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ANALYSIS OF SATELLITE BASED LAND SURFACE EMISSIVITY (LSE) OF LAPAI AND ENVIRONS, NIGER STATE, NIGERIA

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Abstract

This study analyzed satellite based Land Surface Emissivity (LSE) of Lapai and environs, Niger State, Nigeria. Thus, LSE effects have the capacity to cause health disasters in an urban center. This study adopted the algorithm for deriving LSE from Satellite Lansat 5, 7 and 8 using infrared sensor and surface emissivity from Google Earth Engine to generate the imageries. The imageries were derived in three epochs of 2000, 2010 and 2022 respectively. The findings showed that in the year 2000, LSE was highest in the south-eastern, north-eastern and the eastern segments of Lapai and its environs. In the year 2010, LSE was highest in the north-eastern, south-eastern and the eastern segments of the study area. Currently in the year 2022, LSE concentrated on Lapai central area. The distribution of LSE across the Lapai town and environs is as a result of random alteration of the biophysical components of the earth surface such as building, farming and other development purposes. Therefore, it is recommended that the government of Niger State and other policy makers should encourage urban greening and tree planting in order to ameliorate the effects of LSE on human health.

Keywords: Emissivity, Environs, Land, Surface, Temperature

1. Introduction

Land Surface Emissivity (LSE) which is the energy radiated from urban material surfaces per second with the values between 1 (high) and 0 (low). Emissivity in the view of [1] is the percentage of warmness a black surface releases between 0 and 1. Thus, LSE is the proportion of radiated energy on the surface of a material compared to that released from a black body all at the same temperature, wavelength and conditions of view [2]. However, LSE determines the efficacy of urban surface areas to convert sensible heat into latent heat. It is the radiation of solar energy from material surface area to the surrounding air [3]. In the city and its environment exists strong relationship between the various land surfaces and LSE characterized by the alteration of the biophysical features. It is necessary to control effects of LST as they impact on land, air and water bringing about more energy demand in the cities. Many approaches have been designed to cushion the effects of LST by regulating material albedo, emissivity, evapotranspiration and impermeable surfaces [4].

Pavement temperatures are affected by solar radiation, solar reflectance, emittance, heat capacity, surface roughness, heat transfer rates and permeability. The two most popular pavement types used currently are asphalt and impervious concrete, which can reach surface temperatures of 48°C to 67°C [5]. Thus, for LST to reduce; low heat conductor materials are encouraged to improve the thermal and permeability properties of conventional pavements that propagate severe heat. The [6] reported that within urban environments, paved areas account for approximately 30-45% of exposed surfaces thereby increasing the LSTof an area.

Urban greening is the exposed space in urban area primarily covered by varieties of plants and trees [7]. Many studies have recommended the use of vegetation to subdue LST effects. This is because vegetation achieves cooling through many methods such as seasonal shading of urban infrastructure, through evapotranspiration and minimizing ground temperature differences. For instance, peak temperatures of un-shaded materials have more thermal conductivity than shaded surfaces with temperature of about11-25°C lesser

[5]. Evapotranspiration and other shading materials can help reduce peak summer temperatures by 1-5°C [8]. Therefore, trees and other plants help cool the environment, making urban greening a simple and strong way to reduce LST.

Generally, LST has the capacity to raise air pollution and greenhouse gas to form ozone, more particulate matter and acid rain. When the ambient air temperature is above the comfort threshold, it will result to heat cramp, respiratory problems, heat stroke and eventual death as well as loss of economic growth. Thus, LST can impair quality of water bodies which could result to the death of aquatic life and food shortages [9]. In addition, the demand for energy will continuously increase with rise in UHI. For instance 0.6^0C increase in temperature will lead to 2% energy demand. Thus, 10% of global energy demand is used to compensate for heat island [10] [11]. It is on this background that this study investigated the analysis of satellite based Land Surface Emissivity (LSE) of Lapai and environs, Niger State, Nigeria.

2. Methodology

Lapai is an African and Nigerian city situated at latitude $6^0$32’30”E and $6^0$34’10”E and longitude $9^0$2’30”N and $9^0$4’10”N GMT (Figure 1). This study adopted the algorithm for deriving LSE from Satellite Lansat 5,7 and 8 using infrared sensor and surface emissivity from Google Earth Engine to generate the imageries. The imageries were derived in three epochs of 2000, 2010 and 2022 respectively. The Landsat 5, 7 and 8 satellites were suitable for LSE as they were loaded with thermal infrared radiometers. The single channel algorithm was applied for dependability of data and emissivity was used to enable flexibility of algorithm implementation. Thus, LSE process was carried out in the Google cloud computing servers, with direct access to the GEE satellite data catalogue. However, by applying single channel technique, the LSE was calculated from the radiance-at-the-sensor.

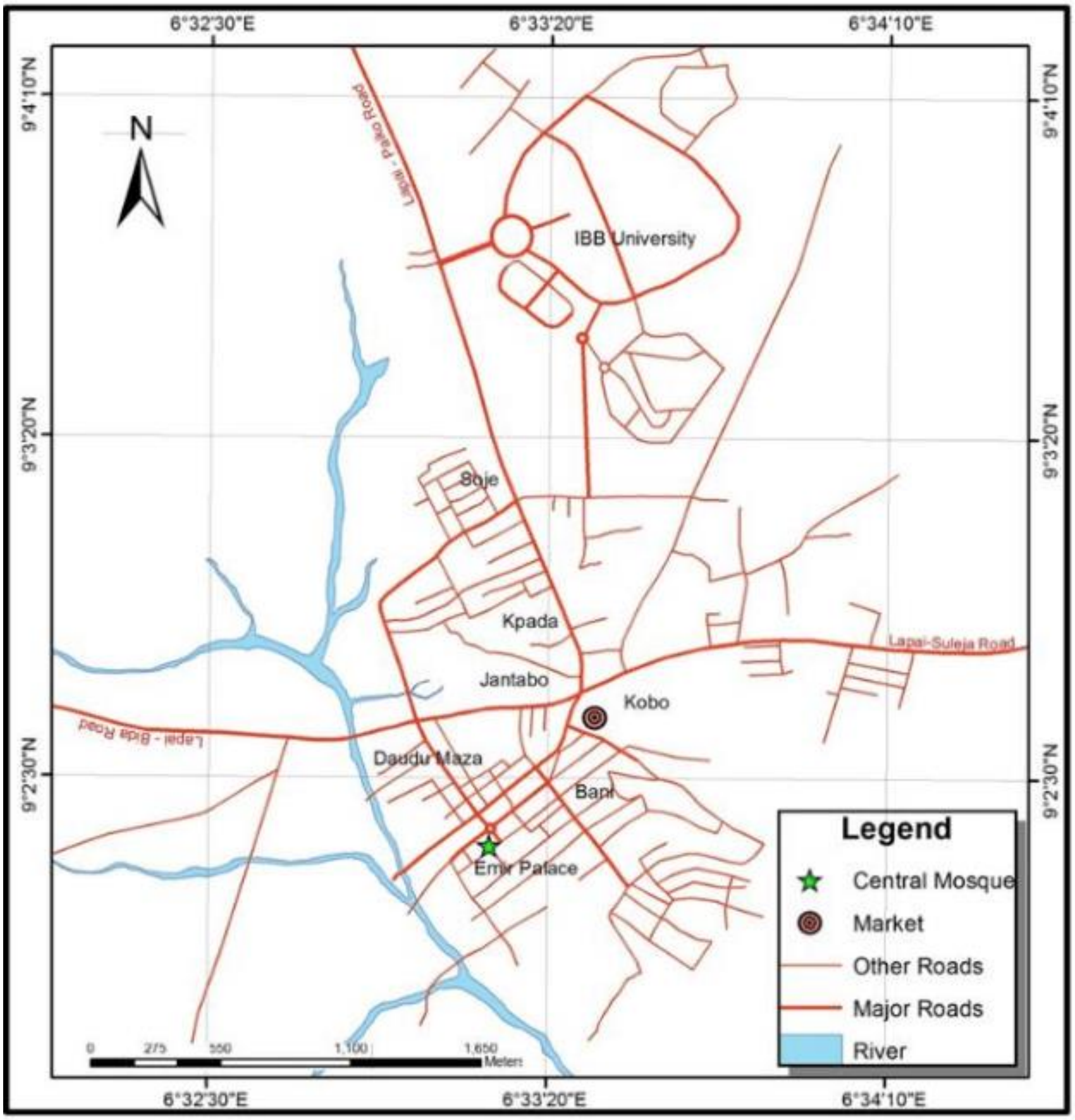

Figure 1. Study Area Map of Lapai and Environs

3. Results

Land Surface Emissivity (LSE) which is the energy radiated from urban material surfaces per second with the values between 1 (high) and 0 (low). Emissivity in the view of Li, Weisz and Zhou (2007) is the percentage of warmness a black surface releases between 0 and 1. Thus, LSE is the proportion of radiated energy on the surface of a material compared to that released from a black body all at the same temperature, wavelength and conditions of view (Peres et al., 2004). LSE determines the efficacy of urban surface areas to convert sensible heat into latent heat. It is the radiation of solar energy from material surface area to the surrounding air (Chen, Zhuang, Xu, Niu, Zhang and Xiang, 2000). In the city and its environment exist strong relationship between the various land surfaces and LSE characterized by the alteration of the biophysical features.

In the year 2000, Land Surface Emissivity (LSE) had minimum value of 0.50 and maximum value of 1 having the range of 0.5 showing the least in the studied year (Table 4.3). In 2010, LSE had minimum value of

0.00 and maximum value of one (1) with a range of one (1) showing that 2010 had the highest emissivity regime. In 2022, LSE had minimum value of 0.01 and maximum values of one (1) with a range of 0.99 indicating the second year with the highest LSE. In the year 2000, LSE concentrated on the northern segment of Takun, central section (Lapai) and southern area (Kusokpogi) as in Figure 2. Still in the year 2000, LSE was highest in the south-eastern, north-eastern and the eastern segments of Lapai and its environs. In the year 2010, LSE concentrated on northern part (Takun), central section (Lapai) and southern segment (Kusokpogi) as in Figure 3. In this year 2010, LSE was still highest in the north-eastern, south-eastern and the eastern segments of the study area, indicating the part with highest pavement materials that can radiate heat to the ambient air and environment. Also, in the year 2022, LSE concentrated on Lapai central area (Figure 4). In this year, there was low LSE at the surrounding of Lapa town. Still in 2022 year, LSE concentrated on Lapai main town and the southern segment of the study area. This is an indication that more development activities are growing toward the southern segment of the study area with increased urban fabrics and exposed bare surfaces.

Table 4.3: Area Concentration and Direction of LSE over the Study Years

Year	**LSE Level**	**LSE Range**	**Area Concentration and Direction of LSE**
2000	0.50 – 1.0	0.5	Northern (Takun), central (Lapai) and southern (Kusokpogi) area
2010	0.00 – 1.0	1	Northern (Takun), central (Lapai) and southern (Kusokpogi) area
2022	0.01 – 1.0	0.99	Central (Lapai) area

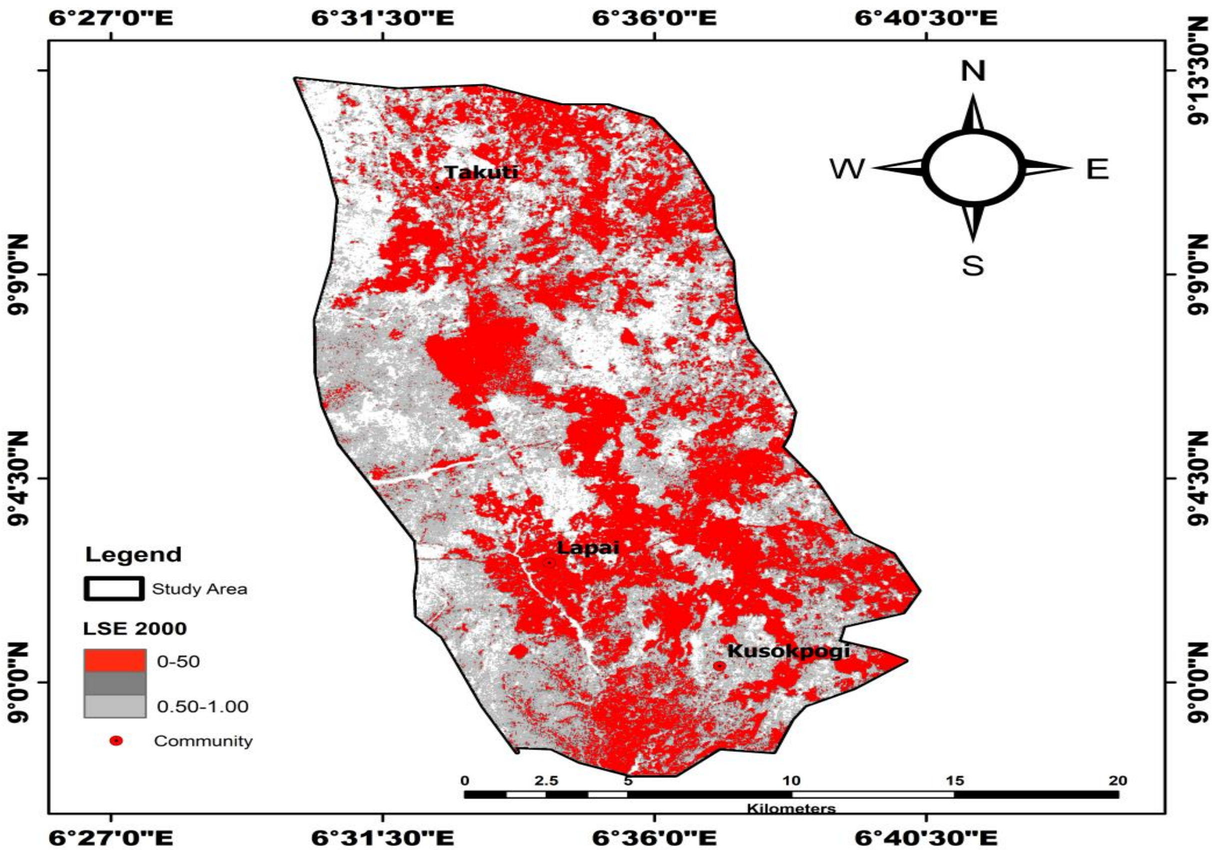

Figure 2: Land Surface Emissivity (LSE) of Lapai and Environs, 2000.

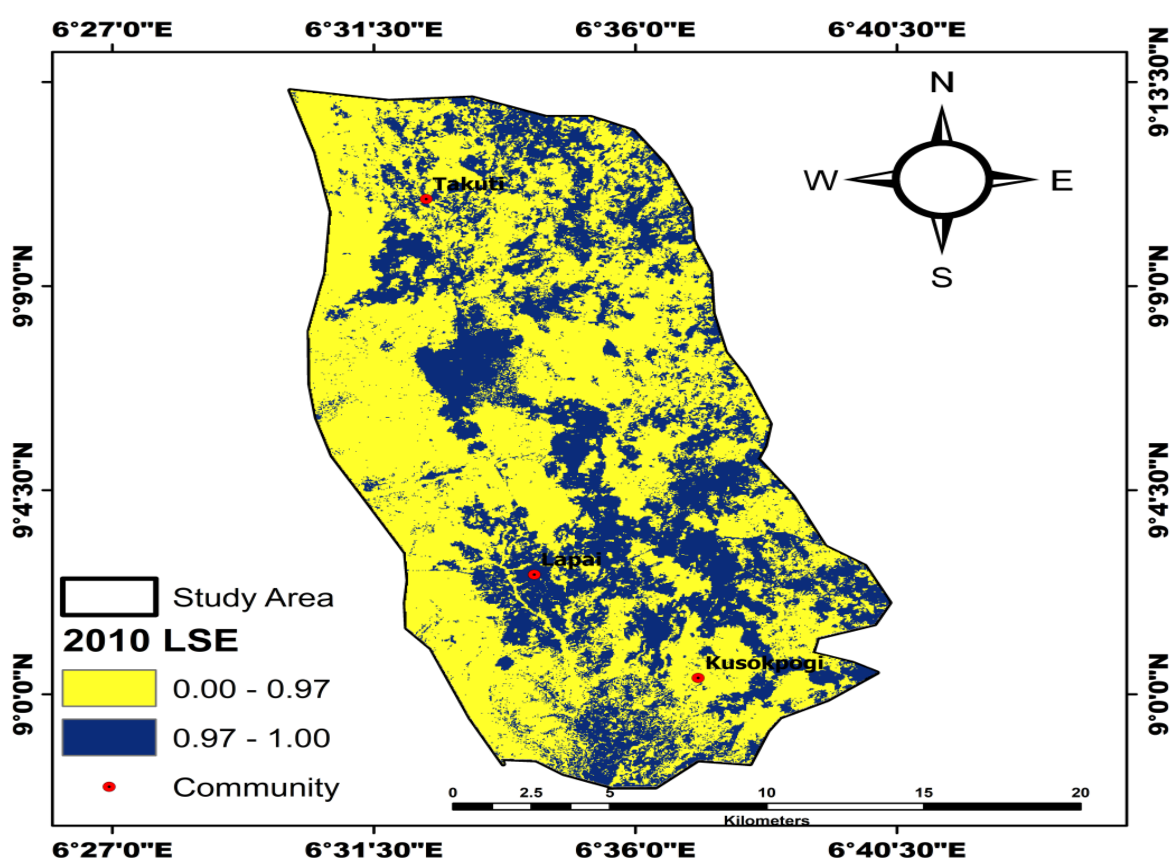

Figure 3: Land Surface Emissivity (LSE) of Lapai and Environs, 2010.

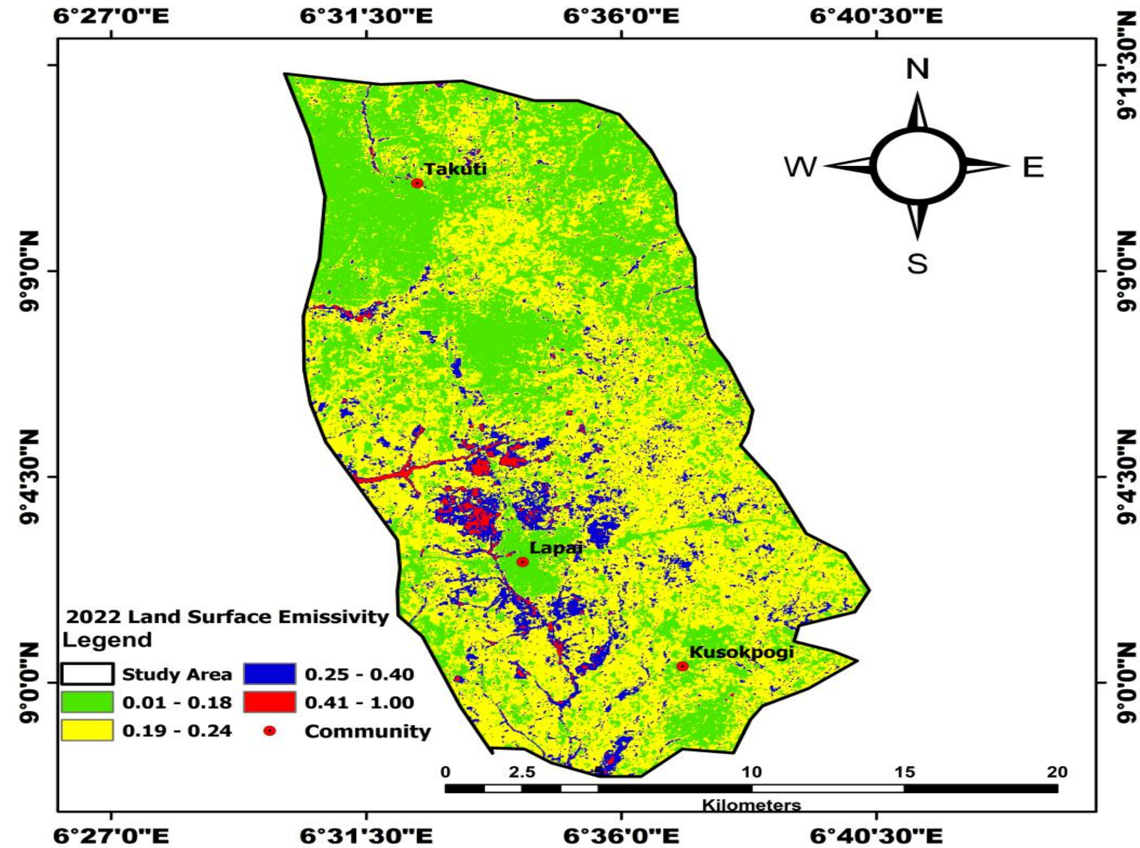

Figure 4: Land Surface Emissivity (LSE) of Lapai and Environs, 2022.

4. Discussion

Different materials have their various land surface emissivity conduction on the surface of the earth. The emissivity of materials is distributed across the urban surface area. For instance, vegetation and water bodies have more emissivity values than urban materials. This is in tandem with Robert Hadfield (2005) who studied emissivity of crop plants such as mature Phalaenopsis, Paphiopedilum, Malabar and chestnut recording the values of 0.9809, 0.9783, 0.981 and 0.9848 respectively. Sand, water and green grass have emissivity values of 0.949 - 0.962, 0.993 - 0.998 and 0.975 - 0.986 compared to the low emissivity of urban materials such as concretes 0.95-0.97,cement 0.54, gravel 0.28, bricks 0.90-0.94, asbestos 0.96 and aluminum 0.05-0.77 respectively (Electronic Temperature Instrument [ETI], 2018). In this vein, emissivity is higher at the rural fringes than the inner city as plants and water bodies at the fringes quickly use energy for evapotranspiration and free the energy in them thereby keeping the rural fringes cool. Thus, heat is expected to concentrate on the inner city than the rural fringes. In this vein, temperature increases from rural fringes to the city center and emissivity deceases from rural fringes to the city center due to differences in urban materials, water bodies and vegetation between the city center and the rural outskirts (Nwaerema, Ojeh, Amadou and Atuma, 2019).

5. Conclusion

This study analyzed satellite based Land Surface Emissivity (LSE) of Lapai town and environs, Niger State, Nigeria. The study adopted satellite remote sensing approach drawn from data of the Landsat Enhance Thematic

Mapper (ETM+). Statistical range was employed to understand the pattern of LSE as it is influenced by land use types of the study area. The study expresses the characteristics of urban pavement materials, bare land and vegetation areas as they contribute to the pattern of LSE in an urban center. The growing population of a city has greater effects on LSE as people continue to build houses and develop other infrastructures thereby altering the biophysical components of the earth surface. Within the 22 years of this study, LSE has been ranging between zero (o) and one (1), showing years of high LSE and low LSE in the study area. Thus, LSE is noticed to be randomly high across the various segments of Lapai city and environs. This shows that activities of altering the biophysical components of the earth surface have been random within the study period. This could be as result of random farming and built-up areas that have exposed the surface of the earth to LSE occurence. Currently in the year 2022, LSE has fully concentrated on the center of Lapai town due to high impact of built-up areas that have altered the earth surface. It is recommended that the government and policy makers should encourage tree planting and urban greening in order to cushion the effects of LSE on the health of the city dwellers.

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