Correlation analysis of the impact of land cover change and ratio vehicles on the dynamic of land surface temperature: case studies of Cirebon City, Province of West Java

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Abstract. Global warming is causing an increase in surface temperature due to the depletion of vegetation and the increasing number of vehicles. In urban areas, an increase in temperature can significantly degrade the urban heat island phenomenon, in the long run, it is capable of changing the microclimate. Surface temperature and density of vegetation retrieved from multi-temporal satellite remote sensing data. This research aims to analyze the effect of vehicle and vegetation ratio against the surface temperature in Cirebon town. This research utilizes data Landsat-5 TM and Landsat-8 OLI who validated with data on the MODIS period in 1998, 2008, as well as 2018. The interaction between surface temperature and density of the vegetation the spatial correlation analysis revealed through. Throughout the years 1998 until 2018 an increase in the surface temperature of 1.18 °C, which in follow with an increase in the number of vehicles at 142,171 unit for eighteen years and decrease in the area vegetation be 12,683 km\textsuperscript{2}. The highest surface temperature is centered on CBD, port, congestion-prone areas, industrial zones, and terminals.

Keywords: land cover change, ratio vehicles, surface temperature, remote sensing

1. Introduction and Background Research
The phenomenon of microclimate change such as the increase in surface temperature occurring in major cities in Indonesia is heavily influenced by human activity that leads to the rise and change of atmospheric composition that impacts microclimate change and macroclimates in the world [1]. The dynamics of the earth's surface temperature are heavily influenced by human activity, such as the exhaust gas of vehicles, factories, or continuous changes in land use. Geographic conditions and land use in a region also affect developing microclimate conditions, no matter the land-use factor or land cover of a region that is a little more to the surrounding air temperature, because it will influence the absorption of sunlight [2]. The negative impact of urban area development and industrialization is the declining environmental quality that triggered the increase in air temperature. When compared to natural factors, human activity has a greater role in increasing the temperature and release of greenhouse gases. The increase in air temperature is also triggered by the conversion rate of land that causes a decrease in meeting vegetation land [3]. Motor vehicle activity produces exhaust emissions

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causing air pollution, resulting in decreased air quality. Pollutants issued by motor vehicles include carbon monoxide (O), nitrogen oxide (NOx), hydrocarbons (HC), Sulfur dioxide (SO2), lead (Pb) and carbon dioxide (CO2). Of these types of pollutants, carbon monoxide (CO) is one of the most pollutants produced by motorists and affects the increasingly diverse and increasingly varied layers that cover the atmosphere [4]. As we know together, air pollution or the change of one of the air compositions from the normal state, resulting in a change in temperature in human life. The continued development of transportation followed by market demand, apparently, has encouraged the development of a disaster. Nowadays, we have all learned that the influence of air pollution can also lead to warming the greenhouse effect (ERK) will lead to global warming or (global warming) [5]. As time goes on, a significant increase in temperature can bring about urban heat island phenomena that change the patterns of microclimate, resource consumption and community lifestyle. Climate change is directly or indirectly influenced by human activity by experiencing changes in atmospheric composition that will enlarge the climate diversity observed in a fairly long period. Surface temperature dynamics can also be influenced by the conditions of rising greenhouse gas concentrations caused by changes in the atmospheric radiation energy equilibrium. Ramanathan et al., (1979) gave a review on the influence of increased CO2 concentration, one of the greenhouse gases, in the atmosphere against the equilibrium of radiation energy in the troposphere surface system and also its influence on Earth’s surface temperature [6]. The impact of human activity, economic growth, and growing industry are what can increase the concentration of CO2 and CH4 gases in the atmosphere that can raise the surface temperature. The increase in air temperature generally corresponds to the urbanization rate and increasing population. One of the urban areas in West Java is experiencing rapid development in the city of Cirebon which serves as the core region for Ciayumajakuning [7]. The role has made the city of Cirebon experience an increase in land function over the sub-urban area. The area that is dominated by vegetation land is converted to an awakened land for settlements, industries, amenities, and transportation infrastructure to meet the needs of urban communities coupled with the use of construction materials that can absorb heat and has low albedo capacity. Besides, the impact of increasing air temperature in Cirebon is getting worse when combined with the wind of the beetle during the dry season period [8]. The study of air temperature and vegetation density in Cirebon should be considered carefully as it relates to urban resilience. Spatially, both observations can be done effectively and efficiently by utilizing remote sensing satellite imagery data that has multi-temporal and multi-spectral resolutions [9]. Estimation of surface temperature (LST) obtained from thermal channels (bands) analyzed using the radiative transfer equation, while vegetation density information was obtained through normalized difference vegetation index (NDVI) involving the band Near-range infrared (NIR) [10]. Both of these information can also be used for the analysis of urban heat island phenomena. Therefore, the study aims to analyze the impact of land cover change and ratio vehicles on the dynamic of land surface temperature.

2. Method

2.1. Location Research

Literature review and a field survey conducted throughout Cirebon City in March-July 2019. Administratively, the research location is in Cirebon City, West Java province, Indonesia. The city of Cirebon has an area of 37.36 km² and is divided into five sub-districts and 22 villages [2]. This area is a municipality directly adjacent to the Java Sea and surrounded by Cirebon regency. Cirebon is a mega thermal region with rainfall 1,000-2,000 mm/year and wind traversed from the Kumbang’s mountain [11]. The appeal of Cirebon City as a trading location and government triggered the urbanization and expansion of the Gementee region, township, and the current municipality. These dynamics also have an impact on changes in air temperature, air pollutions, and vegetation land can also lead to warming the greenhouse effect.
2.2. Data Acquisition
Observations of the dynamics of surface temperature and vegetation density in Cirebon for 20 years are divided into three times, namely 1998, 2008, and 2018. The research utilizes the imagery of Landsat-5 TM and Landsat-8 OLI acquired from USGS, while data validators are derived from the MODIS Terra/Aqua satellite imagery of NOAA which has a conversion constant DN 0.02 (see table 1). The selection of research data sources is based on spatial, temporal, spectral, and data availability parameters in the same period. Beside, LANDSAT and MODIS satellite imagery data have other advantages that are open and accessible online.

| Dataset         | Band – Thermal (B6) | Resolution | Criteria                  | Source          |
|-----------------|---------------------|------------|----------------------------|-----------------|
| Landsat-5 TM    | Band – Red (B3)     | 30 m       | AOI has cloud cover < 5 %  | Earth Explorer  |
|                 | Band – NIR (B4)     | 30 m       |                            | USGS            |
|                 |                     | 120 (30) m |                            |                 |
| Landsat-8 OLI   | Band – Thermal (B11)| 30 m       | AOI has cloud cover < 5 %  | Earth Explorer  |
|                 | Band – Thermal (B12)| 30 m       |                            | USGS            |
|                 | Band – Red (B4)     | 100 (30) m |                            |                 |
|                 | Band NIR (B5)       |            |                            |                 |
| MODIS           | LST (MOD11)         | 1000 m     | AOI has cloud cover < 5 %  | GSFC Earthdata  |
| Terra / Aqua    | NDVI (MOD13)        | 250 m      | AOI has cloud cover < 5 %  | GSFC Earthdata  |
|                 | (MYD13)             |            |                            | NASA            |

2.3. Data Analysis Techniques
Analytical techniques before processing for the analysis of surface temperature and vegetation density, satellite imagery data requires a pre-processing stage consisting of geometric, radiometric and atmospheric corrections. This stage is useful for obtaining the best spatial and spectral accuracy of each image. Determination of the surface temperature (LST) value is obtained by using the radiative transfer equation as follows

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

Where \(L_\lambda\) is the value of TOA spectral radiation, \(M_L\) as a factor of thermal band rescaling and \(A_L\) indicates the value of thermal band constants. The spectral radiation value is further converted to brightness temperature by referring to the metadata of each dataset for satellite imagery, the brightness temperature value can be used as a reference to LST. Conversion of spectral radiation values refers to the following equation.

\[
T = \frac{K_2}{\ln\left(\frac{K_1}{L_\lambda}\right)}
\]

Where \(T\) is the temperature value in the Kelvin unit, \(K_2/K_1\) as the calibration constant obtained from the metadata, \(L_\lambda\) is the spectral radiation value. Once the value of the surface temperature is known and converted in degrees Celsius, determining the value of vegetation density by the NDVI method involves the red (band) and close-up infrared (NIR) canals. NDVI values can be known through the following equations.

\[
NDVI = \frac{NIR\, \text{band} - \text{Red\, band}}{NIR\, \text{band} + \text{Red\, band}}
\]
The NDVI value below 0 indicates the body of water, a value of 0 – 0.2 is an awakened land with minimal vegetation density, while the 0.2 – 0.4 value indicates a mixed-vegetation area\textsuperscript{16.17}. The higher the NDVI value indicates the high value of the vegetation density in an area where the value of > 0.4 is expressed as fully vegetated. Meanwhile, the spatial correlation between the value of surface temperature and vegetation density can be obtained by the band collection statistics method because the research data has a normal distribution\textsuperscript{18}. This method involves an inter-layer covariant value as the basis for determining the correlation value that refers to the following two equations.

\[ Cov_{ij} = \frac{\sum (x_{ik} - \bar{x}_i)(y_{jk} - \bar{y}_j)}{n-1} \]

\[ Corr_{ij} = \frac{Cov_{ij}}{\sigma_i \sigma_j} \]

Where \( Cov_{ij} \) is a covariant value of layer I or J as the value of LST or NDVI per cell, \( \mu \) shows the average value, N as the number of cells, \( Corr_{ij} \) as the correlation value between layers, and \( \delta \) is the standard deviation value. Accuracy of observation of surface temperature and the vegetation density obtained from the LANDSAT image obtained by comparing both values with the result of the MODIS image of Terra/Aqua. Testing is conducted by a test-F method that utilizes covariant analysis result data because data meets the rules of parametric statistics, the similarity of results is demonstrated when the value of the F-count is < F-table [12].

2.4. Data Correlation
After going through the acquisition phase and data analysis from Citra Landsat, then analyzing the factor of human activity that has a big role in increasing the temperature of the surface of the number of motor vehicles in the get from the Central Statistical Board Cirebon, West Java. To know the trend of increase or ratio of the number of vehicles in the research on making a bar chart, then in the correlation between surface temperature data, vegetation cover and the ratio of increase in the number of vehicles.

3. Result and Discussion
In 1998 the surface temperature (LST) Cirebon city reaches 29.19 °C. Its value continues to change to 30.31 °C in 2008 and 30.37 °C in 2018. Table 2 shows the average surface temperature in the city of Cirebon for 20 years has increased by 1.18 °C. In the period 1998-2008 the rise in surface temperature reaches 1.12 °C, while the lower surface temperature increase occurs in the 2008-2018 period at 0.06 °C. The surface temperature in Cirebon has a confusing distribution pattern and continues to decline towards sub-urban areas. Locations with higher surface temperatures are generally central business districts (CBD), industrial areas, ports, congestion spots (traffic hours), and terminals. It can be seen at the potential point of motor vehicles in the vital areas such as stations in the Kejaksan subdistrict, terminals in the district Harjamukti and industrial areas and shopping centers such as Grage Mall has the potential to pass vehicles of 13,001-20,000 vehicle units (figure 1). Surface temperature dynamics also show an increase in high-temperature area ratios, where 2018 areas with a surface temperature of > 30 °C reach 71.7 percent or 28.7 km\(^2\) (figures 2).

| LST | Min. | Maks | Average | Std.Dev | NDVI | Min. | Maks | Average | Std.Dev |
|-----|------|------|---------|---------|------|------|------|---------|---------|
| 1998 | 20.32 | 35.01 | 29.19 | 1.77 \( 1998 \) | -0.40 | 0.67 | 0.28 | 0.18 |
| 2008 | 20.15 | 35.48 | 30.31 | 1.84 | 2008 | -0.41 | 0.64 | 0.16 | 0.13 |
| 2018 | 22.31 | 34.94 | 30.37 | 1.28 | 2018 | -0.19 | 0.46 | 0.17 | 0.08 |

Table 2. Surface temperature Dynamics (LST) and vegetation density (NDVI).
Dynamic changes are not only experienced by the surface temperature, but also the density of vegetation and the ratio of vehicle numbers in Cirebon. The average vegetation density suffered a significant decline throughout 1998-2008. This phenomenon can be found in the Harjamukti subdistrict and Kesambi district which is the concentration of the industrial area as well as transportation solids as shown in figure 3. In the year 2018, very high vegetation density (NDVI >
0.40) in Cirebon City was almost no because it left only 0.2 percent or 77 km², but 20 years ago the existence reached 31.9 percent or 12.76 km². The ratio of vehicles each year on average has an increase that tends to fluctuate throughout 2000-2017 which is in the data from BPS Cirebon city. The peak was in 2017, and the number of vehicles reached 202,813 units of motor vehicles in Cirebon city which shows the amount of air pollution that is issued to the atmosphere is very high, causing an increase in surface temperature. Gases that are produced from the smoke of a motor vehicle such as carbon monoxide (O), nitrogen oxide (NOx), hydrocarbons (HC), Sulfur dioxide (SO₂), lead (Pb) and carbon dioxide (CO₂) and carbon monoxide (CO), will cause a layer of gas in the atmosphere to thicken and cause these gases to absorb and reflect the wave radiation emitted by the earth so that the heat will be stored in surface of the Earth. This dynamic indicates the change in vegetation cover as the urban area followed by the increasing volume of vehicles, causing the average temperature in the city center to become hotter than the surrounding area.

Figure 3. The bar chart above shows the dynamics of (a) surface temperature (LST), (b) vegetation density (NDVI), and (c) vehicles.

The dynamics of surface temperature, vegetation density and the ratio of the number of vehicles in Cirebon are indicated to have interconnected spreads. The test results of spatial correlation between the two during the period 1998-2018 have a value of -0.284 with a significant rate of 0.05. This proves the value of surface temperature and vegetation density is opposite to each other, where high-temperature phenomena can be found in areas with low vegetation density and vice versa. A stronger negative correlation occurred in the year 1998 and continued to weaken until now as presented in table 3. The dynamics of vehicles in Cirebon are seen to increase annually by following the change in its vegetational density. Meanwhile, both surface temperature, vegetation density, and vehicle ratio have a positive correlation with the previous period, where the increase in the third value of this phenomenon occurs locally and along with the effects that propagated [14, 15]. Such an effect is easily found in areas where human activity is increased spatially.
Table 3. The relationship between surface temperature (LST) and vegetation density (NDVI).

|          | LST 2018 | NDVI 2018 | LST 2008 | NDVI 2008 | LST 1998 | NDVI 1998 |
|----------|----------|-----------|----------|-----------|----------|-----------|
| LST 2018 | 1        | -0.13784  | 0.83429  | -0.10067  | 0.47793  | 0.06991   |
| NDVI 2018| -0.13784 | 1         | -0.17643 | 0.72696   | -0.44034 | 0.63224   |
| LST 2008 | 0.83429  | -0.17643  | 1        | -0.21122  | 0.59802  | -0.02152  |
| NDVI 2008| -0.10067 | 0.72696   | -0.21122 | 1         | -0.40017 | 0.69617   |
| LST 1998 | 0.47793  | -0.44034  | 0.59802  | -0.40017  | 1        | -0.50494  |
| NDVI 1998| 0.06991  | 0.63224   | -0.02152 | 0.69617   | -0.50494 | 1         |

Observations of the dynamics of surface temperature and vegetation density with Landsat imagery have good accuracy. Based on the results of the different tests (test-F) by utilizing the image data MODIS Terra/Aqua, the value of the surface temperature and vegetation density has the same value of variance. The comparison between the surface temperature of Landsat and LST MODIS images has an F-count value of 0.931 which is lower than the F-table value reaching 4.091. Meanwhile, the vegetation density value of the LANDSAT image also has similar results to the MODIS imagery because the results of the variance comparison indicate a smaller F-count value of (1,265 < 4,065). Therefore, both Landsat and MODIS images can be utilized collectively in the observation of surface temperature dynamics and vegetation density in Cirebon, although both images have different spatial resolutions. The dynamic in Cirebon city has increased surface temperature values following declining vegetation density and increasing the number of vehicles each year. This indicates the interaction between environmental conditions and the climatic phenomenon. The trend of surface temperature rise has a multiplier effect for both the environment and human health problems, increasing power consumption, disruption of ecological balance, crop failure, to urban heat island. The strong interaction between surface temperature, vegetation density, and increasing number of motorised vehicles shows the right solution of handling temperature increases can be through various green programs such as restoration City park, Green Belt, reforestation the boundary of the river and mangrove on the beach, and cultivate the urban community awareness to have roof garden and to avoid the surrounding yard [16]. In terms of regulation, industrial area arrangement, control over land function, transportation arrangement, until the use of construction materials that have high albedo need to be strengthened again so that the rise of surface temperature can be controlled [3].

4. Conclusion
The surface temperature, vegetation density, and many motor vehicles in the city of Cirebon in the 1998-2018 period experienced different dynamics. The surface temperature has an average increase of 1.18 °C, the average vegetation density is decreasing, and the ratio of the number of motor vehicles incurred increases. Spatially, the high-temperature areas are spreading more and more that are compared with the decrease in the meeting area and the increasing number of motor vehicles in Cirebon. The surface temperature, vegetation density and a dynamic number of motor vehicles correlate negatively and significantly. This phenomenon shows that the decrease in vegetation and the increasing of motorized vehicles will have an impact on rising surface temperatures that in the long term can provide a variety of negative effects for both the environment and humans. Therefore, the strengthening of public awareness and related parties in overcoming it needs to be improved.

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