Comparison of Changes in Urban Heat Island (UHI) in 2013 and 2018 Using Satellite Imagery Data Landsat 8 (Case Study: Central Jakarta City)

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ABSTRACT

Climate change is an issue of global concern, one of which is Urban Heat Island (UHI). The phenomenon of Urban Heat Island is the main problem in every developing city in the world against global warming. Urban Heat Island or Hot island is a phenomenon where the air temperature of the building's dense city is higher than the surrounding open air temperatures both in the village and in the suburbs. This problem is also supported by the high urbanisation process in a city that seemed to never stop. The purpose of this research is to determine the change in the value of UHI (Urban Heat Island) values in central Jakarta city in 2013 and 2018. The method used is Split Window Algorithm (SWA). Split Window Algorithm uses band 10 and band 11 on Thermal Infrared Sensor (TIR), Band 4 and band 5 on Optical Land Imager (OLI). Results of changes in the spread of LST in central Jakarta City 2013 the dominant temperature value 32-38 °C While in 2018 the dominant temperature at 38-44 °C is also available in some areas of temperature 44-51 °C and the result of changes in the spread of UHI year 2013 to 2018 increased 90 % in which in the year 2013 is still dominated by the temperature value 8-8 °C (low to moderate) while for the year 2018 look low classification significantly decreased and the temperature value 4-0 °C spread all over the region, for a temperature value of 0-5° C (high) impacted UHI Increased almost scattered throughout the study area and most affected is in Kemayoran district.

Keywords: Climate, Urban Heat Island, Split-Window Algorithm, Land Surface Temperature

INTRODUCTION

According to Putuhena (2011) Climate change is an issue of global concern, one of the phenomena of climate change occurring in Indonesia. Increasing some gases results in higher solar energy absorption. This condition leads to an increase in air temperature in the earth and triggers climate change. UHI (Urban Heat Island) or Hot island is a phenomenon where the air temperature...
of the building’s dense city is higher than the surrounding open air temperatures both in the village and in the suburbs. According to the EPA (Enviromental Protection Agency) (2005), The UHI phenomenon is the main problem in every developing city in the world against global warming. This problem is also supported by the high urbanisation process in a city that seemed to never stop.

According to Lo and Faber (1997) says that there is a strong correlation between the effect of Urban Heat Island with the population density in the metropolis, today Jakarta has become a huge metropolis city with Human Development Index (HDI) The highest of 77.36 points (Indonesian Central Statistics Agency, 2009). The estimated population in 2013 shows that the population density in Indonesia is most likely in the province of DKI Jakarta with a population density of 15.063 (Kemendagri, 2013) so that the city of Jakarta has a big problem namely Urban Heat Island Effect (Potsiou, 2010). According to the International Federation of Surveyors (2010) Jakarta is one of the metropolitan cities in Indonesia that contributes to the world’s 18th carbon emissions. The region with the most powerful Urban Heat Island intensity is in the central Jakarta area (Sabika Nabila, 2018) due to the number of tall buildings and concrete has absorbs heat during the day and is suspended longer.

The data used in the study is Landsat 8 satellite imagery, BMKG temperature data and the administrative boundary map of central Jakarta. Landsat 8 is the main data to be used to determine the classification of soil temperature and urban heat Island in the city of central Jakarta, BMKG temperature data is used for validation with the result of ground level temperature and the map of the administrative boundary as Supporting data for Mauri boundary analysis of the subdistrict that is affected by the data description of research can be seen in Table 1. In this study requires band Thermal Infrared sensor (TIR) i.e. band 10 and band 11 used to calculate the Temperature of Brightness (TB), Land surface Emissivity (LSE), Land Surface Temperature (LST) and UHI and band Optical Land Imager (OLI) i.e. band 4 and band 5 which Used to calculate NDVI. This research was conducted in central Jakarta City, DKI Jakarta, with geographical coordinates 106° 50'-26.4 "and 6°12'-46.91" LS. The area of the administrative area is 48.13 km2. The research location map can be seen in Figure 1.

<table>
<thead>
<tr>
<th>Data Information</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citra Landsat 8</td>
<td><a href="http://www.earthexplorer.usgs.gov">www.earthexplorer.usgs.gov</a></td>
</tr>
<tr>
<td>08 Juli 2013</td>
<td></td>
</tr>
<tr>
<td>06 Juli 2018</td>
<td></td>
</tr>
<tr>
<td>Map of central Jakarta City</td>
<td><a href="http://www.tanahair.indonesia.go.id">www.tanahair.indonesia.go.id</a></td>
</tr>
<tr>
<td>Scale 1: 25.000</td>
<td></td>
</tr>
<tr>
<td>Temperature data</td>
<td><a href="http://www.dataonline.bmkg.go.id">www.dataonline.bmkg.go.id</a></td>
</tr>
<tr>
<td>08 Juli 2013</td>
<td></td>
</tr>
<tr>
<td>06 Juli 2018</td>
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METHOD

In this section, the data processing starts from collecting data in the form of landsat 8 satellite data in 2013 and 2018 as well as the administrative boundaries of Central Jakarta City. The next step is radiometric correction on the image to improve the quality of the image due to satellite monitoring that causes damage to the atmosphere, imagery that has been carried out geometric correction is cut according to the administrative boundaries of the city of Central Jakarta and then carried out to Process the Surface Surface Temperature (LST) and Urban Heat Island (UHI). The results of this processing show changes in LST and UHI in 2013 and 2018. To be more clear and detailed can be seen in Figure 2 below.

Flowchart

Data collection

Landsat satellite imagery 8 2013 and 2018

Radiometric correction

Map of Central Jakarta City Administration scale 1:25.000

Cropping

Calculation Brightness Temperature (TB)

Calculation NDVI (Normalized Difference Vegetation Index)

Calculation FVC (Fractional Vegetation Cover)

Calculation LSE (Land Surface Emissivity)

LST (Land Surface Temperature)

Validation

Temperature Data (Central Jakarta BMKG station)

Map of spread of UHI in 2013 and 2018

UHI (Urban Heat Island)

Figure 2. Flowchart Research

Process

The UHI value is excommunicated based on the calculation data of Land Surface Temperature (LST). LST value has been previously known, the number is still Kelvin then it should be changed to unit Celsius because to calculate UHI requires the value of LST which is the force Celsius. The equation is used to calculate UHI as follows (Ma, et.al 2010) Equation 1:

\[ \text{UHI} = T_{\text{mean}} - (\mu + 0.5 \alpha) \]  

(1)
Where:
UHI : Urban Heat Island
T\text{mean} : LST (Land Surface Temperature) (°C)
\mu : Mean LST (°C)
\sigma : Standard deviation value LST (°C)

Top of Atmospheric Spectral Radiance

The conversion to the TOA Spectral Radiance value uses the Radiance rescaling factors with the following Equation 2:

\[ L_\lambda = M_L Q_{\text{cal}} + A_L \]  

Where,
\( L_\lambda \): TOA spectral radiance (Watts/(m\(^2\) * srad * μm))
\( M_L \): Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number).
\( A_L \): Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number)
\( Q_{\text{cal}} \): Quantized and calibrated standard product pixel values (DN).

Land Surface Temperature

LST was calculated by applying a structured mathematical algorithm viz., Split-Window (SW) algorithm. It uses brightness temperature of two bands of TIR, mean and difference in land surface emissivity for estimating LST of an area (Equation 3)

\[ \text{LST} = TB_{10} + C_1 (TB_{10} - TB_{11}) + C^2 (TB_{10} - TB_{11})^2 + C_0 + (C_3 + C_4 W) (1 - m) + (C_5 + C_6 W) \Delta m \]  

Where,
\( \text{LST} \): Land Surface Temperature (K)
\( C_0 - C_6 \): Split Window Coefficient
\( TB_{10}, TB_{11} \): TB value (K) band 10 and band 11
\( m \): Average LSE band values 10 and band 11
\( W \): Atmospheric Water Vapour Content = 0,013 (Latif, 2014)
\( \Delta m \): Difference between LSE band 10 and band 11

| Table 2. Split Window Coefficient\(^{(1)}\) |
|---|---|
| \text{Constanta} | \text{Value} |
| \text{C0} | -0,268 |
| \text{C1} | 1,378 |
| \text{C2} | 0,183 |
| \text{C3} | 54,300 |
| \text{C4} | -2,238 |
| \text{C5} | -129,200 |
| \text{C6} | 16,400 |
ANALYSIS AND DISCUSSION

Land Surface Temperature

In Figure 3 shows the change in the spread of LST in central Jakarta City in 2013 and 2018 is experiencing significant changes. In the year 2013 the dominant temperature value 32-38 °C While in 2018 the dominant temperature at 38-44 °C is also in some areas of temperature 44-51 °C, this is in accordance with the development of the city of central Jakarta that annually many land growth is awakened and population density.

Data validation temperature from BMKG

Temperature data from BMKG in July year 2013 showed a minimum temperature value of 25,0°C, the maximum temperature of 32.4 °C and an average temperature of 28.4 °C, the difference between temperature from BMKG and the temperature output of LST year 2013 i.e. 1-19 °C whereas for BMKG temperature data in July Year 2018 minimum temperature value of 24.2 °C, maximum temperature 33.4 °C and an average temperature of 28.1 °C the difference with the result LST Citra year 2018 is 7-13 °C. This is due to data from BMKG station is climate data while LST data is soil surface temperature data, causing differences from BMKG temperature data and LST result data (LANDSAT satellite image data 8).

Urban Heat Island

Figure 3. Results of LST in July 2013 and 2018

Figure 4. Results of UHI in July 2013 and 2018
UHI in the year 2013 to year 2018 experienced a significant increase in which the year 2013 affected areas of the UHI almost nothing, while in the year 2018 increased with high. This is due to the increase in population from year to year to cause changes to some environmental components. If viewed from the UHI spread on the map, the change of UHI year 2013 to 2018 increased 90% where in 2013 is still dominated by the temperature value-8-8 °c (low to moderate) while for the year 2018 look low classification significantly decreased and temperature value- 4-0 °c spread almost all over the region, for a temperature value of 0-5 °c (height) affected the increase in almost scattered throughout the study area and most affected is in Kemayoran district.

CONCLUSION

Based on the results obtained from this research, it can be concluded as follows is Land Surface Temperature (LST) and Urban Heat Island (UHI) distribution map in central Jakarta City from 2013 and 2018 showed an increase from 2013 to 2018 there was an increase of 90% when viewed from the map of UHI distribution. Increasing the spread of Land Surface Temperature (LST) and Urban Heat Island (UHI) high in the city of central Jakarta is caused by expanding the conversion of vegetation land into land awakened with the development of Central Jakarta every year.

REFERENCES


