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Effect of Urban Growth on Urban Thermal Environment: A Case Study of Sekondi-Takoradi Metropolis of Ghana

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Abstract
The Sekondi-Takoradi Metropolis of Ghana has been experiencing fast urban growth over the past two decade. This urban growth has resulted in changes in the surface cover which consequently has cause remarkable urban thermal environmental problems. This research used two multi-temporal Landsat Thematic (TM) and Enhanced Thematic Mapper Plus (ETM+) images of the years 1991 and 2008 respectively to evaluate the effect of urban growth on land surface temperature (LST) using an integrated remote sensing and GIS approach. Several remote sensing techniques were used to carry out urban growth analysis. This assisted in determining the changes that have taken place over the 17 year period. The integrated use of remote sensing and GIS was subsequently employed to analyse the effect of urban growth on surface temperature. Local climate change was also studied using multi-decade temperature data. The results showed that urban development had increased surface radiant temperature in the study area by 4.3 $^{\circ}$C in the urban expanded areas. The results suggest that urban expansion has a certain effect on the monthly average surface temperature as well the seasonal average temperature changes of the Metropolis.
Keywords: Land Surface Temperature, Urban Growth, Remote Sensing, Urban Heat Island, NDVI

1. Introduction

During the last decades the world has undergone unprecedented urban growth and most of this growth has occurred in developing countries especially in Africa. These occurring urban growths have severely altered the biophysical environment. In terms of ecological impact, urban expansion has been identified as one of the most significant and long-lasting forms of land use and land cover change and its extent of increase is linked to population growth and economic development (Bounoua *et al.*, 2009). Urban growth, both in population and in areal extent, transforms the landscape from natural cover types to increasingly impervious urban land. The result of this change can have significant effects on local weather and climate (Landsberg, 1981).

By replacing the landscape with impervious materials such as asphalt, buildings, roads, parking lots, metals and other paved surfaces, urban areas usually have higher solar radiation absorption and a greater thermal conductivity and capacity such that heat is stored during the day and release at night. The removal of natural cover types and subsequent introduction of these urban impervious materials modify the energy balance of the earth surface, with a successive rise in surface temperature. This alteration of the land cover modifies the urban climate, causing it to be warmer than surrounding rural environment and is referred to as urban heat island (UHI) (Voogt *et al.*, 2003). This increase in surface temperature in urban areas could potentially results in the development of meteorological events like modification of precipitation pattern, increase energy and air conditioning demands and raise pollution levels. The development of UHI can potentially contribute to global warming and affect the environmental quality and the long-term sustainable development of localities that continue to experience it.

In the Sekondi-Takoradi Metropolis (SKM) of Ghana, land-use-land-cover (LULC) patterns have experienced changes due to accelerated economic development and population increase. Urban growth keeps on increasing and pressure on the environment is occurring. Massive natural land covers are disappearing, being converted to urban or associated uses. Land which was initially covered with vegetation is now being covered with reflective impervious structure such as road and building. These land cover modifications could therefore have diverse environmental and meteorological problem. There is therfore the need to evaluate the effect of urban growth both at local and regional scale.

In the past, temperature changes (UHI) studies were carried out using traditional methods for isolated areas, and with in-situ measurements of ground meteorological data (air temperature) (Streutker, 2002; Weng, Lu , & Schubring, 2004). This traditional approach of using in-situ measure data even though considers the temporal resolution; its spatial resolution is limited. Satellite remote sensing has the ability to monitor changes in urban surface temperature on all scales, and subsequently provide qualitative physical data, present heterogeneous disturbed land surface characteristics. All of these can chiefly facilitate our understanding of urban and suburban environment and its relationship with urban growth.

Considerable research has been done using remote sensing to detect the thermal properties of urban surfaces. For instant, Matson et al, (1978) used NOAA 5 satellite nighttime thermal infrared imagery to obtain maximum urban-rural temperature differences ranging from 2.6°C to 6.5°C for more than 50 selected cities in the midwestern and northeastern United States. Weng (2001) also used Landsat TM data to evaluate the effect of urban expansion on surface temperaute in the Zhujiang Delta of China. Additionally, over the past decades, land surface temperature (LST) studies and UHI have been carried out using remote sensing. Initially, the principal methodology of LST and UHI analysis was to establish certain models by regression analysis using observational samples, then covert DN values to air temperature. However, recently, more preference is given to the use of the actual temperature of land surfaces to describe UHI, which is believe to correspond closely with near ground air temperature achieving more reliable and accurate results . (Nichol & Wong) (Lui & Zhang, 58)
Due to the simplicity of using radiation temperature, several researchers still prefer to use it in analysing urban thermal environment. Also, in recent times, there have been several research work to investigate the relationship between vegetation abundance in terms of normalised difference vegetation index (NDVI) and LST (Weng, Lu , & Schubring, 2004). This research used Landsat Thematic Mapper (TM) and Enhance Thematic Mapper Plus (ETM+) data to assess the impact of urban growth on land surface temperature (LST) in the Sekondi-Takoradi Metropolis of Ghana as well as to investigate the relationship between LST and NDVI. Historical climate data spanning a period of three decade collected by the Ghana Meteorological Agency was also used to analyse the temperature trend in the study area and assess the impact of urbanisation on local climate.

2. Materials and Methods

2.1 Study Area

Sekondi-Takoradi Metropolis is located between Latitude 4° 52' 30" N and 5° 04' 00" N and Longitudes 1° 37' 00" W and 1° 52' 30"W. Bounded to the north of the metropolis is the Mpohor Wassa District, the south by the Gulf of Guinea, the West by the Ahanta West District and the East by Shama District. The metropolis is strategically located in the south-western part of the country, about 242 km to the west of Accra and approximately 280 km from the La Côte d'Ivoire in the west. The Metropolis lies within the South-Western Equatorial Zone. It therefore has fairly uniform temperature, ranging between 22^{o}C in August and 30^{o}C in March. In recent times however, the maximum temperature of the metropolis is said to be increasing throughout the year. Sunshine duration for most part of the year averages 7 hours per day. Relative humidity is generally high throughout the year between 50% and 70% in the dry season and 75% and 85% in the wet season. (STMA, 2012). Figure 1 is a map of the study area.

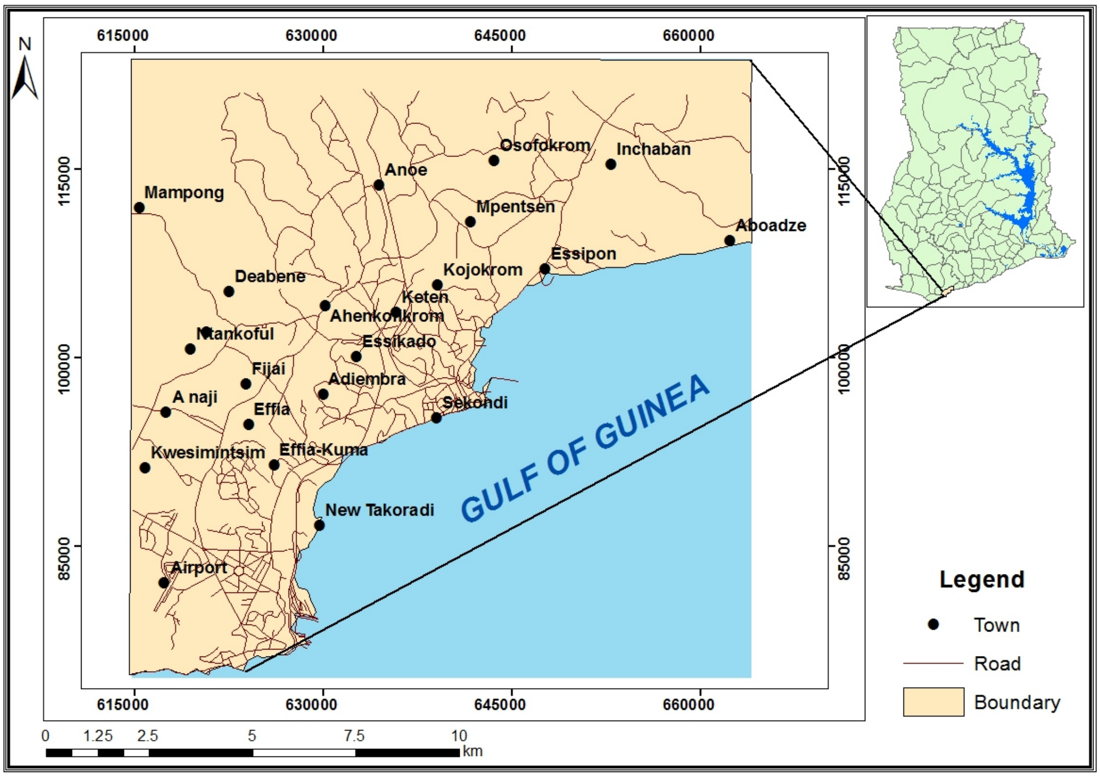

Figure 1 Map of Ghana Showing the Study Area

2.2 Materials

This study used a time series of Landsat satellite images - Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) as remote sensing data acquired on 1st January 1991 and 1st February 2008 respectively. The satellite images were obtained from the U.S. Geological Survey (USGS). Additionally, reference data which includes, topographical maps, aerial photographs and land cover map of the study area were also used. Geographic data (GPS points) were collected for rural-urban areas during field navigation. Climate data was also obtained from the Ghana Metrological Agency.

2.3 Methods

2.3.1 Image Pre-processing and Classification

The 2008 ETM+ images had some lines at both the eastern and western side, and therefore there was the need to remove those lines before the image could be used. Therefore, scan lines off error in the 2008 ETM+ image was removed with the help of the NASA IDL Virtual Machine Application Frame_and_Fill. This application uses a previous image without those scan line off error to correct an image with the scan line off error. The two Landsat images used were then geo-referenced and re-projected unto the Ghana Datum War Office coordinate systems using a total of 50 ground control points (GCP) collected from a topographical map. Even though the acquired images were already reference unto the UTM WGS 84 projected coordinate system, there was the need for another rectification because there was a shift in the images. After superimposing the raw acquired images, it was observed that, one of them had shifted and therefore they were not lying on each other. This necessitated the rectification to ensure that the two images were all lying at the same location. After applying the necessary radiometric and geometric corrections, the thermal bands which had spatial resolution of 120 m for TM and 60 m for ETM+ were resampled to a 30 m by 30 m pixel resolution using the nearest neighbour resampling technique. This was done so the pixels of the thermal band could match the pixels of the other spectral bands. Using a well-defined boundary of the study, a subset which covers the study area was created by masking.

2.3.2 Detection of Urban Growth

In order to detect and measure urban growth areas, a land cover classification was performed. Supervised classification was used to classify the individual geo-referenced images into urban-rural areas. The Maximum Likelihood Algorithm which classifies images according to the covariance and variance of the spectral response patterns of a pixel was the parametric rule used during the classification. Urban land uses for both the 1991 and 2008 was extracted from the classified images. After the extraction, the two urban land images were then overlaid and a spatial analysis was performed to obtain an image of urban growth areas. This urban growth image showed areas which experienced urban growth during the period of investigation. Subsequently, the study area was divided into four zones to enable further analysis of urban growth within each of these four zones. Additionally, the amount of urban growth within each of the four zones was also determined.

2.3.3 Determination of LST and NDVI from Landsat TM and ETM+

Urban growth normally leads to a modification of the earth's surface since natural vegetation is replaced with impervious surfaces. These impervious surfaces cause a redistribution of incoming solar radiation, subsequently inducing a rural-urban contrast in air temperature and surface radiance (Weng, 2001). The effect of urban development on surface temperature was therefore evaluated for the metropolis.

The corrected images resulted in digital numbers that are measures of at-satellite radiance. A model was created to transform the digital numbers (DNs) from the radiometrically corrected TM and EMT+ thermal data (band 6) into surface temperature values using several equations. The DNs were converted first to at-satellite radiance using the following equation:

$$L_{\lambda} = Grescale \times QCAL + Brescale \qquad (1)$$

This can also be expressed as

$$L_{\lambda} = LMIN + (LMAX - LMIN) \times DN / 255 \qquad (2)$$

Where: Grescale = Rescaled gain, Brescale = Rescaled bias, L_{λ} = Spectral Radiance, QCAL = the quantized calibrated pixel in DN, LMIN = Spectral Radiance of DN value 0, LMAX = Spectral Radiance of DN value 255.

The spectral radiance values were transformed to radiant surface temperature values in kelvin using the following equation:

$$T_b = K_2 \Big/ ln\left(K_1 / L_{\lambda} + 1\right) \qquad (3)$$

T_b = Surface Temperature in Kelvin
K_1 = Calibration Constant 1 (607.76 for TM and 666.09 for ETM+)
K_2 = Calibration Constant 2 (1260.56 for TM and 1282.71 for ETM+)

The Surface temperature in kelvin was finally converted to surface temperature in degree Celsius (T_c) using the following equation

$T_c = T_b - 273$ (4)

Since normalised difference vegetation index (NDVI) is a good indicator of surface radiant temperature, a NDVI image was computed for the 1991 and 2008 images. Reflectance value from visible band (P_3) and near-infrared band (P_4) of the images were used to compute NDVI values according to the following equation:

$$NDVI = \frac{(P_4 - P_3)}{(P_4 + P_3)} \quad (5)$$

Using the concept of image differencing, images of surface temperature change and NDVI change between 1991 and 2008 were produced. The surface temperature change map, the NDVI change map and the urban growth areas map were all overlaid to analyse how all these changes have interacted with each other. The surface temperature change map was also overlaid on a map showing the four zones to assist in analysing the temperature changes which has occurred within each of the four zones.

3 Results and Discussion

3.1 Results

3.1.1 Urban Growth in the SKM

Table 1 shows the area extent of rural-urban areas in the study area. It is evident from this table that, there has been a significant urban growth in the metropolis for the 17 year period. Urban areas have increased by 83.04% whiles non-urban or rural areas have decrease by 36.72%. Figure 2 shows the spatial occurrence and areal extent of the urban growth that has taken place within the 17 year period. The overlay of the urban growth map with a map of the various constituencies (zones) in the metropolis shows the spatial occurrence of urban growth within the administrative constituencies of the SKM. Table 2 shows that the greatest urban growth occurred in the Effia-Kwesimintsim (47.76%) followed by Sekondi (19.85%) whiles the least was recorded in Takoradi (6.69%).

Table 1 Area Extent of Land Cover Types

Land Cover	1991		2008		Change 1991-2008	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Non-urban	9357.69	69.60	5920.63	44.07	3437.06	-36.72%
Urban	3812.70	28.38	6978.94	51.95	3166.24	+83.04%
Water	263.06	1.96	533.88	3.97	270.82	+102.94
Total Area	**13433.45**	**100.00**	**13433.45**	**100.00**		

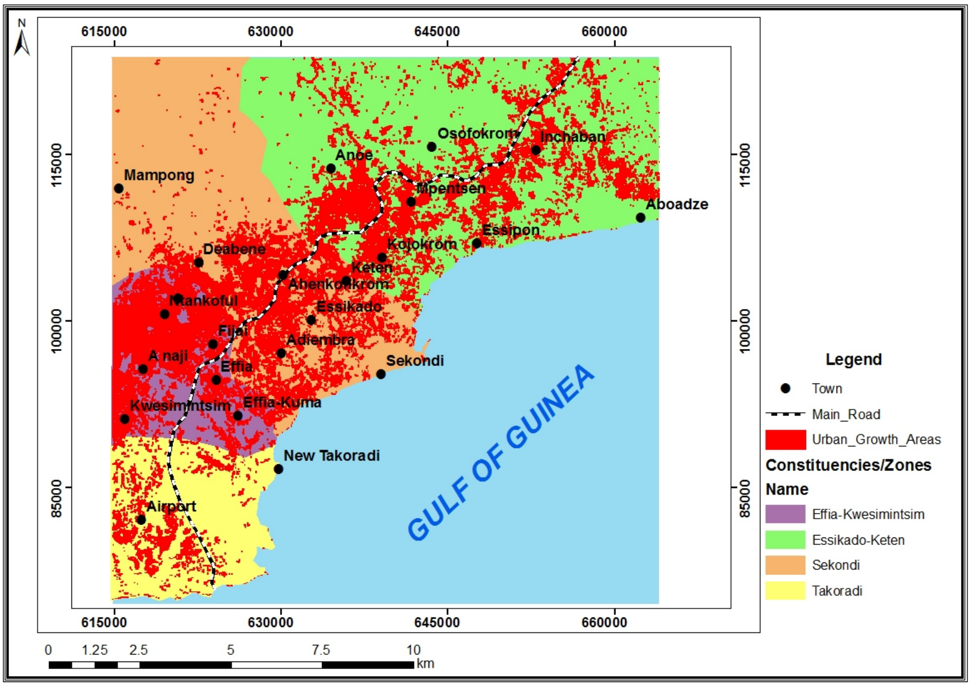

Figure 2 Map of Urban Expanded Areas

Table 2 Amount of Urban Expansion in Each Constituency or Zone

Name of Constituency/Zone	**Urban Expansion (%)**
Takoradi	6.69
Effia-Kwesimintsim	47.76
Sekondi	19.85
Essikado-Keten	17.29

3.1.2 Impact of Urban Growth on LST in the SKM

Digital remote sensing does not only provides a measure of the magnitude of surface temperatures of an area, but also the spatial extent of the surface heat island effects (Srivanit *et al.*, 2012) . Also in order to appreciate the impacts of urban growth on surface radiant temperature, the characteristics of the thermal signatures of each land cover type must be studied first.(Weng, 2001). Table 3 depicts the averages of the radiant land surface temperatures by rural-urban areas both in 1991 and 2008. It can be observed that for both years, the highest surface temperature was exhibited by urban land (29.63 ± 0.70 in 1991 and 33.93 ± 0.72 in 2008), followed by non-urban (rural) land (26.24 ± 0.84 in 1991 and 29.44 ± 1.11 in 2008), whiles the least surface temperature was exhibited by water bodies (25.54 ± 0.44 in 1991 and 25.99 ± 1.98 in 2008). This mean that urban growth increase surface temperature since natural vegetative cover is replace with non-transpiring non-evaporating impervious surfaces such as metals, concrete and stone (Weng, 2001). The small deviations of surface temperature for urban areas indicates that, urban or built-up area do not undergo a wide variation in surface temperature because of the dry nature of urban materials. The result further shows that the urban growth has increase the surface temperature of the metropolis by 4.3 °C in the urban expanded areas.

Table 4 Average Surface Temperature in Degree Celsius

land Cover	**Mean Temperature ± SD**	
	1991	**2008**
Urban/Built-up	29.63 ± 0.70	33.93 ± 0.72
Non-Urban	26.24 ± 0.84	29.44 ± 1.11
Water	25.54 ± 0.44	25.99 ± 1.98

Figure 3 and 4 show the spatial distribution of surface radiant temperature in 1991 and 2008 respectively. It is evident from this figure that areas with higher surface temperature were located in the most urbanised centres of the metropolis such as the Market Circle, Takoradi Airport, Aboadze Thermal Plant and the Takoradi Port and Harbour.

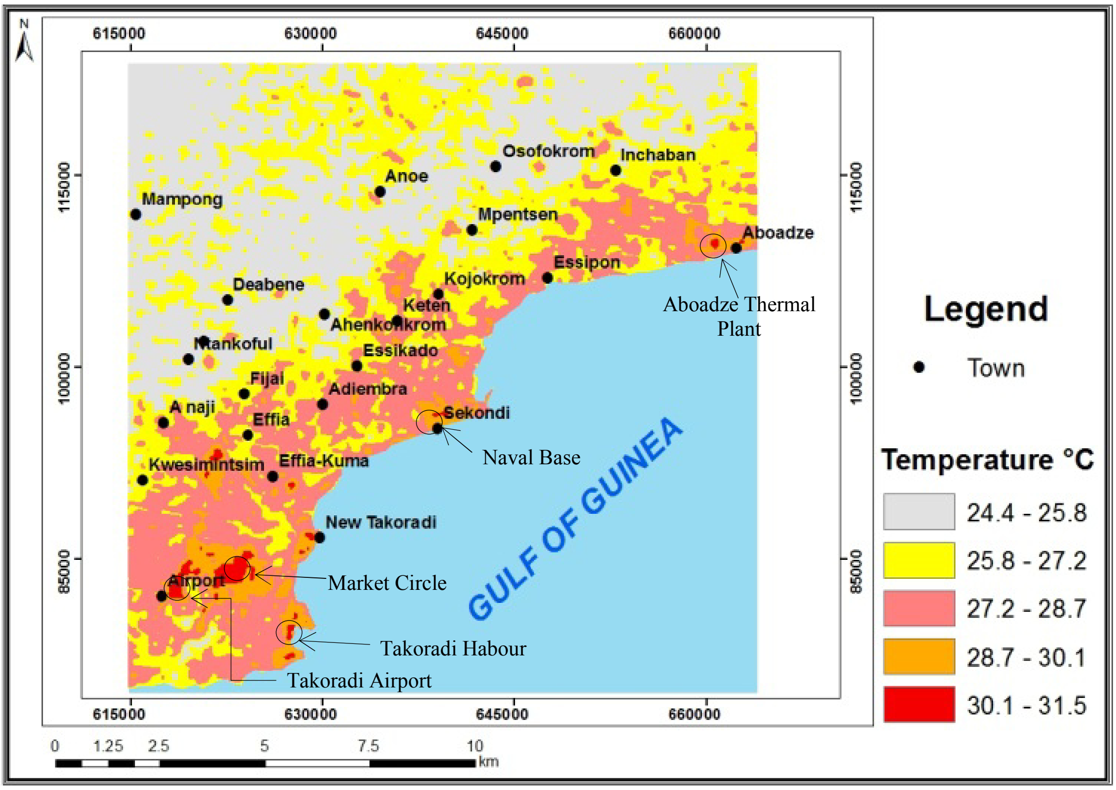

Figure 3 Map of LST Derived from TM (January 01, 1991)

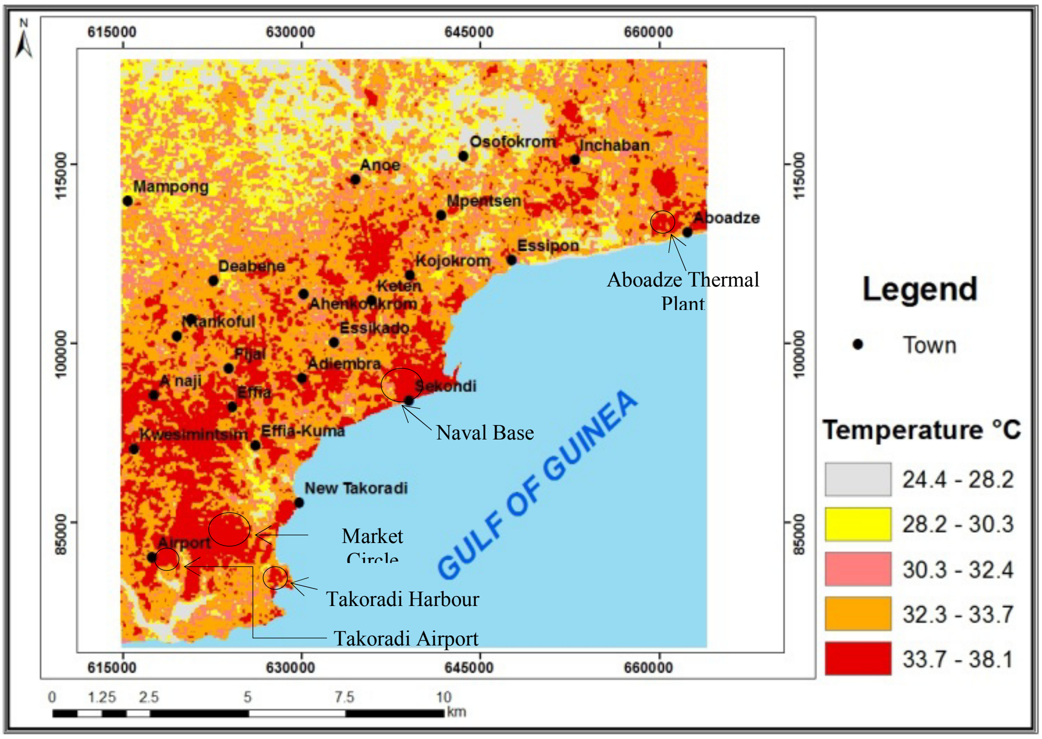

Figure 4 Map of LST Derived from ETM+ (February 02, 2008)

It can be observed from the figures above that, areas which had low LST in 1991 had their LST increased in 2008. Notable among such areas are residential areas like Kwesimintsim, Effia-Kuma and Anaji. All these three areas are within the Effia-Kwesimintsim constituency which happened to have experienced the high urban growth.

Figure 5 shows the temperature increased areas. It can observe from this figure that the greatest surface temperate rise in terms of area extent occurred in the Effia-Kwesimintsim zone which also happened to have experienced the highest urban growth whiles the Takoradi zone which experienced the least urban growth recorded the least increase in land surface temperature.

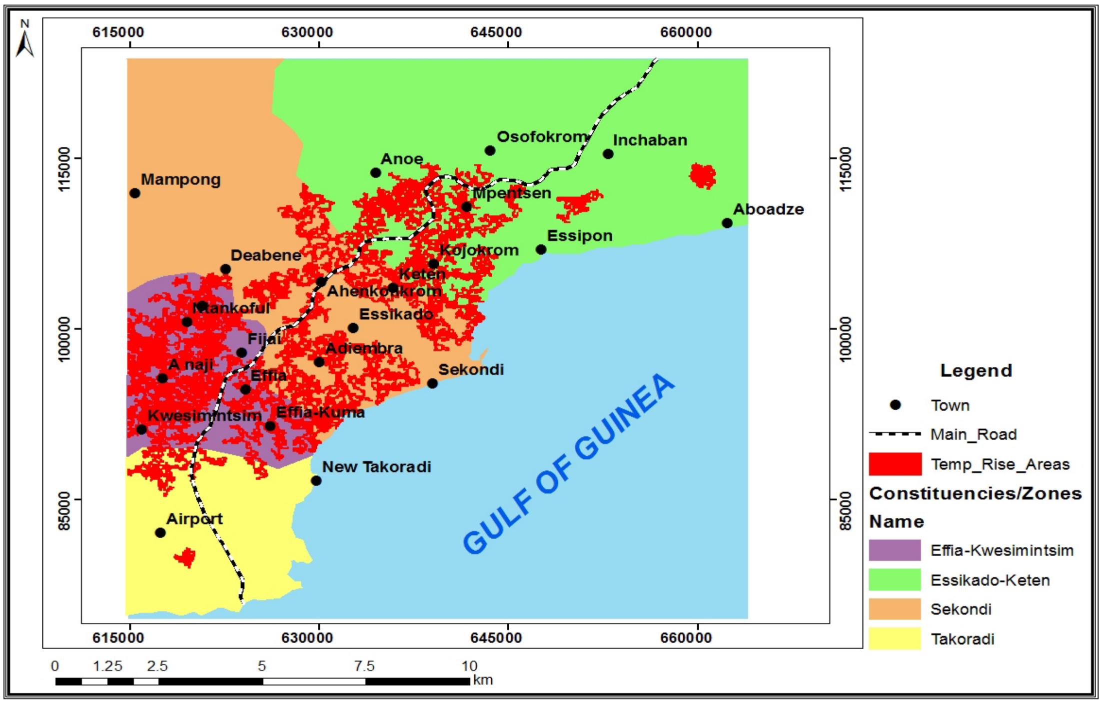

Figure 4 Map of Temperature Increased Areas

3.1.3 Relationship between LST and NDVI

NDVI has been widely used as an indicator of vegetation abundance to estimate LST in studies of urban heat islands (Srivanit *et al.*, 2012). NDVI maps for the two dates (1991 and 2008) are shown in Figure 5 and 6 respectively. From the figure it can be observed that, in both years smallest NDVI values were recorded in urban areas whiles highest NDVI values were recorded in non-urban (vegetated/rural) areas. Again in this study, NDVI and LST were found to be closely correlated in all land cover categories, especially in urban and vegetated/rural areas. The relationship between LST and NDVI was investigated using Pearson's Correlation. Table 3 shows the Pearson's correlation coefficient between LST and NDVI in 1991 and 2008. Using the one-tail Student's *t-test*, the significance of each correlation coefficient was determined. The highest negative correlation in 1991 (0.969) was observed in non-urban areas land whiles the highest negative correlation in 2008 (0.964) was observed in urban areas. Generally, urban areas exhibit smaller NDVI values than non-urban areas, with consistent decrease in the mean NDVI as the mean LST increases. Indeed there is a consistent decline in NDVI with increased level of urban development.

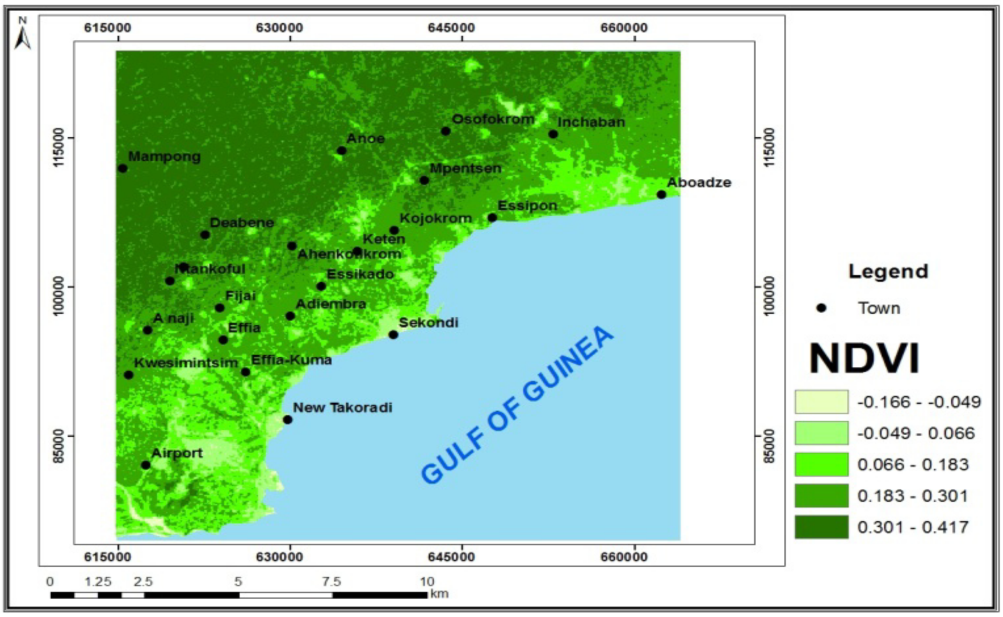

Figure 5 Map of NDVI Derived from TM (January 01, 1991)

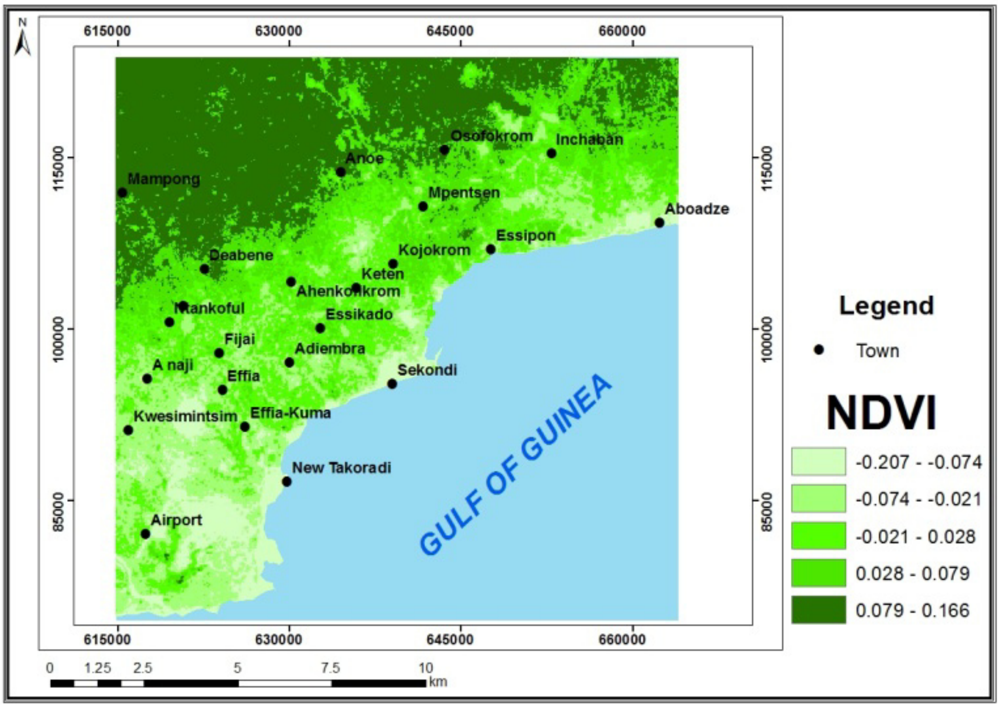

Figure 6 Map of NDVI Derived from ETM+ (February 01, 2008)

Table 3 Pearson's Correlation Coefficient between NDVI and Surface Land Cover Type (Significant at 5% Level)

Land Cover	1991	2008
Non-Urban	-0.698	-0.969
Urban	-0.924	-0.964
Water	-0.486	-0.257

A sample of 250 randomly generated points was also used to investigate the relationship between LST and NDVI for the various land cover categories. Figure 6 and 7 is a scatter plot which explains the pattern between NDVI and LST for 1991 and 2008 respectively.

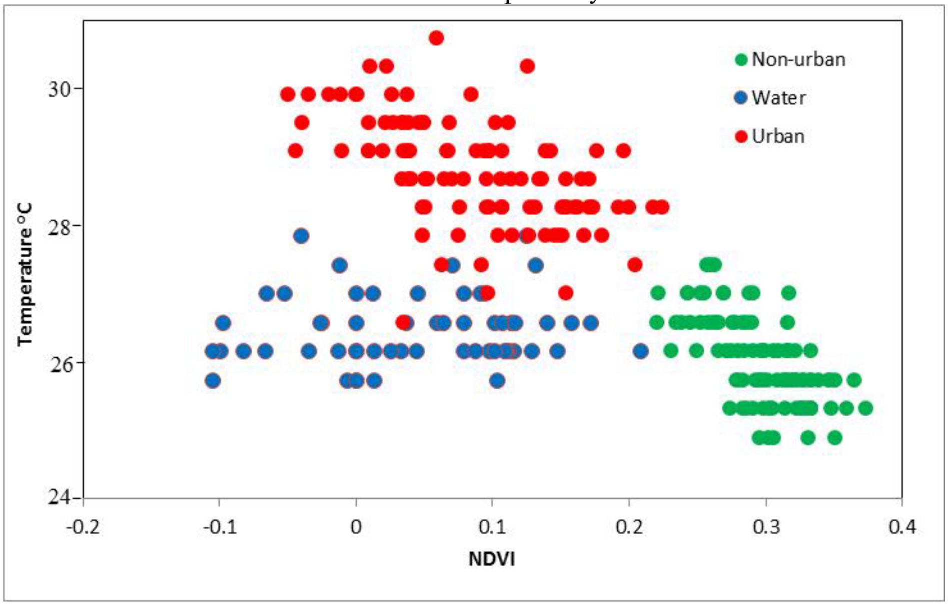

Figure 6 Scatterplot of NDVI versus LST for 1991

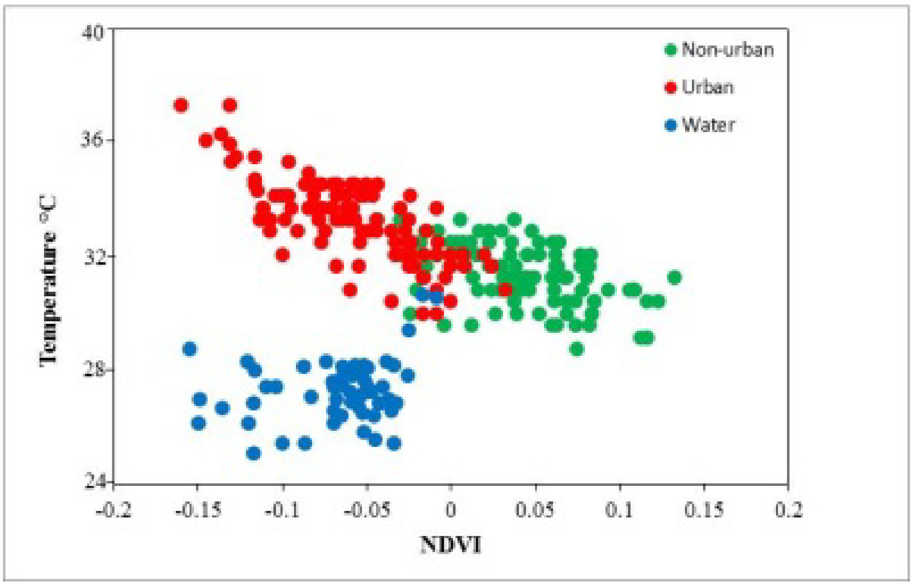

Figure 7 Scatterplot of NDVI versus LST for 2008

3.1.4 Analysis of Climate Data

Temperature obtained from Landsat thermal infrared band is the brightness temperature (also known as blackbody temperature). It differs from air temperature that is controlled by both atmospheric conditions and radiation from the sun and the earth surface (Xian *et al.*, 2004). Historic climate data collected from the Ghana Metrological Agency was used to investigate multi-decade temperature change in the metropolis. Figure 8 is a scatter plot of three decade minimum temperature of the metropolis. The linear regression line with least-square r^2 = 0.4976 shows a yearly increase of 0.03 °C. This analysis complement the observation that (the temperature in the metropolis is rising) was made from the analysis of the satellite images.

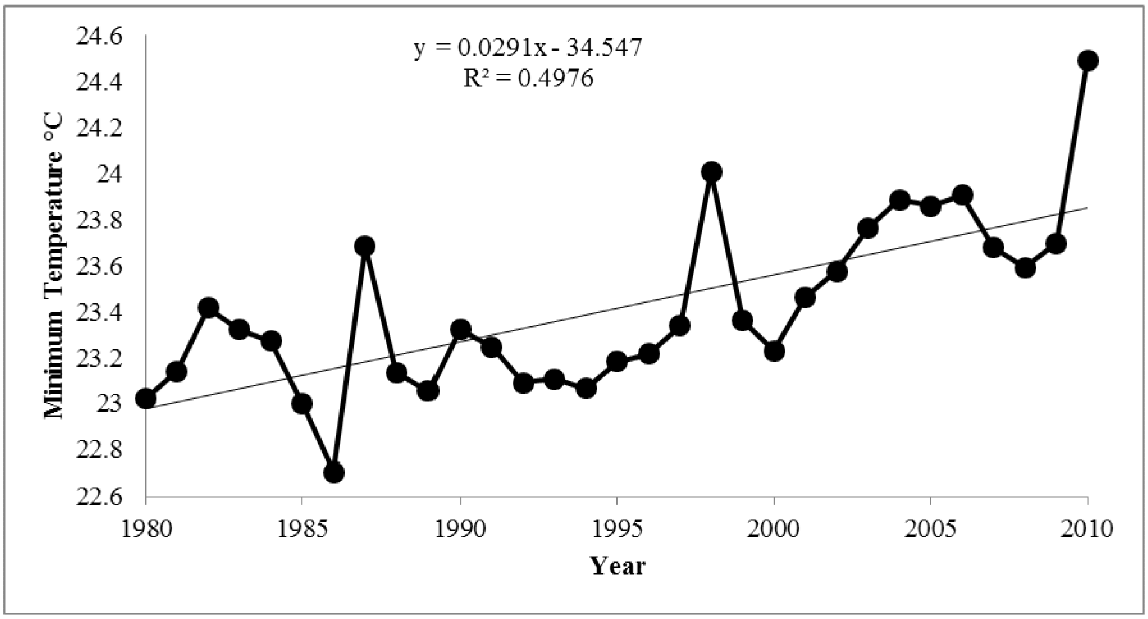

Figure 7 Average of Minimum Temperature for the Metropolis

3.2 Discussion
3.2.1 Effect of Urban Expansion in SKM
With the integrated approach of remote sensing and GIS, the effect of urban expansion on surface temperature was examined. It was observe that the highest surface temperatures were recorded in urban/built-up areas such as the Takoradi Market Circle, Takoradi Harbour Area, Takoradi Airport and Aboabze Thermal Plant. This is because urban/built-up areas are predominately composed of materials and structures which are mostly non-transpiring and non-evaporating. These materials tend to absorb more of the heat energy from the sun in their dense mass. When the heat is release mainly at night, it raises the air temperature as well as increase the consumption of energy in buildings. The standard deviations of the surface temperatures for both years were also small in urban/built-up areas for both years (±0.70 for 1991 and ±0.72 for 2008). This is an indication that urban areas do not experience a wide change in surface radiant temperature (Weng, 2001). Urban areas are generally composed of surfaces which are rough and dry, as natural vegetated surfaces are replaced with impervious surfaces which hinder solar radiation from penetrating through them(Xian *et al.*, 2004).

Impervious surfaces effectively seal surfaces, prevent heat from penetrating, repel water and subsequently prevent precipitation (Kent *et al.*, 2002). As a result of these properties of impervious surface, much of the incoming solar energy that could have been employed to evaporate water is instead transformed into sensible heat. This effectively raises the temperatures of these surfaces and of the overlying atmosphere (Kent *et al.*, 2002). In addition to this, impervious surfaces act like rocky desert surfaces in that they tend to have high thermal conductivities and heat storage capacities in comparison to vegetated rural, pervious surfaces . Anthropogenic activities in most urban areas also produce emission of heat which causes an increase in the surface temperature of such areas. It is therefore of no doubt why high temperature was recorded in urban/built-up areas for both years (29.63 °C for 1991 and 33.93 °C for 2008).

Among the four zones, the Effia-Kwesimintsim zone experienced the greatest change in surface temperature. This zone also happens to have experienced the highest urban expansion. It is therefore indicative that in the past, the zone was predominantly non-urban or rural, composed of high vegetation cover. However, in recent time, the rich vegetation of the zone has been replaced with non-evaporating non-transpiring impervious surfaces such as concrete buildings, asphalt roads, metallic roofing system and paved surfaces. This rapid urbanisation could be responsible for the increase in surface temperature.

The averaged triple-decade climate data of the metropolis indicates that, the annual monthly daytime temperature has a 0.3°C per-decade increasing trend. The long term effect of this temperature increase could potentially modify the general climate condition of the metropolis (Manu *et al.*, 2006).

3.2.2 Relationship between NDVI and LST in SKM
Results of the study indicate that, higher NDVI values were recorded in non-urban areas which had low surface temperature values, whiles lower NDVI values were recorded in urban areas which had high surface temperature values. This shows an inverse correlation between land surface temperature and NDVI for all the land cover

classes. The strongest of this relationship was observed in urban/built-up areas (0.924 for 1991 and -0.964 for 2008). This means that the amount of vegetation available in an area influences the area's surface temperature.

4 Conclusion

An integration of remote sensing and GIS approach was applied to assess the effect of the rapid urban growth in the Sekondi-Takoradi Metropolis on surface temperature for the period 1991-2008. The study examined the spatial distribution of urban surface temperature according to land-cover types and NDVI with remotely sensed data. This research has demonstrated that the intensity of urban development has a significant impact on radiant surface temperature. According to the study, urban development had increased surface radiant temperature in the study area by 4.3°C in the urban expanded areas. Also the averages of the multi-decade climate data of the metropolis indicate that, the annual monthly minimum temperature has 0.3°C per-decade increasing trend in the area.

References

Bounoua, L., Safia, A., Masek, J., Peters-Lidard, C., & Imhoff, M. L. (2009). Impact of Urban Growth on Surface Climate: A Case Study in Oran, Algeria. *Journal of Applied Meteorology and Climatology, 48*, 217-219.

Kent, B. B., John, M. M., & Martin, R. C. (2002). Impervious Surface and the Quality of Natural and Built Environment. *Department of Geographic and Environmental Planning, Towson University, 8000 York Road, Baltimore, Maryland*, 3-6.

Landsberg, E. H. (1981). *The Urban Climate.* New York: Academic Press.

Manu, A., Twumasi, A. Y., & Coleman, L. T. (2006). Is It the Result of Global Warming or Urbanization? The Rise in Air Temperature in Two Cities in Ghana. *Promoting Land Administration and Good Governance 5th FIG Regional Conference*, (pp. 1-4). Accra, Ghana.

Matson, M., McClain, P. E., & Pritchard, A. J. (1978). Satellite Detection of Urban Heat Islands. *Mon. Wea. Rev., 106*, 1725-1730.

Srivanit, M., Hokao, K., & Phonekeo, V. (2012). Assessing the Impact of Urbanization on Urban Thermal Environment: A Case Study of Bangkok Metropolitan. *International Journal of Applied Science and Technology, 2*(7), 243-254.

STMA. (2012). *1*. Retrieved April 02, 2012, from http://stma.ghanadistricts.gov.gh

Streutker, D. R. (2002). A Remote Sensing Study of the Urban Heat Island of Houston, Texas. *Journal of Remote Sensing, 23*, 2595-2608.

Voogt, J. A., & Oke, T. R. (2003). Thermal Remote Sensing of Urban Areas. *Remote Sensing of Environment, 86*, 370-376.

Weng, Q. (2001). A Remote Sensing-GIS Evaluation of Urban Expansion and Its Impact on Surface Temperature in the Zhuijiang Delta, China. *International Journal of Remote Sensing, 22*(10), 1999-2014.

Weng, Q., Lu , D., & Schubring, J. (2004). Estimation of Land Surface Temperature -Vegetation Abundance Relationship for Urban Heat Island Studies. *Remote Sensing of Environment, 89*, 467-483.

Xian, G., & Mike, C. (2004). Evaluation of Urbanisation Influences on Urban Climate with Remote Sensing and Climate Observations. *SAIC/USGS National Center for Earth Resources Observation and Science, Sioux falls, SD 57198*, 1-7.

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