The Geographical Investigation on the Hot Spot Analysis of the Land Surface Temperature Changes in Yangon City

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Abstract

Yangon City is old capital, densely populated and rapid urbanization area of Myanmar. This study was investigated human impacat of urban environment characterization on surface temperature changes of Yangon City. Moreover, the intension of this study is to analyze with demonstration and verify the spatial distribution property of the LST with urban spatial information related with Normalized Difference Vegetation Index (NDVI) using the Remote Sensing (RS) data and Geographic Information System (GIS). The main data was six Landsat images selected the images of less than 10 percent cloud cover condition for the summer and winter seasons and downloaded the required images. The single channel method and spatial statistical method were applied to process for LST variation. The study revealed that the LST was increased 1.43 ºC from 1996 to 2006 and added again 1.46 ºC between 2006 and 2015. The result of the Zonal statistical analysis pointed out that the mean LST of downtown was warmer than suburban areas. The 95 % confidence levels of specific hot spot area lied at the downtown and with closely townships of suburban 1.

Key Words: *Yangon City, Land Surface Temperature (LST), human activities*

1. Introduction

Nowadays, increase temperature of global warming is consequence of transformation of urbanization. The rapidly urbanization was the main drivers of human activities and it was affected on the Land Surface Temperature (LST), seriously impact especially urban and its surrounding area. Climate Change Vulnerability Index (CCVI) 2013 stated that Yangon has been facing warming and vulnerable to climate change condition. According to the earth observatory of National Aeronautics and Space Administration (NASA), the global warming is the usually rapid increase in Earth's average surface temperature over the past century due to the greenhouse gases released as people burn fossil fuels. (http://earthobservatory.nasa.gov/GlobalWarming). One of the report of Climate Change Vulnerability Index (CCVI) 2013, Yangon was becoming 'vulnerable to climate change'. Based on the above discussion, the temperature of Yangon City have risen noticeably in recent years as a hotter weather changes related with the human activities. Yangon City area was still dynamic transforming with the urbanization, industrialization both vertically and horizontally. For the associated problems of human activities on LST changes how to impact seasonal, regional and

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specific area of the study area. So, this was the main important considering of this paper become to the changes of land surface temperature of Yangon City.

Research Objectives

- To seek the reasons of warming temperature of Yangon city
- To examine the correlation of LST and NDVI
- To analysis on hot spot area of LST and impact on LST

Study Area

Yangon City was the former capital of Myanmar and lying between 16° 41' 00" N to 17° 5' 30" N latitudes and 95 ° 59' 30" E and 96° 27' 30" E longitudes (Fig. 1.1). To better the study sites can be described, Downtown, Suburban 1 and suburban 2. In this paper, our research interest focused on the Yangon City area covering an area of approximately 633 square kilometer including water body.

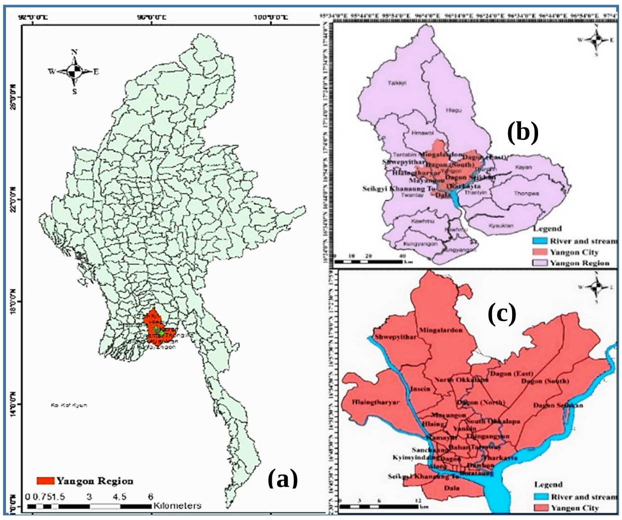

Fig. 1.1 Location of Study Area

(a) Union of the Republic of Myanmar (b) Yangon Region (c) Yangon City

2. Data and Methodology

In this study, the main data was six Landsat images. For the processing of Landsat Thematic Mapper (Landsat 5 TM) dated March 25, 1996 (0 % cloud cover) and March 5, 2006 (8% cloud cover) and Landsat 8 Operational Land Imager (OLI) dated March 30, 2015 (3.56 % cloud cover) for the summer season and Landsat Thematic Mapper (Landsat 5 TM) dated December 22, 1996(0 % cloud cover) and December 18, 2006 (0% cloud cover) and Landsat 8 Operational Land Imager (OLI) dated December 11, 2015 (0.22% cloud cover), were used.

To operate the retrieve for the LST, the calculation of NDVI and Land Surface Emissivity (LSE) were necessary to apply to estimation of LST. The post processing stages were conducted the spatio-temporal changes pattern on the visual interpretation of LST and NDVI and Hot Spot Analysis. The principal of NDVI is that the reflexes rates are differ at the NIR and RED band. This equation is denoted as the following formula (Chander et al., 2009).

$$\mathrm{NDVI} = \left(\frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}\right)$$

ε is land surface emissivity, which was obtained using NDVI Threshold Methods. P_v is the vegetative proportion obtained according to Carlson and David (1997) as:

$$P_v = \{(\mathrm{NDVI} - \mathrm{NDVI}_{min}) / (\mathrm{NDVI}_{max} - \mathrm{NDVI}_{min})\}^2$$

Where P_v indicated the vegetation proportion, ε due to ε_{veg} P_v + ε_{soil} (1- P_v), where ε_{veg} is vegetation emissivity, ε_{soil} means soil emissivity.

The most appropriate procedure to retrieve LST from a SC located in the TIR region. The main goal of the SC method is to obtain an algorithm to retrieve LST from one thermal band of the sensor (Jiménez&Muñoz and Sobrino, 2003). Six images of this research works made to the goal of LST maps with SC method with the aid of raster calculator of spatial analysis tools.

The processing for Calculation of LST, LST was retrieved from the thermal infrared band (TIR) of Landsat TM 5. First, the Digital Numbers (DNs) of band 6 are converted to radiation luminance (R_{TM6}, m W cm^{-2} sr^{-1}) by the following formula,

$$R_{TM6} = \frac{V}{255}\,(R_{max} - R_{min}) + R_{min}$$

Where, R_{TM6} is the spectral radiance, V represents the Digital Number of band 6 received by the sensor, R_{max} is the minimum DN; R_{min} (Wm^{-2} $sr^{-1}\mu m^{-1}$) are the minimum and maximum detected spectral radiances, (R_{max} =1.896, R_{min} =0.1534 (mW^{*} $cm^{-2*}sr^{-1}$)).

Standard Landsat 8, the digital numbers of TIRS band data were transform OLI and TIRS band data was converted to Top of Atmosphere (TOA) spectral radiance using the radiance rescaling factors provided in the metadata file with the following equation;

$$L_{\lambda} = M_L\, Q_{cal} + AL$$

Where, L_{λ} means TOA spectral radiance and M_L is band specific multiplicity rescaling factor from the metadata, AL indicates for band specific additive rescaling factor from the metadata and Q_{cal} can be Quantized and calibrated standard product pixel values. Brightness temperature (T_b) is the microwave radiation radiance traveling upward from the top of Earth's atmosphere. The calibration process has been done for converting thermal DN values of thermal bands of TIR to $T_{b.}$ For finding T_b of an area the TOA spectral radiance of (L_{λ}) was needed.

The second step, the radiation luminance of the all satellite images were converted to at-satellite brightness temperature in Kelvin, T (K), using the following formula for all Landsat images.

$$\mathrm{Tb} = \frac{K_2}{\mathrm{In}\left(\frac{K_1}{L_{\lambda}} + 1\right)}$$

Where, T_b defines the meaning of the effective at satellite brightness temperature in Kelvin (K)**,** $\mathbf{L_{\lambda}}$ is TOA spectral radiance and K_1 and K_2 are the band specific thermal conversion constant from metadata (pre-launch calibration constants). The following Table 2.1 distinguished the respective value of band conversion constant from metadata.

Table 2.1 The Value of Band Specific Thermal Conversion Constant from metadata

Sensor	K_1 (watt/ (m^2 x ster x µm))	K_2 (watt/ (m^2 x ster x µm))
Landsat 5 TM	1260.56	607.76
Landsat 8 OLI	BAND_10 = 774.8853 BAND_11 = 480.8883	BAND_10 = 1321.0789 BAND_11 = 1201.1442

The calculated radiant temperatures were corrected for emissivity by using the NDVI. The emissivity corrected LST were computed according to (Artis and Carnahan, 1982) and (Weng et al., 2004) as:

$$LST = \frac{T_B}{1 + \left(\lambda \times \frac{T_B}{p}\right) \ln \varepsilon}$$

Where, T_B is at-satellite brightness temperature (K), w (**λ**) indicated wavelength of emitted radiance (wavelength of emitted radiance) (11.5 □m), and P can calculate from the formula of h*c / s (□) (1.438* 10^{-2} m K). H is Planck's constant (6.626* 10^{-34} J S), S defines the Boltzmann constant (1.38* 10^{-23} J/K), C means velocity of light (2.998* 10^{-8} m/s), the value of P is 14380.

3. Results and Discussion

Analysis on LST

The spatial variation of summer' LST and winter' LST of Yangon City can be found in Fig. 3.1. In summer, the minimum LST of summer in 1996 was 25.11 ºC and 40.6 ºC in 2006 was continuous rising to 25.89 ºC in 2015. The maximum LST trend 37.43 ºC, 33.77 ºC and 36.72 ºC from 1996, 2006 and 2015.

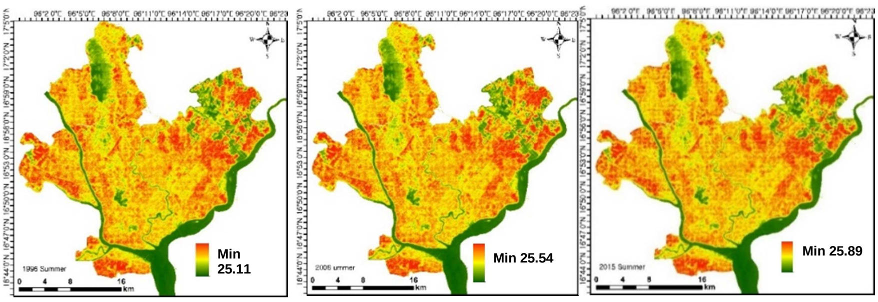

Fig. 3.1 Spatial Variation of LST in summer situations (unit : ºC)

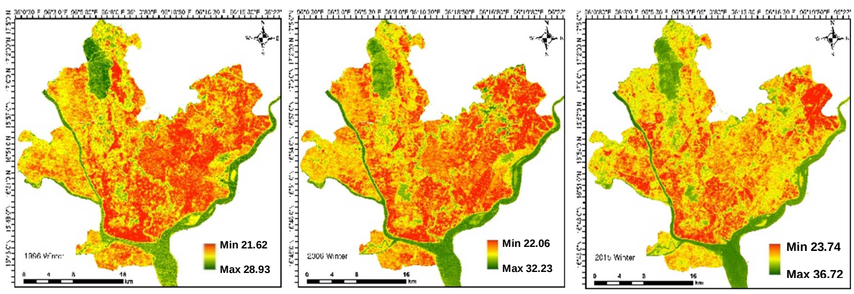

Fig. 3.2 Spatial Variation of LST in winter situations (unit : ºC)

Table 3.1 Maximum and Minimum LST of the summer and winter (unit : ºC)

Period	Summer				Winter			
	MIN	MAX	MEAN	STD	MIN	MAX	MEAN	STD
1996	25.11	37.43	31.24	2.29	21.62	28.93	24.28	1.05
2006	25.54	39.77	32.25	2.26	22.06	32.23	26.12	1.62
2015	25.89	40.60	33.32	2.62	23.74	36.72	27.97	1.64

Fig. 3.2 illustrated the spatial variation of LST in winter situation of Yangon City. LST of winter enlarged from 1996 to 2015 especially at the built up area. According to Table 3.1, the minimum LST was elevated from 21.62 ºC, 22.06 ºC to 23.74 ºC between 1996, 2006 and 2015. The maximum LST trend 28.93 ºC, 32.23 ºC and 36.72 ºC from 1996, 2006 and 2015.

Analysis on LST Changes

The changes of mean LST of three periods can be found in Table 3.2. According to this result, the changes for summer, the mean LST were 1.01 ºC in 1996-2006, 1.07 ºC in 2006-2015 and total changes of LST was 2.08 ºC from 1996-2015. The winter LST changes were 1.84 ºC in 1996-2006, 1.85 ºC in 2006-2015 and total changes represented 3.69 ºC in 1996-2015.

Tabel 3.2 Different LST of summer and winter(unit : ºC)

Period	Summer			Winter		
	MIN	MAX	MEAN	MIN	MAX	MEAN
1996-2006	0.43	2.34	1.01	0.44	3.3	1.84
2006-2015	0.35	0.83	1.07	1.68	4.49	1.85
1996-2015	0.78	3.17	2.08	2.12	7.888	3.69

Analysis on NDVI

Fig. 3.3, 3.4 and Table 3.3 showed the spatial distribution of NDVI situation in summer and winter from 1996 to 2015.

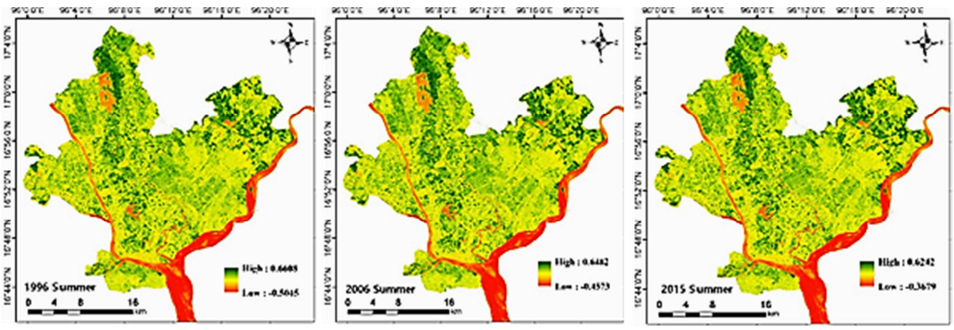

Fig. 3.3 Spatial Variation of NDVI in summer situations

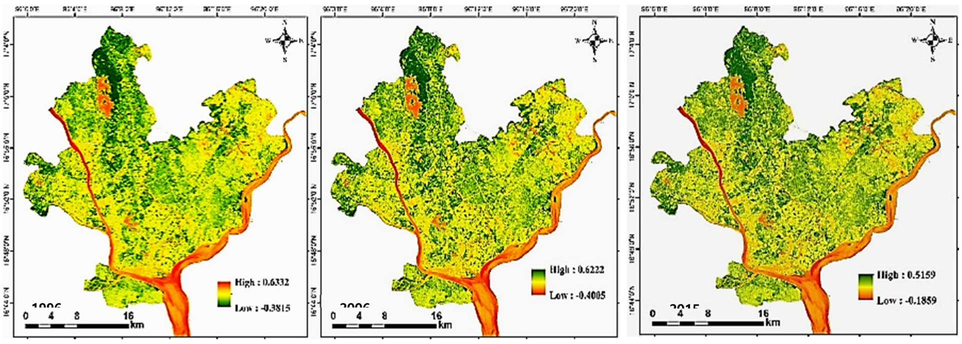

Fig. 3.4 Spatial Variation of NDVI in winter situations

The minimum NDVI was (-0.5045), (-0.4573), (-0.3679) and maximum NDVI was 0.6608, 0.6482, 0.6242 for the summer for three periods. In winter, the minimum NDVI value showed (-0.3815), (-0.4005) and (-0.1859) and maximum NDVI was 0.6332, 0.6222 and 0.5159 in 1996, 2006 and 2015 (Table 3.3).

Table 3.3 Maximum and Minimum LST of the summer and winter (unit : ºC)

Year	Summer			Winter		
	MIN	MAX	STD	MIN	MAX	STD
1996	-0.5045	0.6608	0.1876	-0.3815	0.6332	0.15
2006	-0.4573	0.6482	0.179	-0.4005	0.6222	0.148
2015	-0.3679	0.6242	0.112	-0.1859	0.5159	0.096

Analysis on NDVI Changes

Generally, the maximum NDVI value of summer and winter were declined from 1996 to 2015. In summer season, the changes of NDVI value (-0.013) in 1996-2006, (-0.024) in 2006-2015 and (-0.037) in 1996-2015. In winter condition, changes of NDVI value (-0.011) in 1996-2006, (-0.106) in 2006-2015 and (-0.117) in 1996-2015. In 2008, the strong Nargis cyclone hit across the Ayeyarwady areas including Yangon region. Most of the big trees lost and cleared after the Nargic. Therefore, the NDVI value decreased from 2006 to 2015. The total changes of maxumum was (-0.08) within 20 years.

Hot Spot of Gdtis-Ord Gi* statistic in summer

Fig. 3.5 was the average LST of every township both summer and winter in Yangon City. This figure showed that over 90 % confidence level of hot spot condition placed at the downtown area for all three periods. Most of the townships of suburban areas showed that not significant conditions. A few cold spot area can be found some townships at the suburban areas.

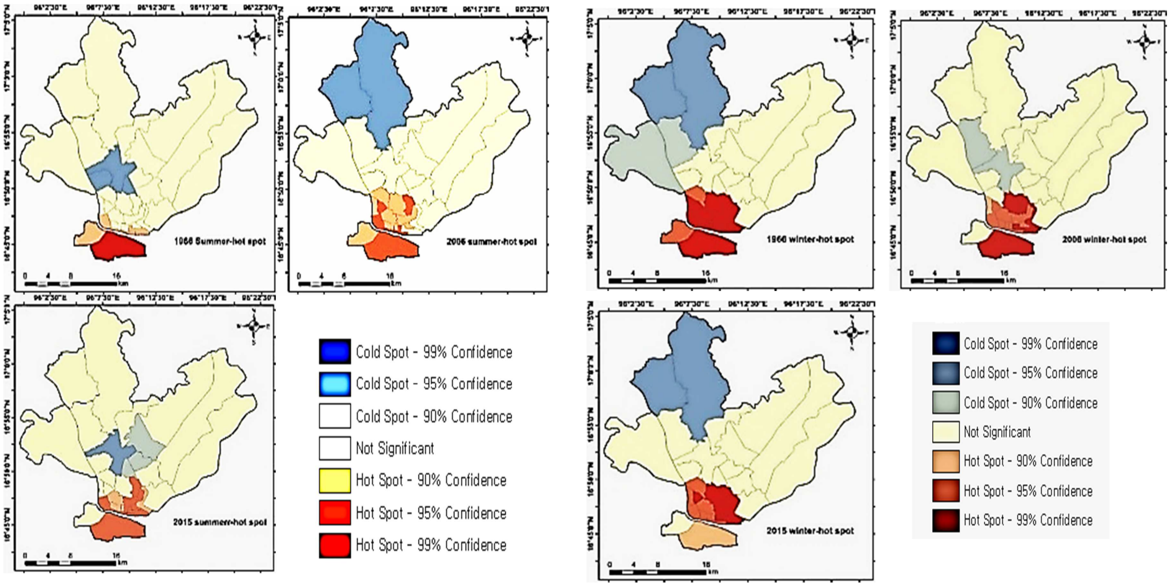

Fig. 3.5 Average LST of Hot Spot area in summer (left) and winter (right) (1996, 2006 and 2015)

In 1996, over 90 % confidence level of hot spot can be seen at some townships of downtown and suburban1. In 2006, Mayangon Township of middle part in suburban 1, Shwepyithar and Mingalardon Townships of suburban 2 and Mayangon and South Okkalapa Townships of suburban 1 in 2015 were 90 % confidence level of cold spot condition. The 90% confidence levels of cold spot took place at the edge townships of suburban 2 in 1996 and 2006 and suburban 1 in 2015. Most of the townships in suburban 1 and 2 were not significant situation.

Hot spot of Gdtis-Ord Gi* statistic in winter

For the winter case, the hot spot area was more soundly at the downtown with adjacent townships (in suburban 1) area with above the 95 % and 90 % confidence levels for three periods. The 90 % confidence level of cold spot can be seen at the townships of the fringe in suburban 2 area of 1996 and 2015 and the small area of suburban 1 in 2006.

Not significant condition covered the center of suburban 1 and eastern part of the suburban 2 in 2006, some townships of suburban 1 and all townships of suburban 2 in 2006 and, western and eastern parts of the suburban 1 and 2 areas for 2015.

4. Summary

Nowadays, Yangon will be undergoing major alterations in its economic, social and infrastructures accompanied with country's changes. According to Yangon vision 2040 with the current growth rate, Yangon city will become 10 million population and turn into one of the world's megacities (AsiaNews, 2013). The challenges of the urban environmental problems widely experienced, due to the luck of planning and mismanagement of limited land resources. Although Yangon is believed to be highly vulnerable to climate change, no previous study has investigated the impacts of human activities on the spatial and temporal distribution of temperatures.

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