THE EFFECT OF ENVIRONMENTAL CONDITION CHANGES ON DISTRIBUTION OF URBAN HEAT ISLAND IN JAKARTA BASED ON REMOTE SENSING DATA

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Abstract. Anthropogenic activities of urban growth and development in the area of Jakarta has caused increasingly uncomfortable climatic conditions and tended to be warmer and potentially cause the urban heat island (UHI). This phenomenon can be monitored by observing the air temperature measured by climatological station, but the scope is relatively limited. Therefore, the utilization of remote sensing data is very important in monitoring the UHI with wider coverage and effective. In addition, the remote sensing data can also be used to map the pattern of changes in environmental conditions (microclimate). This study aimed to analyze the effect of changes in environmental conditions (land use/cover, Normalized Difference Vegetation Index (NDVI) and Normalized Difference Build-up Index (NDBI)) toward the spread of the urban heat island (UHI). In this case, the UHI was identified from pattern changes of Land Surface Temperature (LST) in Jakarta based on data from remote sensing. The data used was Landsat 7 in 2007 and Landsat 8 in 2013 for parameter extraction environmental conditions, namely: land use cover, NDVI, NDBI, and LST. The analysis showed that during the period 2007 to 2013, there has been a change in the condition of the land use/cover, impairment NDVI, and expansion NDBI that trigger an increase in LST and the formation of heat islands in Jakarta, especially in the area of business centers, main street and surrounding area, as well as in residential areas.

Keywords: urban heat island, Landsat 7, land use/cover, NDVI, NDBI, Jakarta

1 INTRODUCTION

The development and growth of the city in Jakarta area took very quick process. This condition is strongly influenced by its position as the capital of the Republic of Indonesia, the administrative center, economic center, and a business center. The impact of urbanization to areas of Jakarta steady continues, so it encourages human activities and dynamic developments.

In order to meet the needs of development and growth, it causes the changing of land use, particularly for business and residential space. Furthermore, anthropogenic activity has resulted on occurring less comfortable and warmer environments.

Anthropogenic activity is changing the surface physical characteristics (albedo, thermal capacity, thermal conductivity, and humidity), which further affects the changes of local energy balance. In addition, the changes of land use from the green condition (natural) into road asphalt/concrete, buildings, and industrial areas would change the radiation and energy exchange at the land surface, so that surface balance will be disturbed and will result in increased surface temperatures. In addition, the heat released by human activities, such as burning and motor vehicle exhaust gases, air pollution, and the use of household appliances (air conditioner), refrigerators, etc.); will add to the heat temperatures in urban areas. The increase in surface temperature has resulted in an increase of sensible heat flux and air temperature. This condition will potentially lead to the phenomenon of urban heat island (UHI), this is a phenomenon that occurs due to a temperature difference of urban striking compared to the surrounding area. UHI is one indicator for the evaluation of urban environmental conditions (comfortable). UHI phenomenon was initially introduced by Howard in 1833.

UHI phenomenon can impact on climate change and local weather conditions, changes in local wind patterns, spurring the development of clouds and fog, increase the number of lightning events, and increase rainfall. Therefore, the detection and monitoring of UHI phenomenon is very important and necessary in order to provide information and advice for planning and urban environmental protection. UHI phenomenon can be observed on the surface temperature distribution changes pattern by using remote sensing data.

Some studies used observational temperature data network or through temperature measurement stations mounted on a flying spacecraft. The rapid development of satellite technology allowed the study of UHI is done by utilizing the thermal data or remote sensing infrared sensors, as done by Voogt and Oke (2002), Kim (1992), Nichol (1994, 1996a, 1996b), and Weng (2001). The combination of thermal remote sensing data usage with urban micro meteorology can be used to study the causes of the UHI phenomenon. Remote sensing data utilization has increased UHI assessment and modification of the urban climate. The advantages of remote sensing data usage is able to monitor the surface temperature to a wider area, to map a better and more efficient temperature pattern, and the surface temperature information can be directly linked with the patterns of land use. Thus, the information can be used as a spatial planning and urban policy.

Study of remote sensing data utilization to estimate UHI on the surface was pioneered by Rao (1972). Further, Roth et al. (1989) and Shangming and Bo (2001) also conducted a study by using data NOAA AVHRR, MODIS (Ochi *et al.*, 2002), Landsat TM and ETM^{+} (Kim, 1992; Nichol, 1994; 1996a; 1996b; Weng, 2001), the combination of temperature data observation station with a temperature brightness map (T_b) of the data AATSR (Advanced Along Track Scanning Radiometer) on ENVISAT satellite (Fabrizi *et al.*, 2010), Landsat TM and ASTER (Liu and Zhang, 2011). NOAA-AVHRR data usage was done by Roth *et al.*, 1989, Shangming and Bo (2001) and MODIS which was done by Ochi *et al.*, 2002, because the two types of data have the high temporal frequency which enables data to be gained at the day and night. The best NOAA-AVHRR and MODIS imagery is the image acquired at 02:30 (night) and 14:00 (day), further, can be used as the UHI data. It is related to the formation of maximum heat island that can be represented by the surface temperature (T_s) in the day and night. Streutker (2002) used AVHRR level 1b HRPT (High Resolution Picture Transmission) data of NOAA-14 to lower the T_s data. This T_s data is intended to assess the UHI surface temperature and to correlate between UHI and temperatures in the village in some areas in Houston, Texas, United States. Meanwhile Khomarudin (2004) detects the presence of UHI in Gresik, Surabaya and Sidoarjo based energy balance model developed by Narasimhan and Sirivasan (2002 in Khomarudin, 2004) using data from NOAA-AVHRR and Landsat.

Another parameter that can be used as an indicator of UHI is ISA (Impervious Surface Area) and NBBI (Normalized Difference Build-up Index) and/or a combination of several parameters. Yuan and Bauer (2007) used ISA percentage, NDVI (normalized difference vegetation index), and the LST (land surface temperature) which derived from Landsat TM and ETM+ as an indicator of UHI. This indicator was observed in four different seasons in the metropolitan area of the Twin Cities, Minnesota, and USA. ISA was used to estimate the relative amount of resistance surface area (such as sidewalks, parking areas, and material roof of the building) as a main indicator of water quality and urban land use (Arnold and Gibbon, 1996 in Imhoff *et al.*, 2010). Imhoff *et al.*, (2010) also used ISA data derived from Landsat 7 ETM+ and IKONOS, LST 8 daily and 16 day composite NDVI from MODIS and SRTM data to characterize differences in temperature or detect UHI in various cities in the US mainland. Liu and Zhang (2011) used Landsat TM and ASTER data to analyze the effect of UHI in Hong Kong in 2005. The LST distribution was derived from Landsat TM (band 6) by using a single-window algorithm and ASTER (band 13: 10:25 - 10.95 μm and band 14: 10.95 - 11.65 m) with split-window algorithm. LST distribution patterns were used to characterize the influence of local conditions to UHI. Subsequently, Liu and Zhang (2011) correlated LST with NDVI and NDBI to analyze the impact of the presence of vegetated land and land up to UHI, as UHI can be used as an evaluation index of ecological urban area. NDBI is the ratio of the difference between the value of the middle infrared band (MIR = middle infrared) and near infrared (NIR = near infrared) to total value of MIR band (band 5) with the NIR (band 4). NDBI is one of the indexes that can be used to obtain better information about the undeveloped land. The results of this study revealed a negative correlation between NDVI and LST, and a positive correlation between NDVI and NDBI. It means that the increase of vegetated land area will decrease the value of UHI, otherwise the increase in the built area will increase the value of UHI. Moreover, Zhang and Wang (2008) have studied the relationship between temperature rise and the increase in urban areas. Their research results show that there is strong correlation between the shape of the heat island (UHI), population density and urban centers (built up land).

This study aimed to analyze the effect of changes in environmental conditions (land use/cover, NDVI, and NDBI) to the distribution of the urban heat island (UHI). In this case, the UHI is identified from changing patterns of LST in Jakarta based on data from remote sensing. This activity is a result of the development of previous research activities (Prasasti *et al.*, 2015) that the results have been presented at the Annual Scientific Meeting Proceedings XX 2015, Indonesian Society of Remote Sensing in Bogor.

2 MATERIALS AND METHODOLOGY

2.1 Location and Data

This research took Jakarta province as study location (Figure 2-1). The area of Jakarta is 664 km^2, with a population density is about 15,174 people/km^2, which was ranked the ninth most populous city in the world.

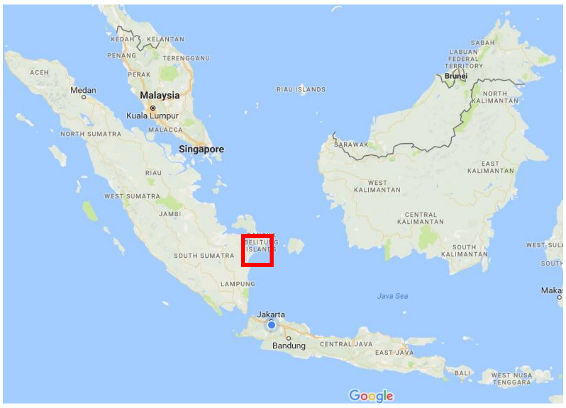

Figure 2-1: Location of research in DKI Jakarta Province (red box), Indonesia (Source of map: Google Maps)

The data used in this study were Landsat 7 ETM+ dated August 25, 2007 and Landsat 8 dated August 25, 2013 on the path/row 122/064 and 122/065. This data was obtained from the LAPAN's

(National Institute of Aeronautics and Space), Remote Sensing Technology and Data Center. Additional supporting data is the air temperature data from two stations in Jakarta, the Observatory Station and Tanjung Priok Station on the same date as the date of acquisition of both Landsat data. These data were obtained from the National Climatic Data Center (NCDC), National Environmental Satellite Data and Information Service (NESDIS) (http:// www7.ncdc.noaa.gov/CDO/cdodata.cmd).

2.2 Methods

Environmental condition para-meters used in this study is the change in land use/cover, NDVI, NDBI, and LST. Furthermore, the steps being taken in this study are described as follows:

- Extracting land use/cover by using unsupervised classification tech-niques with Isodata methods.
- Extracting value of Normalized Difference Vegetation Index (NDVI) by using the following equation:

$$NDVI = \frac{NIR - R}{NIR + R} \quad (2\text{-}1)$$

NIR is the near infrared band and R is the red band. NDVI value is used as an environmental parameter that indicates the condition of the vegetation greenness level changes.

- NDBI value calculation. NDBI is one of the indices used for information extraction conditions of the built land in urban areas. NDBI value is obtained by equation (Zha et al., 2003):

$$NDBI = \frac{MIR - NIR}{MIR + NIR} \quad (2\text{-}2)$$

MIR is the middle infrared channels (band 5 on Landsat ETM$^+$) and NIR is the near infrared band (band 4 on Landsat ETM$^+$).

- The calculation of the value of Land Surface Temperature (LST) is done through the following steps:

  - Converting the digital number (DN) 6 Landsat ETM$^+$ channel into spectral radiance value (using the following equation (Landsat Project Science Office, 2002):

$$L_\lambda = 0.0370588\, xDN + 3.2 \quad (2\text{-}3)$$

  - Converting the spectral radiance into temperature brightness (Tb) with the assumption that the value of emissivity is uniformly by using equation (Landsat Project Science Office, 2002):

$$T_b = \frac{K_2}{ln\left(\frac{K_1}{L_\lambda} + 1\right)} \quad (2\text{-}4)$$

T_b is the temperature brightness (K), L_λ is the value of the spectral radiance (W/m^{2}ster µm), and K_2 and K_1 are constant calibration.

  - Calculating LST with the equation (Artis and Carnahan (1982) in Weng et al. (2003)):

$$LST = \frac{T_b}{[1 + (\lambda T_b/\propto) \ln \varepsilon]} \quad (2\text{-}5)$$

h : Planck's constant (6.626 x 10^{-34} Js)
c : Light speed (2.998 x 10^8 m/s)
λ : the wavelength of the emitted radiance
$\alpha = hc/K$ (1.438 x 10^{-2} mK

LST is used as an environmental parameter that indicates the state change the distribution pattern of surface temperatures in the study area. In addition, any change of the distribution pattern of LST is also used as a means in detecting the UHI phenomenon in Jakarta.

Further, analyzes were conducted based on the pattern of changes in parameter extraction results of the land use/cover, NDVI, NDBI, and LST in 2013 to 2007. Then, the condition of the average air temperature was also conducted. Moreover, the maximum temperature and minimum temperature of the two stations in the area of Jakarta on the same two dates with the date of acquisition of both Landsat images were also compared.

3 RESULTS AND DISCUSSION

Changes in environmental conditions in the Jakarta area were analyzed based on changing conditions of land use/cover, NDVI, and NDBI. Meanwhile, changes in environmental temperature conditions were analyzed from the value of LST. LST value was also used to analyze the UHI distribution changes pattern. These analyses were used to compare the changes which are occurred in 2013 to 2007. The details land use/cover, NDVI, LST, and this NDBI were obtained from remote sensing data extraction Landsat ETM$^+$ in 2007 and Landsat 8 in 2013.

Classification results of land use/ cover in the area of Jakarta in 2013 showed that the high density built-up land increased sharply compared with 2007, from 30.4 ha to 43.2 ha, an increase of approximately 20.37% of the total area of Jakarta. Meanwhile, vegetated area declined from 5.8 ha to 2.5 ha (approximately 4.97%) (Table 3-1). Thus, from 2007 to 2013 there has been a significant change in the land use/cover in Jakarta area. The increased of high density built-up land area shows in all areas of Jakarta, especially in North and Central Jakarta (Figure 3-1 and 3-2).

Table 3-1: Total area of each land use/cover class in Jakarta 2007 and 2013 (Source: data processing)

Land Use/Cover	**Area (Ha)**		**Area Percentage (Ha)**	
	2007	**2013**	**2007**	**2013**
High density developed land	30.4	43.2	45.92	65.55
Moderate density developed land	18.5	14.2	27.95	21.55
Low density developed land	9.2	3.4	13.90	5.16
Vegetation	5.8	2.5	8.76	3.79
Water body	2.3	2.6	3.47	3.95
Total Area	**66.2**	**65.9**	**100.00**	**100.00**

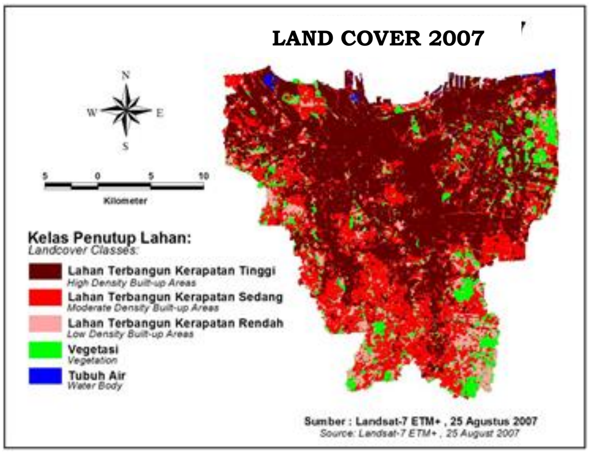

Figure 3-1: The result of land use/cover classification of Jakarta in 2007

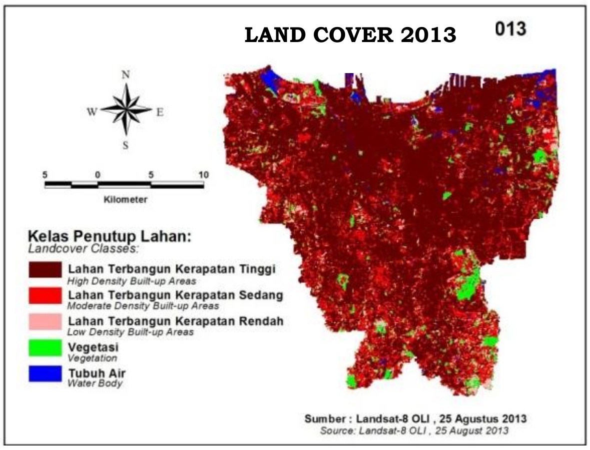

Figure 3-2: The result of land use/cover classification of Jakarta in 2013

Figure 3-3 shows that in 2013 vegetated area level is decreased compare to 2007, it is demonstrated by NDVI value, in most areas of Jakarta, especially in Central Jakarta City, North Jakarta City, eastern and northern part of West Jakarta City, western and northern part of East Jakarta City and northern part of South Jakarta City. Generally, the decreased levels of greenness occurs because the construction of roads, industrial areas, residential areas/settlements, as well as business centers. On the other hand, Halim Perdana Kusuma area, northern part of West Jakarta City, eastern part of North Jakarta City and eastern parts of East Jakarta City seems to increase their green area. The increase in the level of greenness can occur due to the expansion of the Green Open Space (RTH) program or the city park developed by the Jakarta administration.

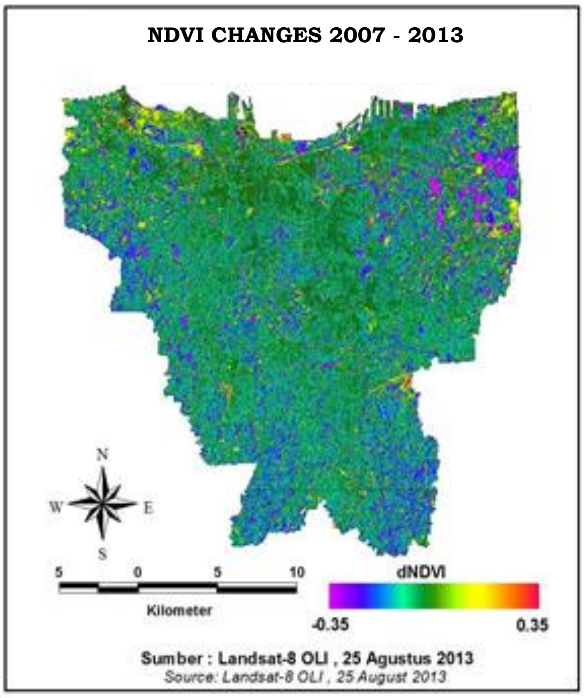

Figure 3-3: The distribution pattern changes in NDVI values during the period 2007-2013 in Jakarta

The changes of NDBI value is caused by the differences of NDBI value between 2013 and 2007. Based on changes in NDBI value, during the period 2007-2013 there appeared to be the expansion of the built-up area in the Jakarta area (the bright green to yellow color). As indicated by changes in NDVI value, the expansion of built area occurs due to widening of roads, housing, business centers, and industry. It can be seen from the pattern of changes in NDBI value that form road patterns and changes in NDBI value around roads. In some places, there is a NDBI decrease value (blue color). It can be occurred due to revitalization of the lake which done by the Jakarta administration (Figure 3-4).

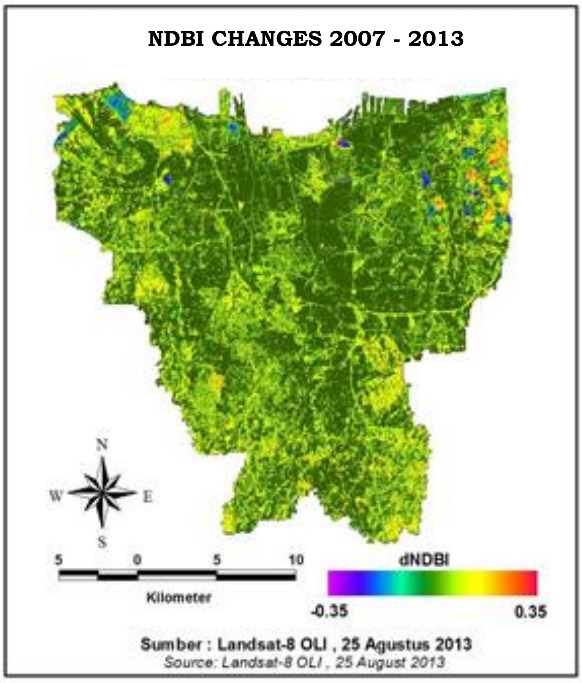

Figure 3-4: NDBI value distribution pattern changes during 2007-2013 in Jakarta

However, there are weaknesses in the use of NDBI value in describing the built area as proposed by Cibula et al. (1992), Gao (1996), and Xu (2007). Since NDBI value is calculated based on the allegation that the middle infrared (MIR) wavelength of developed area spectral response is higher than the wavelengths of near infrared (NIR). However, this condition is not always confirmed true. Cibula *et al.*, (1992) and Gao (1996) found that the reflectance values of certain types of vegetation in the Landsat 5 TM is seen rising on the condition of the leaf water content decreases. Even on a dry vegetation, the reflectance values at wavelengths MIR is higher than in the NIR wavelength (Gao, 1996), which can cause positive NDBI value in vegetated areas. Xu's study (2007) also gets the same result, some vegetated areas have positive NDBI values with an average of 0.01 in the Fuzhou area. Therefore, Xu (2007) suggested to characterize the developed area in an urban area by not only using NDBI, but also should be combined with SAVI and NDVI or MNDWI (Modified Normalized Difference Water Index). This combination is expected to correct the noise caused by vegetation and water bodies, so that NDBI value accuracy is increase. The surface water bodies which contain high suspended materials, it will also reflect stronger MIR wavelengths compare to NIR wavelength. The higher concentration of suspended material, the higher of reflection value at a MIR wavelength will be. This condition causes the surface of dry vegetation and surface water bodies with high suspended concentrations will generate positive NDBI value. This condition can lead to bias in the calculation of NDBI value. The accuracy of NDBI degree in describing the developed land is lower than 78.7% as produced by Wu et al. (2005), who used NDBI value to extract developed land in the urban area in the city of Xi'an, China.

The changes of land use/cover, reduction of vegetation greenness (NDVI), and the rise of built-up land (NDBI) are alleged to have led to increased temperature conditions and allegedly resulted in the formation of heat islands in the Jakarta area. LST value in 2007 derived from Landsat ETM$^+$ on August 25, 2007 reached the highest level in the range 299 K - 303 K (26^o C – 30 ^{o}C) with an area of less than 1%, and most of the area (approximately 33% of DKI Jakarta) were in 289 K – 293 K (16 ^{o}C – 20 ^{o}C) temperature range and 19% were in 283 K – 288 K (10 ^{o}C – 15 ^{o}C) temperature range. Meanwhile, the highest LST value in 2013 was extracted from Landsat 8 reached more than 308 K (35 ^{o}C) which covered about 4% areas. Generally, about 12-13% areas were in 293 K – 303 K (20 ^{o}C – 30 ^{o}C) range of temperatures.

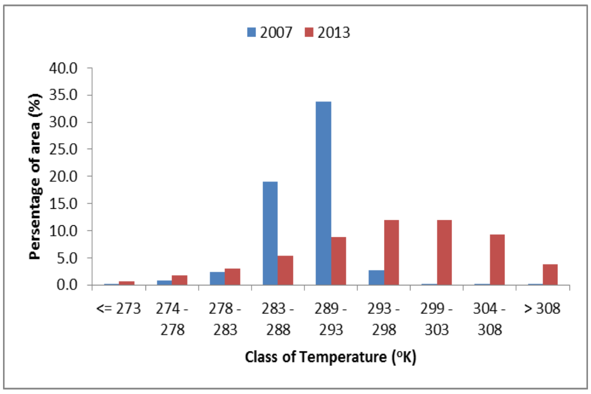

Figure 3-5: The area (%) of each class of surface temperature in Jakarta

Furthermore, based on Figure 3-5, it shows that in 2013 an increase in the percentage of area with temperatures in excess of ≥ 293 K compared to 2007, the previous highest temperature occurs is about 289 K – 293 K. This condition can be caused by the addition of heat from human activities and pollution produced by industry and motor vehicle exhaust. Moreover, it can also be caused by asphalt and concrete road surface and walls of the building that holds the heat received from the heating by the sun. Thus, during 2007 – 2013, there has been an increase in land surface temperature (LST) in Jakarta area (Figure 3-5). The changes in the distribution pattern of LST in Jakarta during the period 2007 - 2013 are presented in Figure 3-6. The changes LST distribution pattern is then used as a parameter detection of the formation of the urban heat island (UHI).

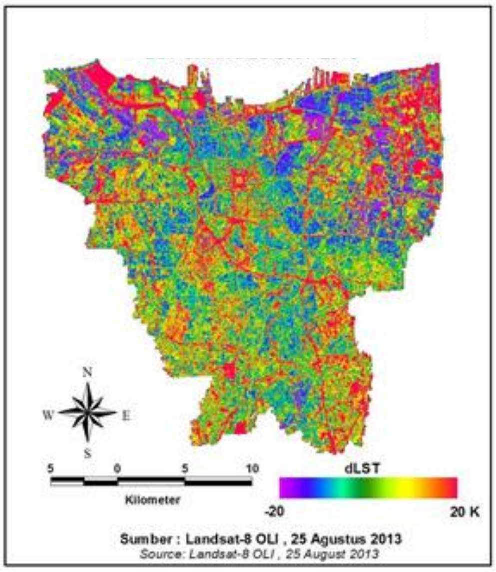

Figure 3-6: LST distribution pattern changes in value during the period 2007-2013 in Jakarta

Figure 3-6 provides information, during the period 2007 to 2013, some areas in Jakarta have an increasing rate of LST. The increase of LST value (red) mainly occur on the surface of built area, such as roads and the surrounding environment, business centers, and residential areas that form the centers of high temperature which indicates the formation of the heat island (UHI). Heat island is generally detected in the industrial park, the city center, the area with the heavy traffic level, and in the area with high population activity, such as around Monas, industrial zones and warehouses around Kamal Muara West Jakarta, around Marunda in North Jakarta, around Lebak Bulus, Jagorawi Highway, Cempaka Putih, Kemayoran, Jatinegara, Gatot Subroto, Duren Sawit, and so on. This condition can be caused by an increase in human activity passing by, an increasing number of vehicles and vehicle exhaust pollution, and so forth. However, in some places there is also a decrease of LST value, as happened in built-up land with a high density, which it should be increased. This is probably due at noon in the surrounding area there is a process of evaporation from human activities (such as drying laundry, evaporation from the surface of the water, and so on) and the process of evapotranspiration from surface vegetation which causes the high moisture level, thus lowering the LST value. Another factor that affects LST value is the atmospheric conditions.

The estimation of LST value is derived from radiation value which channel spectral Thermal Infrared (TIR) emitted initially is hard to get a good accuracy grade, because the value of radiance measured by the satellite is not only depend on the parameters of the surface (temperature and emissivity) but also on the influence of the atmosphere (Li and Becker 1993; Ottléand and Stoll, 1993; Prata et al, 1995). Moreover, the LST is strongly influenced by the heterogeneous land surface characteristics, such as: vegetation, topography, and soil (Liu *et al.*, 2006; Neteler, 2010). LST value is also rapidly changing in time and space (Prata *et al.*, 1995; Vauclin *et al.*, 1982). Therefore, LST estimation of channel TIR emissivity value requires correction and atmospheric correction. In addition, in order to estimate the previous LST, it also needs radiometric calibration process and screening of the cloud (Li and Becker, 1993; Vidal, 1991). Other factors affecting the acquisition value of LST is a model approach or the estimates used (Li *et al.*, 2013).

Moreover, the analysis results of satellite imagery data are compared with the results of temperature measurements at two weather monitoring stations in Jakarta, namely Observatory station and

Tanjung Priok station measured on August 25, 2007 and August 25, 2014. Both of these temperatures measuring station represent the temperature conditions in Jakarta area, because there are only two stations in this region.

The results of measurements of the average air temperature (Tr), the maximum temperature (T_{max}) at noon, and the minimum temperature (T_{min}) at night from two temperature measuring stations in Jakarta area is presented in Figure 3-8 until Figure 3-10. The value of T_r, T_{max} and T_{min} are the temperature measured on August 25, 2007 and August 25, 2013 in accordance with the date of acquisition of satellite data and Landsat ETM$^+$ Landsat 8 OLI which are used in this study. The results of these two measurement stations in Jakarta show T_r (measured on August 25, 2007) in Jakarta the temperature was about 28.60^{o}C (observatory station) - 28.95 ^{o}C (Tanjung Priok station) (Figure 3-7), T_{max} ranged from 32.6 ^{o}C (observatory station) - 33.4 ^{o}C (Tanjung Priok station) (Figure 3-8), and T_{min} ranges 25.0 ^{o}C (observatory station) - 25.8 ^{o}C (Tanjung Priok station) (Figure 3-9). Meanwhile, the condition of temperature on August 25, 2013 shows Tr was about 29.05 ^{o}C (at both stations) (Figure 3-8), T_{max} was 33.6 ^{o}C at both stations (3-9), and T_{min} was 25.2 ^{o}C (at both stations) (Figure 3-9). From the measurement results, we can see that compared with 2007, in 2013 the temperature in Jakarta is rise. The Tr increase (about 0.45 ^{o}C) and T_{max} (1.2 ^{o}C) in Central Jakarta (represented by the Observatory station) was higher than Tr (0.16 ^{o}C) and T_{max} (0.3^{o}C) in North Jakarta (represented in Tanjung Priok station). Moreover, in Central Jakarta the T_{min} also increased, but Tmin was decreased in North Jakarta.

A number of previous studies, assessments and allegations of UHI phenomenon can be done through LST analysis. It is based on Nichol's research (2005) who found that there is a very close relationship between Ts extracted from remote sensing imagery and Ta (air temperature) from observation of climate stations. The coefficient of determination (R^2) between T_s from imagery and T_a in the day and night (at 19:00 to 23:00) are respectively 0.81 and 0.94. It means that approximately 81% (daytime) and 94% (night) T_a values variance can be explained by the value of T_s. Nichol (2005) used ASTER imagery to get the T_s value at night and Landsat ETM$^+$ (cha nnel 6) imagery to get Ts value at day. Thus, it is strongly relevant if the extracted Ts value from the data sensing is used to estimate the value of Ta and to observe the micro-climatic conditions of a city.

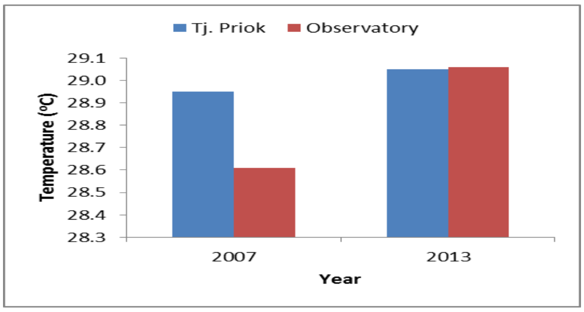

Figure 3-7: The value of the average air temperature measured from Tanjung Priok Station and Observatory station on August 25, 2007 and August 25, 2013

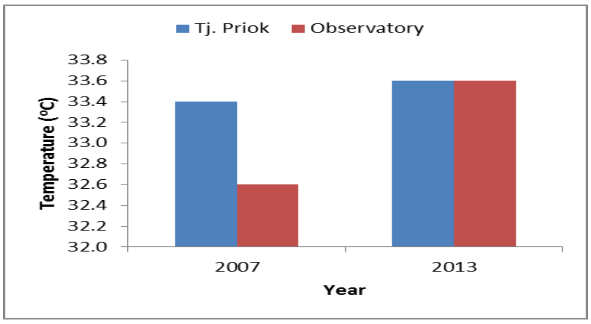

Figure 3-8: The maximum air temperature values measured from Tanjung Priok Station and Observatory station on August 25, 2007 and August 25, 2013

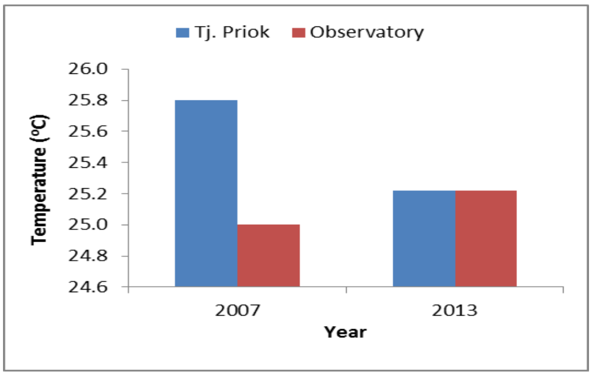

Figure 3-9: The minimum air temperature values measured from Tanjung Priok Station and Observatory station on August 25, 2007 and August 25, 2013

Based on the above explanation, it can be described that there has been a rise in temperature in the area of Jakarta, whether of the satellite observation and measurement of weather stations. From satellite observations, in several downtowns in Jakarta occurred heat islands (UHI). UHI phenomenon in Figure 3-7 is shown by centers of high temperature (red) in several places in Jakarta. UHI phenomenon is formed by the development of business centers, construction of roads and industrial estates and residential developments.

According to Oke (1973) and Shangming and Bo (2001), the spatial and temporal characteristics of UHI vary according to local changes in the urban form and its function. The UHI value is also greatly influenced by local meteorological conditions and geography (topography, the existence of a water body such as lakes or rivers, soil type, etc.) of the local area. In addition, the number of urban population density and size will also affect the intensity of UHI (Oke, 1973).

UHI phenomenon is also strongly influenced by local wind conditions. Strong gusts of wind can reduce temperature difference occurs between air temperature surrounding urban and rural areas through the air mixing process that includes both areas. In addition, the intensity of UHI will also increase along with the increase in population and urban area (Philandras *et al.*, 1999; Torok *et al.*, 2001; Hinkel *et al.*, 2003). This is because the increase in the number of people directly and indirectly will impact on local air temperature increases. Direct influence through the emission of human body temperature, while indirectly through human activities such as: an increase in the use of transportation emitter of greenhouse gases, emissions from household appliances, etc. Oke (1973) and Torok *et al.* (2001) found that the UHI (ºC) increases logarithmically with population growth. Relationship equation between UHI (ºC) with the number of residents is: UHI = 0.73 $\log_{10}$ (population) (Oke, 1973), UHI = 1.42 log (population) - 2.09 (Torok *et al.*, 2001). Based Oke's model (1973), it can be estimated that a temperature difference occurs between urban and rural surrounding in the village with a population of 10 people was about 0.73 ºC, in villages with a population of 100 people is about 1.46 ºC. Meanwhile, in urban areas with a population of 1,000 people is about 2.2 ºC and in a big city with a population of 1 million people was about 4.4 ºC. The result gained by Weng (2001) showed that the expansion of urban areas in Delta Zhujiang, China which covers an area of Hong Kong and several other cities that occurred between the years 1989 to 1997 have increased the surface temperature of about 13 K. This condition is associated with more reduction in the biome (surface vegetation) in the region.

Generally, temperature in urban centers is higher than suburban or rural temperature. The rising temperatures and high levels of air pollution in urban centers will impact on the quality of life and residents' comfortable. The rise in temperature will change the condition of human comfort, health problems (such as respiratory disorders), fatigue, and labor productivity (EPA, 2010; Theeuwes *et al.*, 2012). The annual temperatures average in a city with 1 million people or more will have 1-3ºC warmer than surrounding rural areas (Oke, 1997), while the difference in temperature at bright nights with weak winds will be higher a bit, is about 12 ºC (Oke, 1987).

The results of the overall analysis shows that there is a tendency of the change land use/cover and a decrease in NDVI value and increased of NDBI value occurred in Jakarta during 2007 to 2013 has increased surface temperature and detection of UHI. However, to obtain a quantitative relationship, a further research needs to conduct.

4 CONCLUSIONS

From the results of this study, it can be concluded that the change of land use/cover, reduction in vegetated surface (from NDVI value), and the increased of build area (from NDBI value) has caused the increasing the surface temperature (LST), further, it causes the formation of heat island (UHI) in some areas of Jakarta, especially in business centers area, residential areas and main roads connecting the city center and surrounding areas.

To get better and more quantitative information about the relationship between changes in environmental parameters with the UHI phenomenon, we need to conduct further research between environmental parameters correlate with the surface temperature. In addition, a further research needs atmospheric correction, calibration data, the selection of LST extraction method/algorithm must consider a various surface emissivity factors. It is caused by the land surface thermal emissivity value is more heterogeneous than the sea level.

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