Analysis of Vegetation Density and Surface Temperature in Buahbatu District, Bandung using Landsat 8 Oli/Tirs Satellite Images

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Abstract: Urban Heat Island is a phenomenon of increasing temperature that occurs in the city area compared to the surrounding area. Urban Heat Island is caused by reduced vegetation due to changes in rural land use to urban areas. This study was conducted to analysis the relation between vegetation density (NDVI) and surface temperature (LST) in Buahbatu District as an effort to control the impact of the Urban Heat Island phenomenon. This research was conducted by processing data from Landsat 8 OLI/TIRS satellite images in 2019-2020, namely from May to October 2019 and May to October 2020. Data collection was carried out through Google Earth Engine to retrieve geospatial data visualization (satellite imagery) and USGS to download Landsat 8 satellite imagery on Bands 4 and 5, then the data is processed using Arcmap, and Pearson correlation test is performed on SPSS. The results obtained are a correlation between vegetation density and surface temperature. In Buahbatu District, the correlation between vegetation density and surface temperature shows a value of (-.403*) in 2019 and (-.386*) in 2020. Both show a negative correlation, which means that if an area has high vegetation density, the surface temperature will decrease, and vice versa. In addition, Buahbatu District gets a good UHI with an NDVI above 0.25, and an LST below 30 but not less than 25.

Keywords: NDVI; Land Surface Temperature; LST; Urban Heat Island

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I. INTRODUCTION

The city of Bandung is a city surrounded by mountains, so it forms like a basin. Bandung city has generally cool air, which means it has low temperature. In 2012 it was recorded that the highest temperature in Bandung was 30.9°C, which happened in September. Meanwhile, the lowest temperature in Bandung reached 17.4° C, recorded in July [1, 2]. However, it cannot be denied that several areas of Bandung City have warmer and even hotter temperatures than other cities, for example, Bogor City. The phenomenon of rising temperature in Bandung City is closely related to the Urban Heat Island (UHI) phenomenon or Urban Heat Island, where an urban area has a higher temperature than the surrounding areas [3, 4]. One of the reasons that cause this phenomenon is the high urbanization in Bandung city [5] that eventually leads to UHI and will negatively affect health, energy, and food. According to the U.S. Environmental protection Agency (2014) [6], the influence of urban heat islands in urban areas can affect the environment and quality of life of the community, increase air pollution emissions and the presence of greenhouse gases, which can affect the comfort of living in the city and can endanger health [7].

Among the factors that cause UHI in Bandung is the change in land use from rural to urban areas. These rural areas are generally used as agricultural land and forests. This change in land use from rural to urban areas causes a decrease in vegetation in the area of Bandung City [5]. Vegetation is an assemblage of plants in one place, including the vegetation structure, vegetation proportion, and diversity of green plants that function as land cover, reducing surface runoff and maintaining soil temperature [8]. Therefore, it is necessary to research the effect of vegetation density on surface temperature as an effort to control the impact of UHI. UHI is very important to note because UHI is very influential on the level of heat in an area for sustainable development [9]. An urban place that is very hot will certainly not be an effective place for sustainable development. In accordance with previous research which stated that UHI is the most important component in sustainable development because UHI is the beginning of an analysis of the direction of development that will be developed in an area [10]. In addition, previous research stated that sustainable development must have clear directions and goals, with UHI data presented in the form of the Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) [11]. It is possible to relocate residential areas by looking at UHI as the initial basis for whether the place to be relocated can meet the climate requirements for residents or not [12]. UHI in urban areas, of course, can focus on housing development which is useful if you want to become a green city by installing solar panels in every house. This study aims to analyze NDVI (Normalize Vegetation Index) and LST (Land Surface Temperature) which focuses on Buahbatu District, Bandung City.

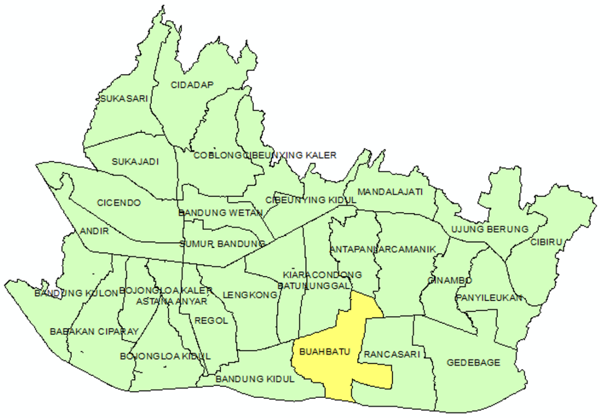


FIG. 1: Study Area

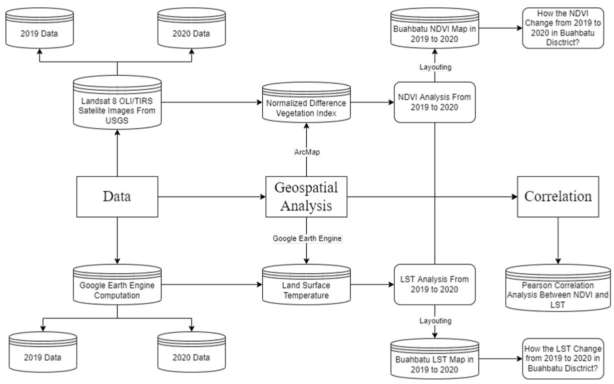


FIG. 2: Research Flowchart

Of course, this research will help sustainable development in the form of initial analysis of development, especially in the Buahbatu disctrict of Bandung City.

II. METHOD

This research was conducted in Buahbatu district, one of the districts in the City of Bandung, West Java. The Buahbatu district has a total area of .814 Ha. The surface elevation of Buahbatu District is 500 m above sea level, with 75 percent of the land being flat and choppy. Administratively, the boundaries of the Buahbatu District are: 1) In the south it is bounded by the District of Bojong Soang; 2) In the north it is bounded by the District of Kiaracondong and Antapani; 3) In the east it is bounded by the Rancasari district, Bandung; 4) In the west, it is bounded by Bandung Kidul district, Bandung, as shown in Fig. 1.

This research was conducted by processing Landsat Thermal Infrared Sensor (TIRS) 8 data in 2019-2020 using a technique in the form of image data, applied to compile the distribution of greenery levels and their correlation with temperature distribution. As in flowchart, this research can be explained in Fig. 2.

TABLE I: Correlation Interpretation

No	r value	Interpretation
1	0.00-1.199	Very Low
2	0.20-0.399	Low
3	0.40-0.599	Middle
4	0.60-0.799	Strong
5	0.80-1.000	Very Strong

The research media used are ArcMap, Google Earth Engine, and USGS, which are used to obtain geospatial data in the form of satellite images from remote sensing results. Data collection was carried out from May 2019 to October 2019 and May 2020 to October 2020.

The research process was first carried out by searching for surface temperature data, obtained through the Google Earth Engine by entering specific code using the Java programming language. Temperature data was obtained through Landsat 8 OLI/TIRS C1 imagery level 1 Band 4, 5, 10, and 11. Then the data is processed through ArcMap to know the distribution of the surface temperature.

The following process looks for NDVI (Normalized Difference Vegetation Index) data by first downloading the Landsat 8 OLI/TIRS C2 L2 image data on the available USGS. Furthermore, the data is processed using ArcMap to obtain vegetation density data. The equation used in the NDVI calculation can be seen on Eq. 1.

$$NDVI = \frac{PIR - R}{PIR + R} \tag{1}$$

And on Landsat 8, the equation becomes:

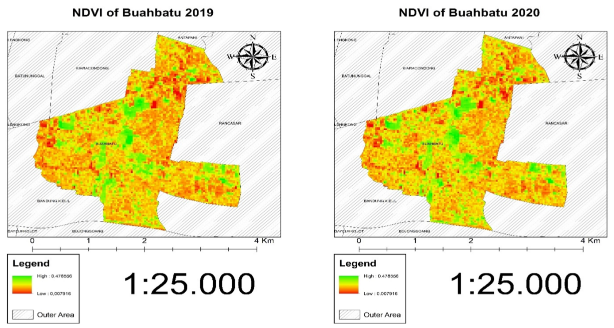
$$NDVI = \frac{B5 - B4}{B5 + B4} \tag{2}$$

Eq. 2 is a calculation of the vegetation index value, which is the measurement value of healthy vegetation. The vegetation index has a value range of -1 to 1. The NDVI -1 value indicates the state of the non-vegetated area and the NDVI 1 value indicates the maximum vegetation area.

To determine the relationship between NDVI, a correlation test was carried out between NDVI (Normalized Difference Vegetation Index) and LST (Land Surface Temperature) through ArcMap and Pearson correlation test on SPSS. The interpretation of the correlation can be seen in Table I [13].

III. RESULTS AND DISCUSSION

Normalized Difference Vegetation (NDVI) or Vegetation Index is data obtained through a mathematical approach based on the reflection of the vegetation canopy in the form of a comparison between the brightness levels of the red band and near infrared band [4]. Vegetation is an assemblage of plants in one place, including vegetation structure, the proportion of vegetation, and the diversity of green plant species that function as land cover [8].



(a) (b)

FIG. 3: NDVI of Buahbatu District from (a) May to October 2019 and (b) May to October 2020.

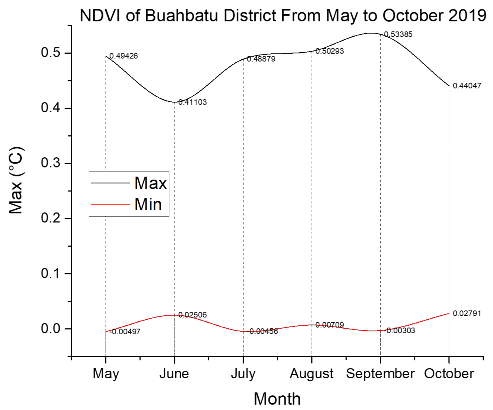


FIG. 4: NDVI Graph of Buahbatu District from May to October 2019.

According to research by Wachid [14], plants can emit or absorb radiation waves emitted to distinguish between vegetation and non-vegetation. According to Sagita [15], non-vegetation areas are residential areas, water areas, vacant lands, and areas with very low vegetation index, will have a minimum ratio of the red band and near infrared band ratio values. Meanwhile, for areas with very dense vegetation, green, and healthy vegetation conditions, the ratio of the comparison value of the red band and near infrared band will be maximum.

The ratio of the red band and near infrared band values is the normality value of the vegetation index or NDVI. According to Mabrur [16], the equation for calculating the NDVI value can be seen on Eq. 1, and the average temperature in 2019 and 2020 in Buahbatu sub-district with a period from May to October can be seen in Fig. 3.

NDVI data from the result of Landsat 8 OLI/TIRS C2 L2 image procession using ArcMap can be seen in Table II.

The vegetation index shown in Table II shows various values. It also show vegetation density from May to October 2019. The maximum values show the highest vegetation density in the Buahbatu district area. Meanwhile, the minimum values indicate the lowest vegetation density in the Buahbatu district area.

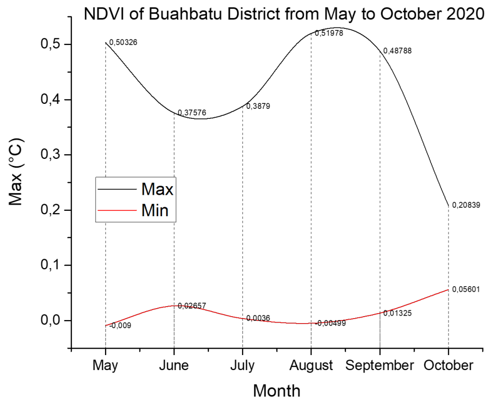


FIG. 5: NDVI Graph of Buahbatu District from May to October 2020.

TABLE II: NDVI of Buahbatu District from May to October 2019

Month	NDVI	
	Max	Min
May	0.49426	-0.0049718
June	0.411034	0.025059
July	0.488785	-0.00456
August	0.502931	0.007087
September	0.533854	-0.00303
October	0.440472	0.027911
Mean	0.478556	0.007916

TABLE III: NDVI of Buahbatu District from May to October 2020

Month	NDVI	
	Max	Min
May	0.503263	-0.009
June	0.375762	0.0265722
July	0.387902	0.0036007
August	0.519783	-0.0049887
September	0.48788	0.0132469
October	0.208391	0.0560087
Mean	0.4138302	0.01424

Table II also shows the level of vegetation density in the Buahbatu district in 2019, with the highest vegetation density level shown in September with the maximum vegetation density being 0.533854 and the lowest vegetation density being -0.00303. Based on the data in Table II, the average value of vegetation density in Buahbatu District is in the range of 0.478556 and 0.007915. This shows that the district of Buahbatu has a fairly high level of vegetation considering that the vegetation range is in the value of -1 to 1.

The level of vegetation density in the Buahbatu district in 2020 is shown in Table III. The highest vegetation density level is shown in August, with a maximum vegetation density of 0.519783, with the lowest vegetation density level being -0.00498866. Based on the data in Table II and III, the

TABLE IV: The Surface Temperature of Buahbatu District from May to October 2019

Month	Temperature (°C) Max	Temperature (°C) Min
May	32.3991	24.3891
June	32.9592	24.5103
July	34.341	24.6033
August	35.264	23.9705
September	34.8223	25.2572
October	37.7044	26.6919
Mean	34.58167	24.90371

TABLE V: The Surface Temperature of Buahbatu District from May to October 2020

Month	Temperature (°C) Max	Temperature (°C) Min
May	28.4528	22.3265
June	28.3206	22.1887
July	28.3359	22.0976
August	27.1824	21.3101
September	27.4158	21.3735
October	27.1824	21.3101
Mean	27.8149	21.76775

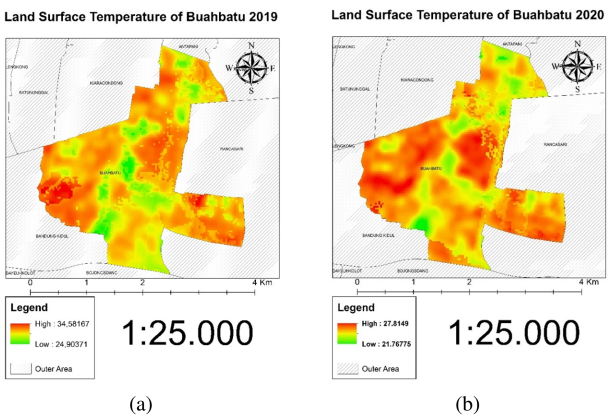


FIG. 6: Land Surface Temperature of Buahbatu District from (a) May to October 2019 and (b) May to October 2020.

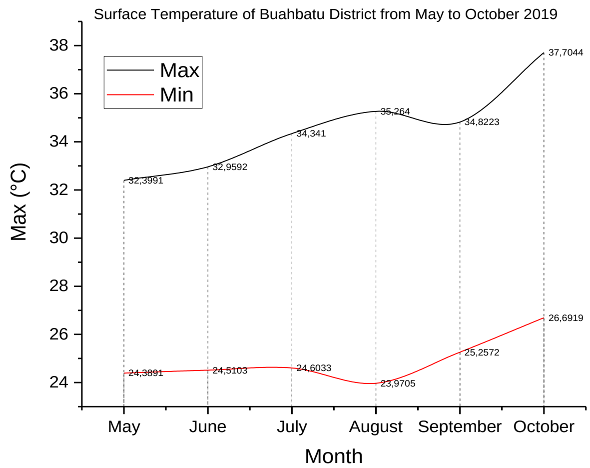


FIG. 7: Graph of Surface Temperature of Buahbatu District from May to October 2019.

average value of vegetation density in Buahbatu District is in the range of 0.413830167 and 0.014239975. The vegetation index of Buahbatu District in 2020 also showed a reasonably high value, similar to the vegetation index of Buahbatu District in 2019.

Fig. 5 shows the NDVI graph from May to October 2020. Based on the graph, the level of vegetation density in Buahbatu District has decreased and increased repeatedly, the same as in 2019. The highest vegetation density level was in August, which was 0.519783. The lowest vegetation level was in May, which was -0.009.

Land Surface Temperature (LST) is defined as the temperature of the outermost part of an object and the first element that can be defined from thermal satellite images and described in pixels with various types of surfaces. The average temperature in 2019 and 2020 in Buahbatu sub-district with a period from May to October can be seen in Fig. 6.

From the surface temperature data conducted on Google Earth Engine and ArcMaps assisted by Landsat 8 OLI/TIRS satellite imagery, the average surface temperature results from the recording period from May to October 2019 and 2020 were obtained. The average surface temperature is considered the surface temperature that represents the year's temperature. Table IV is a table of surface temperatures from Land Surface Temperature (LST) data in 2019 as well as Fig. 7.

The surface temperature data shown in Table IV shows varied surface temperature results. The maximum temperature from May to October 2019 is in the range of 32-37°C. It continued to rise from May to August, and finally decreased in September, then rose again drastically in October. It is similar to the minimum temperature in 2019 when the value continued to increase from May to August, and finally decreased in September, then rose again drastically in October, as shown in the following graph in Fig. 7.

The graph in Fig. 7 shows that the maximum surface temperature in the Buahbatu area in 2019 was in October with a temperature value of 37.7044°C, and the minimum surface temperature in the Buahbatu area in 2019 was in May with a temperature value of 24.3891°C.

Furthermore, the 2020 surface temperature data in Table V gives a reasonably constant surface temperature result. The maximum temperature from May to October 2020 is in the range of 27-28°C, in contrast to 2019, which has a maximum temperature value difference up to 3°C.

Table V also shows that the Maximum Temperature value continued to decrease from May to August, and finally experienced a slight increase in September, then rose again in October. Similar to the Minimum Temperature in 2020, its value continued to fall from May to August, and finally experienced a slight increase in September, then rose again in October, as shown in the graph in Fig. 8.

Fig. 8 shows that the maximum surface temperature in the

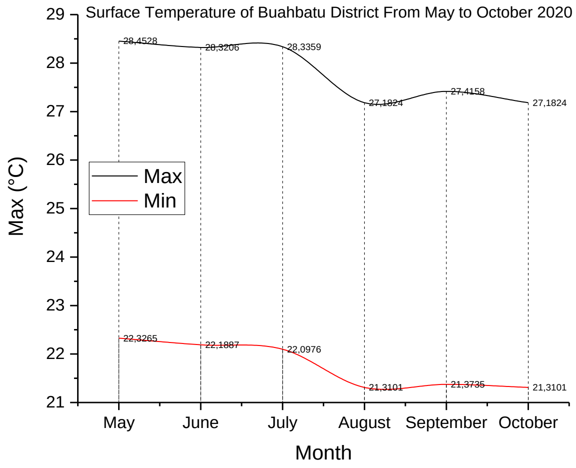


FIG. 8: Graph of Surface Temperature of Buahbatu District from May to October 2020.

Buahbatu area in 2020 was in May with a temperature value of 28.4528°C, and the minimum surface temperature in the Buahbatu area in 2020 was in October with a temperature value of 21.3101°C. Based on NDVI and LST data obtained from 2019 to 2020 in the Buahbatu District area, it shows that NDVI has not changed drastically, but there has been a decline in NDVI in 2020. In addition, LST in 2020 has decreased quite drastically. The results of the analysis on NDVI and LST from 2019 to 2020 that the Buahbatu district is considered feasible because the qualified NDVI is still at the level > 0.25 and the LST is at $25 < X < 30$. Based on the opinion expressed by previous researchers who stated that a good area to be used as a place of resettlement if the place has an NDVI of > 0.25, and an LST of not less than 25 and not more than 30 [17].

The presence of vegetation can reduce temperature because its surface absorbs some of the solar radiation energy and uses it to evaporate water from plant tissue (transpiration) and solid surfaces containing water (evaporation) [18]. Vegetation value is closely related to land surface temperature, proven by the Pearson analysis correlation test in 2019, which can be seen in Table VI.

According to Table VI, Pearson Correlation in 2019, vegetation density to surface temperature, the correlation coefficient value is -.403**. Based on the interpretation of the Pearson correlation, this value shows a moderate correlation because it is in the range of 0.40 to 0.599. The value -.403 also indicates a negative correlation between the vegetation index (NDVI) and surface temperature (LST). The negative correlation value proves that the two variables have an inverse relationship, indicating that the higher the vegetation index value, the lower the surface temperature.

The results of this correlation, as well as in the correlation test conducted in 2020, can be seen in Table VII. It shows that in 2020 Pearson correlation test is the same as the 2019 correlation test in Table VI. The correlation coefficient value in 2020 was -.386**, which shows a negative correlation between the vegetation index and surface temperature. As for the interpretation of the correlation level, it shows a weak correlation because the value is in between the range of 0.20 to 0.399.

In the 2019 and 2020, NDVI and LST correlation data, both show a Sig (2-tailed) of .000, which means that there is a correlation between NDVI and LST. The correlation data is also supported by research conducted by [19] and [20] that a lack of vegetation can affect surface temperature; when vegetation decreases, the surface temperature will increase.

TABLE VI: Pearson Correlations Analysis in 2019

Correlations			
		Land Surface Temperature (LST)	**Vegetation Density (NDVI)**
Land Surface Temperature (LST)	Pearson Correlation	1	-.403**
	Sig. (2-tailed)		.000
	N	7058	7058
Normalized Difference Vegetation Index (NDVI)	Pearson Correlation	-.403**	1
	Sig. (2-tailed)	.000	
	N	7058	7058

**. Correlation is significant at the 0.01 level (2-tailed).

TABLE VII: Pearson Correlations Analysis in 2020

Correlations			
		Land Surface Temperature (LST)	**Vegetation Density (NDVI)**
Land Surface Temperature (LST)	Pearson Correlation	1	-.386**
	Sig. (2-tailed)		.000
	N	6621	6621
Normalized Difference Vegetation Index (NDVI)	Pearson Correlation	-.386**	1
	Sig. (2-tailed)	.000	
	N	6621	6623

**. Correlation is significant at the 0.01 level (2-tailed).

IV. CONCLUSION

Based on the Pearson correlation test, it was found that there is a correlation between NDVI (Normalized Difference Vegetation Index) with LST (Land Surface Temperature), meaning that the level of vegetation in an area affects the surface temperature of the area. The research results obtained regarding the correlation of NDVI and LST in Buahbatu District in 2019 and 2020 show a correlation with the Pearson correlation value of (-.403*) in 2019 and (-.386*) in 2020. Both show a negative correlation. A negative correlation means that if one variable increases, the other variables will decrease, and vice versa. In the results obtained show the relationship between NDVI and LST is inversely. In other words, NDVI in Buahbatu District increased, then LST in Buahbatu District decreased. In addition, Buahbatu District is considered good for residential areas, because the NDVI result is > 0.25 and the LST is not more than 30 but not less than 25.

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