The Effect of Land Cover Changes on Land Surface Temperature in Tangerang Selatan on 2005, 2008, 2013, and 2018

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Abstract. South Tangerang is the city with the highest population growth in Banten Province and one of the cities with the highest economic growth rate in Indonesia. Its causes higher land demand and forces land use/land cover change from non built-up area into built-up area in South Tangerang. Buildings and asphalt in urban areas contribute greatly to high surface temperatures. This study aims to look at changes in land cover that occurred in South Tangerang in 2005, 2008, 2013 and 2018, and the effect on land surface temperature. The data used in this study are Landsat TM (2005 and 2008) and Landsat OLI-TIRS images (2013 and 2018) were used to generate land cover, building density, vegetation density, and land surface temperature. This study uses the decision tree method to generate land cover classification, Normalized Difference Built-Up/Barren Index (NDBI), Normalized Difference Vegetation Index (NDVI), and Land Surface Temperature (LST). The results show that changes in land cover into built-up land are increasing land surface temperature around 0.4 - 0.7°C each year in South Tangerang. Land surface temperature has a positive correlation with building density, and a negative correlation with vegetation density.

1. Introduction
The increasing population in an area, the higher the land demand in that region, which is manifested in physical development, economic facilities, and social facilities[1]. The development that occurs has an influence on increasing the area of built land. Changes in land cover will affect the functioning of ecosystems, biodiversity, and climate[2].

During urbanization, changes in land use or land cover are responsible for the spatial distribution of land surface temperatures[3]. Well-built land cover, such as industry, commercial housing, and sidewalks, has higher surface temperatures, while agri-cultural soils and water bodies have lower surface temperatures. Vegetation has a role in counterbalancing the UHI phenomenon and can even create a cooler area than the surrounding area, because the vegetation is tend to be a canopy and evapotranspiration. Therefore, it is recommended to increase vegetation cover to reduce high urban temperatures[3].

South Tangerang is a city that was formed in 2008. South Tangerang has the highest population growth rate in Banten Province, which is 3.44% in 2010-2017[4]. The population of South Tangerang has increased from year to year, this is because South Tangerang is a city whose location is very strategic compared to other regencies / cities in Banten[5]. This causes the increasing number of land needs in South Tangerang which makes more and more land changes to the built-up area in South Tangerang. Buildings and asphalt in urban areas make a major contribution to high surface temperatures.

This study took 2008 as a reference in comparing changes in land cover that occurred, then taken 5 years before and after 2008, that is 2003 and 2013 to see land cover before and after the formation of South Tangerang, and the latest year land cover in 2018. However, due to the limited data of Landsat imagery in 2003, the imagery used is Landsat imagery in 2005. This study aims to determine the effect of changes in land cover by looking at vegetation density and building density, on land surface temperature in South Tangerang on 2005, 2008, 2013 and 2018.
2. Methods

This research was conducted in South Tangerang which is the city with the highest population growth in Banten Province. Population growth that occurred in the City of South Tangerang caused the increasing of need for residential land which resulted in changes in land cover, from non built-up area into built-up area. Decision tree (DT) is one of the most effective and useful techniques for land cover classification in remote sensing[6]. Otukei and Blaschke, 2010 in Sharma, et al., 2013 compared the prediction of changes in land cover with the decision tree method, maximum likelihood, and support vector machine using Landsat TM and ETM + data, and found that the decision tree method showed better results than the method other.

Image processing to obtain land cover using the decision tree method is processed at ENVI. Samples were taken for each existing land cover class, which are taken randomly. This study uses bands 1-5 for Landsat 5 TM images and bands 1-7 for Landsat 8 OLI images to see digital number variations in each band. Then, look at the average and standard deviation of the digital number of each class. Averages and standard deviations are used to see the digital range of land cover in each band used. The digital number will be separated based on the uniqueness of each land cover class, then it will produce a decision tree that can be seen in figure 1. This stage is carried out in each research year with different samples each year and each class, which is then tested for accuracy using Kappa and Overall Accuracy[7].

Changes in land cover are also seen quantitatively by comparing the building density index and vegetation density temporally using the NDBI and NDVI classification. NDVI (Normalize Difference Vegetation Index) vegetation index can represent the density of vegetation in various types of land cover both in land cover in urban areas and rural area, by comparing the spectral between NIR waves and red waves[8].

\[
NDVI = \frac{(NIR - RED)}{(NIR + RED)}
\]

\[
NDVI = \frac{(Band_4 - Band_3)}{(Band_4 + Band_3)} \quad \text{Landsat 5 TM}
\]

\[
NDVI = \frac{(Band_5 - Band_4)}{(Band_5 + Band_4)} \quad \text{Landsat 8 OLI}
\]
NDBI (Normalized Difference Built-up / Barren Index) is an algorithm to show the density of built-up land by comparing SWIR and NIR waves[9].

\[
NDBI = \frac{(SWIR - NIR)}{(SWIR + NIR)}
\]

\[
NDBI = \frac{(Band5 - Band 4)}{(Band5 + Band 4)} \quad \text{Landsat 5 TM}
\]

\[
NDBI = \frac{(Band6 - Band5)}{(Band6 + Band5)} \quad \text{Landsat 8 OLI}
\]

Changes in land cover / land cover, vegetation density, and building density that occur then are compared with land surface temperature according to the years observed to see the effect of land cover changes on land surface temperature in South Tangerang. The algorithm used to see the surface temperature in this study is the Land Surface Temperature (LST) by using a thermal band in the image. Land surface temperature is obtained from the calculation of the satellite brightness temperature. To get land surface temperature, the band used is a thermal band on Landsat imagery. The thermal band on Landsat 5 TM is band 6 and 7, while on Landsat 8 OLI is band 10 and 11. In this study band 6 on Landsat 5 TM is used, and band 10 on Landsat 8 OLI. Land surface temperature is produced through 3 (three) stages. First, the Digital Number (DN) thermal band is converted to spectral radiance. For Landsat 5, the formula used is as follows[10]:

\[
L\lambda = \frac{(L\lambda_{max} - L\lambda_{min})}{QCal_{max} - QCal_{min}} \times (QCal - QCal_{min}) + L\lambda_{min}
\]

Where:
- \( L\lambda = \text{Spectral Radiance (wm}^{-2}\text{sr}^{-1}\mu m^{-1}) \)
- \( L\lambda_{max} = \text{Radiance Maximum Band 6 (15,303 wm}^{-2}\text{sr}^{-1}\mu m^{-1}) \)
- \( L\lambda_{min} = \text{Radiance Minimum Band 6 (1,238 wm}^{-2}\text{sr}^{-1}\mu m^{-1}) \)
- \( QCal = \text{Digital Number (DN) Band 6} \)
- \( QCal_{max} = \text{Quantize Cal Maximum Band 6 (255)} \)
- \( QCal_{min} = \text{Quantize Minimum Band 6 (1)} \)

For Landsat 8, the formula used is (USGS, 2015 in Wibowo, 2016):

\[
L\lambda = (ML \times QCal) + AL
\]

Where:
- \( L\lambda = \text{Spectral Radiance (wm}^{-2}\text{sr}^{-1}\mu m^{-1}) \)
- \( ML = \text{Radiance Multi Band 10 (0,0003342)} \)
- \( AL = \text{Faktor penambah (0,1)} \)
- \( QCal = \text{Digital Number (DN) Band 10} \)

After obtaining the spectral value of radians, the second step is to change the spectral value of radians to estimate land surface temperature. To find the surface temperature of land from the spectral value of radians, both Landsat 5 TM and Landsat 8 OLI can use the formula[10]:

\[
T = \frac{K_2}{\ln(\frac{L\lambda}{L\lambda_{thermal}} + 1)}
\]

Where:
- \( T = \text{Temperature at the satellite sensor (Kelvin)} \)
- \( K_1 = \text{Calibration constant 1 (607.76) (Landsat 5 TM)} \)
- \( K_2 = \text{Calibration constant 2 (1260,56) (Landsat 5 TM)} \)
- \( K_1 = \text{Calibration constant 1 (774.8853) (Landsat 8 OLI)} \)
- \( K_2 = \text{Calibration constant 2 (1321.0789) (Landsat 8 OLI)} \)
- \( L\lambda = \text{Spectral radiance band thermal (wm}^{-2}\text{sr}^{-1}\mu m^{-1}) \)
The last step is to change Kelvin to Celsius:

$$\text{LST (Celcius)} = T - 273.15$$

3. Results and Discussion

3.1. Land Cover On 2005, 2008, 2013, and 2018

Land cover in this study was classified using the decision tree method. Accuracy test is carried out using 60 sample points that are randomly distributed in each study year to calculate Overall Accuracy and Kappa Coefficient. The results of Overall Accuracy and Kappa Coefficient can be seen in table 1.

| Year | Overall Accuracy | Kappa Coefficient |
|------|------------------|-------------------|
| 2005 | 88%              | 0.85              |
| 2008 | 83%              | 0.79              |
| 2013 | 90%              | 0.87              |
| 2018 | 87%              | 0.82              |

Source: Pengolahan Data

Kappa value of 0.60 is a tolerance threshold value that can be used [12](McHugh, 2012). Kappa value of 0.60 - 0.79 is included in the moderate level of confidence, and 0.80 - 0.90 is in the strong class. Kappa value generated from each research year has a value of at least 0.79 so that the results of the classification of land cover that has been processed can be used.

The land cover class in this study is divided into 5 classes: water bodies, forests, shrubs / dryland, open land, and built-up area which refers to the Indonesian National Standard (SNI) 7645: 2010. The extent of land cover in 2005, 2008, 2013 and 2018 Kota Tangerang Selatan can be seen in table 2.

| Land Cover       | 2005 (%) | 2008 (%) | 2013 (%) | 2018 (%) |
|------------------|----------|----------|----------|----------|
| Water Body       | 2        | 1        | 1        | 0.5      |
| Forest           | 7        | 3        | 2        | 3        |
| Shrubs/Dryland   | 51       | 50       | 28       | 26       |
| Open Land        | 5        | 9        | 10       | 8        |
| Built-up Area    | 35       | 37       | 60       | 63       |

Source: Data Processing

If viewed spatially in Figure 3., in 2005 the dominant land cover was shrubs/drylands which were mostly located in the western part of South Tangerang City. Land that is built tends to be in the northeast of South Tangerang. In 2008, shrubs / dry land began to decrease in the east and north of the City of
South Tangerang, which is an area directly adjacent to Jakarta and Tangerang, which was then replaced by built-up land. In 2013, shrubland cover in the western and southwestern areas of South Tangerang, which borders Tangerang and Tangerang Regency, began to decrease, which was then replaced with built-up land. In 2018, the cover of shrubland/dryland and open land in the South Tangerang are reduced, which replaced by built-up land. The most noticeable land change in 2018 is the construction of a toll road that cuts through the north-south central city of the western part of the South Tangerang, which was originally a shrubs / dry land in 2013. The direction of change in land cover built by South Tangerang comes from the city of Jakarta, from the east towards the west away from the Jakarta and towards Bogor Regency and Tangerang Regency. Shrubland / dry land cover tends to continue to decrease each year, accompanied by an increase of built-up area.

![Image of Land Cover of Tangerang Selatan](image_url)

**Figure 3.** Land Cover of Tangerang Selatan

3.2. Vegetation Density On 2005, 2008, 2013, and 2018

If viewed temporarily, 2018 is the lushest year with an area of high density class that is greater than in 2005, 2008, and 2013. The class of high and medium vegetation density that increases in area in 2018 could be due to the construction of city parks or the provision of trees on the edge of the road so that it becomes a leafier built area.

| Class          | Luas Wilayah NDVI (km²) |
|----------------|-------------------------|
| Non Vegetation | 0.34 0.38 0.48 0.84     |
| Low            | 56.90 78.43 60.74 59.48 |
| Moderate       | 57.28 58.99 54.89 42.53 |
| High           | 50.15 26.87 48.55 61.82 |

Source: Data Processing
3.3. Building Density On 2005, 2008, 2013, and 2018
When viewed temporally, 2005 was the year with the lowest building density. The non-building density class began to decrease in 2013 which was then replaced by the moderate building density class. The density of buildings in each year tends to be east of South Tangerang, which is an area bordering Tangerang Regency and Bogor Regency. The building density class is growing, which is moving west away from Jakarta.

Table 4. NDBI Area

| Class       | Luas Wilayah NDVI (km²) | 2005  | 2008  | 2013  | 2018  |
|-------------|-------------------------|-------|-------|-------|-------|
| Non Building|                         | 91.26 | 51.23 | 67.51 | 65.68 |
| Low         |                         | 24.16 | 27.31 | 20.95 | 16.46 |
| Moderate    |                         | 48.61 | 84.31 | 72.75 | 73.74 |
| High        |                         | 0.65  | 1.84  | 3.48  | 8.81  |

Source: Data Processing
3.4. Land Surface Temperature On 2005, 2008, 2013, and 2018

Based on Tangerang City's surface surface temperature (table 4), land surface temperature increases each year. The average land surface temperature increases by at least 2°C every year, which means that the average surface temperature of South Tangerang will increase by around 0.4 - 0.7°C each year.

| Temperature Class (°C) | 2005 | 2008 | 2013 | 2018 |
|------------------------|------|------|------|------|
| 20-22                  | 0,08 | 0,06 | 0,04 | -    |
| 22-24                  | 14,12| 1,88 | 0,09 | -    |
| 24-26                  | 111,78| 23,77| 1,03 | 0,01 |
| 26-28                  | 37,30| 77,60| 16,51| 1,26 |
| 28-30                  | 1,32 | 48,90| 56,35| 17,60|
| 30-32                  | 0,07 | 11,97| 76,14| 51,24|
| 32-34                  | 0,01 | 0,47 | 14,41| 74,50|
| 34-36                  | -    | 0,02 | 0,10 | 19,72|
| 36-38                  | -    | -    | 0,00 | 0,32 |
| 38-40                  | -    | -    | -    | 0,02 |
| 40-42                  | -    | -    | -    | 0,01 |

Source: Data Processing
Based on the comparison between land surface temperature and vegetation and building density in South Tangerang City in 2005, 2008, 2013 and 2018, it was found that the surface temperature of the land surface was inversely proportional to the density of vegetation. Conversely, the surface temperature of land is directly proportional to the density of buildings, where the higher the value of the density of buildings in an area, the higher the surface temperature of the land.
Land surface temperature is increasing every year, which in this study were used in 2005, 2008, 2013 and 2018. When looking at the relationship of building density, and vegetation density together, building density has a greater effect in land surface temperature compared with vegetation density.

4. Conclusions
South Tangerang City land cover continues to change every year. The most common change in land cover is the conversion of shrubs / dryland (vegetated area) to developed land. The direction of change in South Tangerang land cover tends to start from areas closer to Jakarta, which then move away from
Jakarta which tends to approach Bogor Regency. Land cover changes that occur affect land surface temperature in South Tangerang, where the surface temperature of South Tangerang increases at least 0.4 - 0.7°C annually. Changes in vegetated land cover (high NDVI / low NDBI) to non-vegetation (low NDVI / high NDBI) are likely to raise land surface temperatures in the region. Changes in empty land cover (low NDBI) to land with buildings (low NDVI / high NDBI) also tend to raise land surface temperatures in the region.

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