510.9765	33.80753	32.73667	32.75412	32.65054	32.98721
PERI 7	671858.17	932511.2903	34.51398	30.61222	30.83656	30.63871	31.65037
PERI 8	671864.3	930511.2518	34.10645	30.54556	30.70609	30.53548	31.4734
CORE 9	673831.25	938517.5468	34.02903	32.75222	33.03835	32.81183	33.15786
CORE 10	675830.5	938527.9103	37.19892	32.85556	32.80968	35.89677	34.69023
PERI 11	677830.48	938533.2516	31.61828	30.88778	31.02007	30.84086	31.09175
PERI 12	679830.58	938542.4281	31.49892	31.03556	30.85484	30.92366	31.07824
CORE 13	669831.74	938485.5364	34.0914	32.94667	32.65376	33.12151	33.20333
CORE 14	667829.16	938461.6283	34.11398	32.96222	33.00717	33.11613	33.29987
PERI 15	665835.86	938437.9243	31.73871	30.72778	30.78459	30.76774	31.0047
PERI 16	663832.12	938414.1901	31.84409	30.69111	30.7233	30.92688	31.04634

Source: Author's Fieldwork, (2015).

Table 4.1 shows the temperature reading of the sixteen thermal stations in the study area for the month of April, May, June and July, 2015. The table also shows the coordinate of the station and the spatio-temporal pattern of the temperature record. It was revealed that there was high temperature around the core region, for instance the highest temperature in the month of April, May, June and July was observed in April at core 10 which is 37.6^0, the reason for the increased core temperature is as a result of the activities carried out in the area such as commercial activities, emission of energy from automobiles and engines also the core area is characterized by little vegetation, concretized surface and high reflective surfaces from roofing and building materials. The table also shows lower temperature around the peripheral areas, which is characterized by vegetation's, few building, and the activities carried out in this area are mostly the primary activities such as farming, fishing, crafting among others, thus the rate of emission of energy in the peripheries is low compared to that of the core region.

Presentation and Analysis of Isothermal Map

To constructe a statistical surface and to make an isothermal map of the study area which is a great tool for sustainable development of a nation, the temperature data obtained from the weather stations as shown in table 4.1 was used. Through spatial interpolation, temperature value at a location with no recorded data can be estimated by using the known temperature readings at nearby stations (Chang,2014).

Spatial interpolation method can be categorized into; Global and local interpolation method. The global interpolation method uses every known point available to estimate an unknown value. The local interpolation method, on the other hand uses a sample of known points to estimate an unknown value. The difference between the two lies in the number of known points used in estimation. Example of global interpolation method are trend surface and regression. The local interpolation method include; kriging, Inverse Distance Weighted (IDW), density estimation, splines etc Lloyd and Atkinson (2001)

For this study kriging method of interpolation was used. Kriging is a geostatistical method for spatial interpolation, differs from other local interpolation methods because kriging can assess the quality of prediction with estimated errors. Kriging has since been adopted in wide variety of discipline. There are different types of kriging methods; universal kriging, simple kriging, ordinary kriging, block kriging etc. However, the ordinary kriging method was used because it is reliable (Lloyd,2005; Chang,2014;) The classification scheme used was Equal Interval in order to showcase the natural distribution of values as bulk of values will fall under different colour zone, and this in turn highlight extreme values into characteristic colours for ease of identification. Seven classes were used to illuminate the difference in values.

To generate the isotherm, the sample point was exported to raster and it was then masked with the Digital Elevation Model (DEM) of the area.

Figure show the average temperature surface created by ordinary kriging and figure shows an isotherm map of the surface.

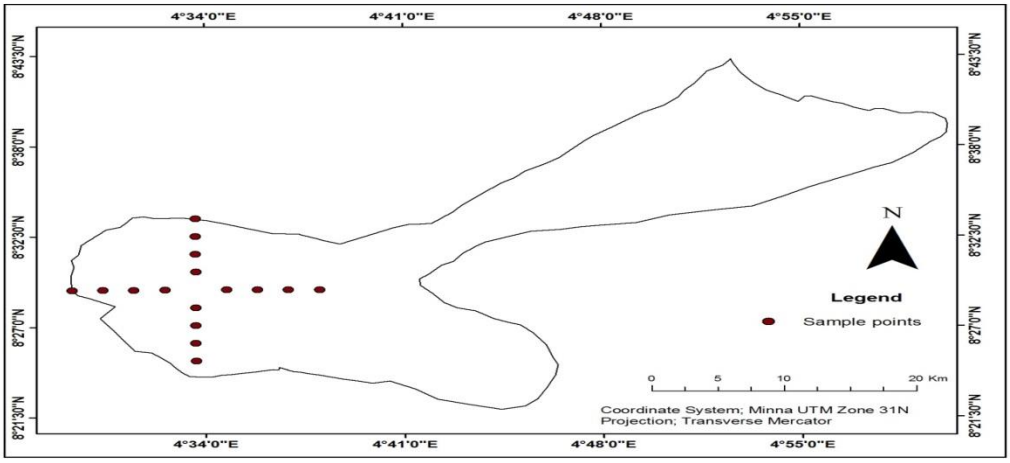

Fig 4.1: The Sample of the Thermal Point in the Study Area.

Source: Office of the Surveyor General of the Federation (OSGOF), Abuja. (2015)

Figure 4.1 shows sixteen (16) sample points in ilorin metropolis(built up area), it shows clearly how these sample points are distributed in the study area. The number and distribution of sampled points can greatly influence the accuracy of spatial interpolation. The basic assumption is that the value to be estimated at a point is more influenced by nearby known points than those farther away.

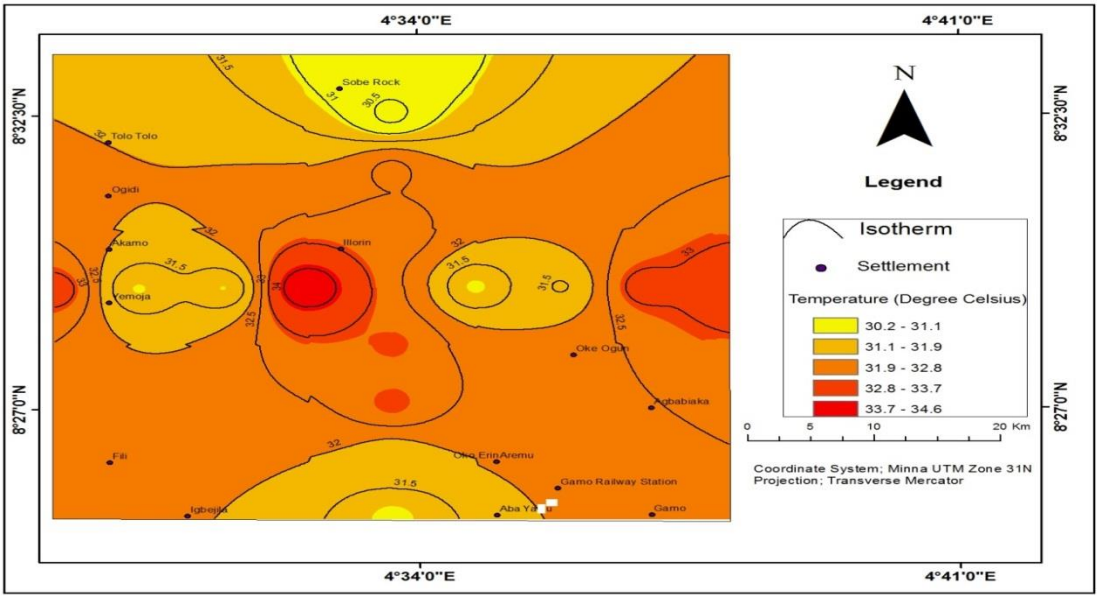

Figure 4.2: Isothermal Map of Ilorin Metropolis for the Month of April, May, June and July2015.

Source: Author's computation, (2015).

Figure 4.2 shows the average Isothermal map of Ilorin Metropolis for the month of April, May, June, and July. From the map we can also see areas on the map showing places of equal temperature (isotherm). Areas with the highest temperature represented with the deep orange colour, followed by the areas with light orange colour. The more lighter the colour the lesser the temperature. From the map i.e. figure 4.2, we can see the various areas within Ilorin Metropolis and their various temperature indicated by lines and shades of colours. The core has higher temperature ranging from 33.7^0 – 34.6^0 and this temperature decreases as one gets to the peripheries. From this isothermal map we can also see pictorially that there is variation between the core and the peripheries also we can also observe that the effect of Urban Heat Island is higher in the core (the Central Business District areas or the more urban areas) than the peripheries (the intermediaries or the rural areas). This temperature variation shown in the isothermal is as a result is as a result of the human activities and the land use type.

CONCLUSION

According to Menaker (2010), sustainable development planning requires very accurate and up-to-date geographical information which drives the need for acquisition of such data in high accuracy (at a reasonable cost and a short time span). It is worthwhile to state from this study, that temperature mapping using remotely sensed data, GPS technology and GIS technique is very important and less tasking compared to the traditional manual map making. It is also cost effective and time saving in view of the size of the study area. The study also reveals the spatio-temporal variation of temperature in the study area, the core areas are characterized with increased temperature. However, the isothermal map serve as a tool and a pointer to the government, geographers, and the general public so as attain the city growth and sustainable development.

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