CORRELATION ANALYSIS OF LAND SURFACE TEMPERATURE BASED ON LANDSAT 8 TIRS IMAGE WITH SRTM TERRAIN DATA IN BANDUNG CITY 2015 AND 2019

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ABSTRACT: Land Surface Temperature (LST) shows high spatial heterogeneity in mountainous areas due to the influence of variations in surface topography factors. The city of Bandung was chosen as the study area to conduct research and determine the LST terrain effects. The method used in this research is the Landsat 8 TIRS thermal band data which is processed using the mono-window algorithm and the SRTM elevation data for 2015 and 2019. The results show that the lowest LST value in Bandung is 21 ° C, and the highest is 34 ° C. , with an average temperature of 26 ° C. For 2019, the lowest temperature is 22 ° C, and the highest is 34 ° C with an average temperature of 28 ° C. There was an increase in LST in Bandung City from 2015 to 2019, with an increase of 1 ° C at the lowest temperature and 2 ° C at the average temperature. The distribution of the dominant temperature has also changed from 2015 to 2019. In 2015 the temperature of Bandung was dominant in the range of 24-27 ° C. In 2019 the temperature distribution will expand and it is balanced between 24-34 ° C. The direction of a consistent inverse linear trend shows the opposite value between LST and elevation. A height correlation was found between elevation and LST values. The correlation coefficient in 2015 is 0.80 and in 2019 it is 0.81 this value is classified as a strong relationship category.

1. Introduction

The excellent methods to identify the energy stability on the earth's surface is the land surface temperature (LST). LST perform a role in hydrological, ecological, agricultural strategies and meteorological processes on the earth's surface (Jiménez-Muñoz and Sobrino, 2008). LST can determine from satellite imagery having thermal bands by various methods depending on the number of the band used (Pu et al., 2006). Cheval and Dumitrescu (2009) found that satellite temperature measurements give better results than obtained from interpolated earth stations. Along with the development and popularity of LST, LST itself is more associated with the relationship between urban heat islands, vegetation density, open land conversion, and else. However, the relationship between the LST and the topography in the area also essential and can be determined. It is also based on a decrease in temperature of 0.6 ° C for every 100 masl increase which is known as the average rate of decrease in temperature, because it is an average value at all latitudes and times (Braak, 1977; Purwantara, 2011). Therefore, it is necessary to consider how much influence this correlation has and which topographic factors have a determining influence on temperature (Peng et al., 2020).

This study has taken the area in Bandung city as an example of a provincial capital city that has various heights. The city of Bandung is located at an altitude of 700 m above sea level. The highest point is in the North with an altitude of 1076 masl and the lowest point in the south with an altitude of 660 masl (Widjaja, 2013). The area surrounded by mountains forms the city of Bandung into a kind of basin (Bandung Basin). The climate of the surrounding mountains influences Bandung climate. However, in recent years the temperature has increased and the rainy season is longer than usual. Naturally, Bandung is a relatively cool area. During 2012, the highest temperature in Bandung was recorded at 30.9 ° C which occurred in September. The lowest temperature in Bandung City in 2012 was 17.4 ° C which is in July (Widjaja, 2013). Several studies related to ground surface temperature were carried out by Khandelwal et al in 2018 regarding the Assessment of Land Surface Temperature Variation Due to Change in Elevation of Area Surrounding of Jaipur, India. The results show a relationship between temperature changes and elevation data as indicated by a consistent inverse linear trend observed between LST and elevation for all seasons. The research by Peng et al (2020) on Correlation analysis of land surface temperature and topographic elements in Hangzhou, China. These results indicate a linear relationship between elevation and LST by showing an inverse trend direction. This means that LST can change according to the influence of elevation. Likewise with the research of Nugroho et al (2016) concerning the Analysis of the Effect of Changes in Vegetation on Surface Temperature in the Semarang Regency Area Using Remote Sensing Methods. The soil surface temperature generated from the altitude data shows an increase with the lower the place.

This research is focused on monitoring changes in surface temperature in Bandung City in 2015 and 2019 derived from Landsat 8 Satellite Imagery. LST values are extracted from Landsat 8 Thermal Infrared Sensor (TIRS) imagery and processed using a mono-window algorithm according to Jiménez-Muñoz et at (2014). The LST results from Landsat 8 images are then correlated with the elevation data obtained from the Shuttle Radar Topography Mission (SRTM) image in the form of Digital Terrain Model (DTM) data to see the relationship between ground surface temperature and terrain conditions in Bandung. City, as has been done in research by Peng et al. (2020), and Khandelwal et al. (2018). LST data were validated using air temperature data such as in the research of Peng et al. (2020) adjusted for the date of image acquisition.

Study Area

This research was conducted in Bandung City, Java Island. Bandung is one of the big cities in Indonesia. Bandung is the capital city of West Java province with geographic coordinates 6 ° 54'53.08 ″ South Latitude and 107 ° 36'35.32 ″ East Longitude. The administrative area is 167.7 km^2. Bandung City is divided into 6 urban sub-regions, namely; Bojonagara, Cibeunying, Karees, Tegalega, Gedebage and Ujungberung. The lowest elevation is 660 masl in the Gedebage sub-region and the highest elevation is 1076 in the Ujungberung sub-region. The geological and soil conditions in the city of Bandung and its surroundings were formed during the quartier era and have alluvial soil layers resulting from the eruption of Mount Tangkuban Parahu. The type of material in the northern part is generally the type of andosol as well as in the area in the central and western parts, while the area in the south and east consists of the distribution of gray alluvial types with clay sediment. Meanwhile, Bandung's climate is influenced by a humid and cool mountain climate, with an average temperature of 23.5 ° C, an average rainfall of 200.4 mm and an average number of rainy days of 21.3 days per month. The city of Bandung has a Monsoonal rain pattern that occurs around October to May.

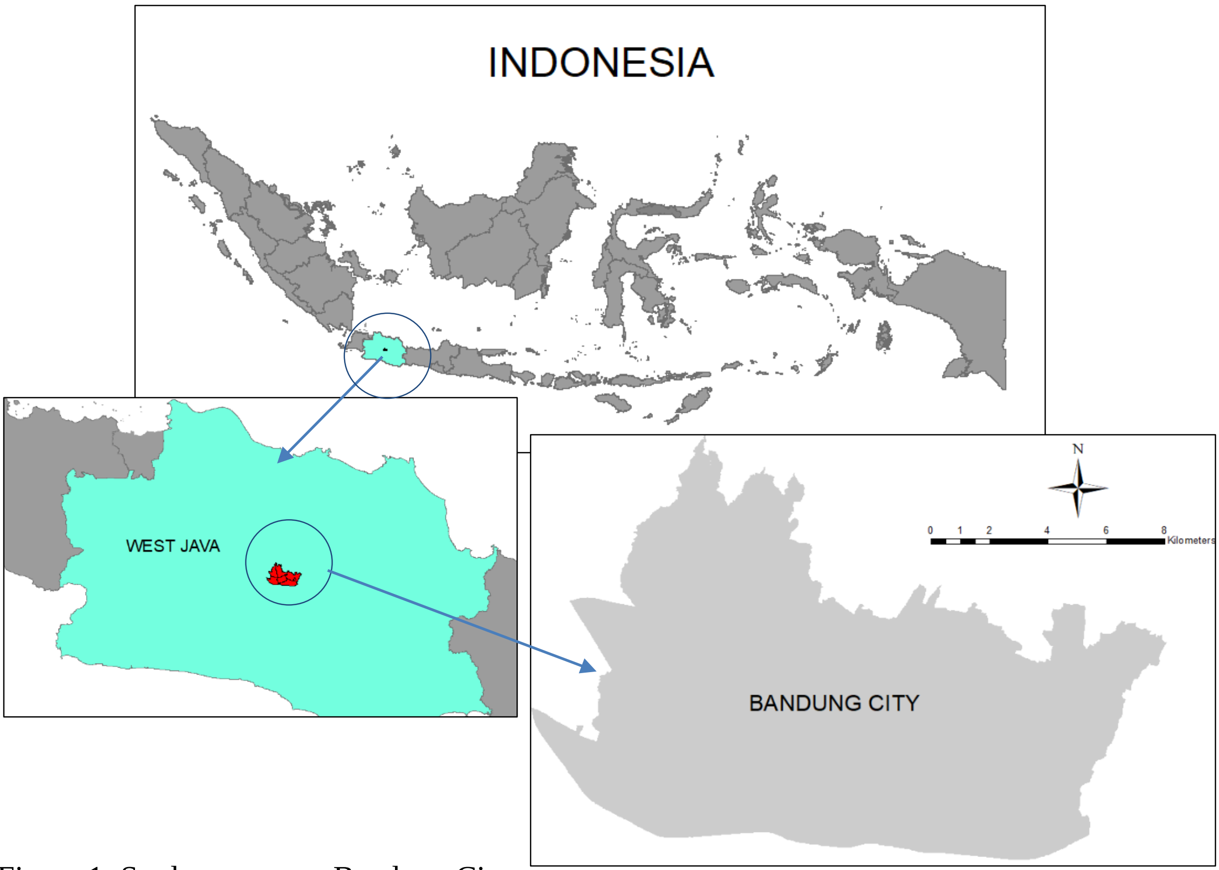


Figure 1: Study area map, Bandung City

2. MATERIALS

2.1 Datasets

Landsat 8 Imagery
Landsat 8 imagery data were taken on path 65 row 122 June 28, 2015 at 03.00 and 2019 on July 21, 2019 at 03.00. Landsat image data is used to obtain the value of the Bandung city land surface temperature. Landsat 8 image data is obtained from the USGS website (http://earthexplorer.usgs.gov).

Digital Elevation Model (DEM) SRTM
Digital Elevation Model (DEM) used is the 30m resolution SRTM, the DEM data is then taken the elevation value and used to see the correlation between the LST results and elevation data. The SRTM DEM image data was obtained from the USGS website (http://earthexplorer.usgs.gov).

Temperature Data From Meteorological Station
This data is in the form of daily air temperature data for 2015 and 2019 from one observation station obtained from the website of the Meteorological Database Center (http://dataonline.bmkg.go.id). The temperature data is taken on the same date as the image acquisition time. Temperature data from meteorological stations will be used for validation with the LST data that has been obtained.

2.2 Methods

Digital Number to TOA Radiance
The equation used to convert DN (Digital Number) values to radians using radiance rescaling factors is as follows (USGS, 2013):

$$L\lambda = MLQcal + AL \quad (1)$$

Desc:
Lλ : Radian image (Watts/(m2 * srad * μm))
ML : Multiplicative scale factor (RADIANCE_MULT_BAND_x)
AL : Additive scale factor (RADIANCE_ADD_BAND_x)
Qcal : Image in DN (Digital Number)

Brightness Temperature

Parameters for calculating this brightness temperature are the images that have been converted to radians and the thermal constant values available in the metadata. The equation is as follows (USGS, 2016):

$$Tb = K2/(\ln(K1/L\lambda+1)) \quad (2)$$

Desc:
K1 : Thermal channel calibration constant (K1_CONSTANT_BAND_x)
K2 : Thermal channel calibration constant (K2_CONSTANT_BAND_x)

Normallized Difference Vegetation Index (NDVI)

NDVI algorithm is obtained from the ratio between the red band and the near infrared band from a remote sensing image, the principle is as follows (Tucker and Scarlet, 1986):

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (3)$$

Desc:
RED : Band 4
NIR : Band 5

Fractional Vegetation Cover

FVC functions to estimate the size of the fraction of an area covered by vegetation with equation 2.4 as follows (Latif, 2014):

$$FVC = \frac{NDVI - NDVIsoil}{NDVIveg - NDVIsoil} \quad (4)$$

Desc:
NDVIsoil : NDVI value for soil
NDVIveg : NDVI value for vegetation

Land Surface Emissivity

LSE calculation uses equation 2.5 as follows (Latif, 2014):

$$LSE = \varepsilon s * (1-FVC) + \varepsilon v * FVC \quad (5)$$

Keterangan:
εs : Emissivity of thermal band soil
εv : Emissivity of thermal band vegetation

Land Surface Temperature

The algorithms designed by researchers to estimate LST, such as Mono-window Algorithm (MWA), Dual Angle Algorithm (DAA), Single Channel Algorithm (SCA) and Split Window

Algorithm (SWA). Based on the algorithms used in this study is the Mono-window Algorithm (MWA) method, the equation is as follows (Jimenez Munoz, 2014):

$$LST = BT/1+ L\lambda *(BT/p)*\ln(LSE) \quad (6)$$

Keterangan:
p : h*C/S (1.438*10^2 mk)

3. RESULTS

3.1 Land Surface Temperature in 2015 and 2019

Based on the processing of LST values in 2015, the results showed a minimum temperature of 21 ° C and a maximum of 34 ° C with an average temperature of 26 ° C. The surface temperature of Bandung City tends to be in the range of 24-27 ° C, shown in Figure 2a. A range of 27-30 ° C seen spreading from the northern part of Bandung City to the city centre and then spreading back to the east. Meanwhile, temperatures of 30-34 ° C are in the northern and eastern parts of Bandung. In 2019, the minimum temperature obtained in Bandung was 22 ° C, the maximum temperature is 34 ° C and an average temperature of 28 ° C shown in Figure 2b. Table 1 shows the percentage change in the temperature range of Bandung City in 2015-2019.

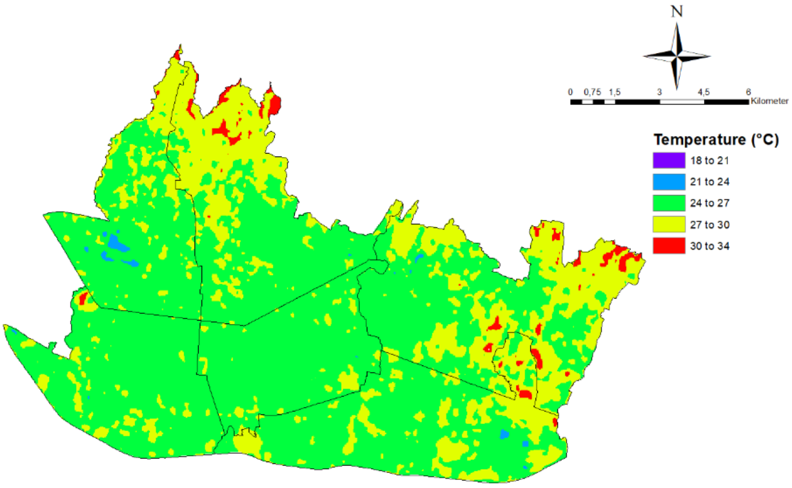


Figure 2a:The spatial distribution of LST in Bandung in 2015

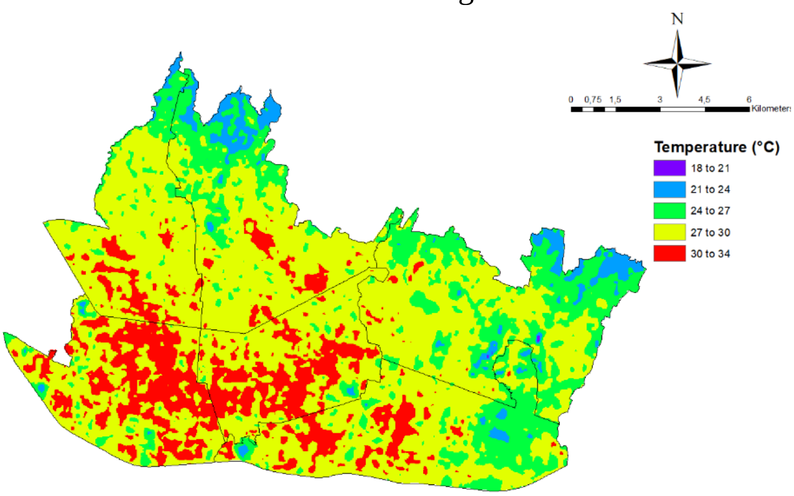


Figure 2b: The spatial distribution of LST in Bandung in

Table 1: Land Surface Temperature changes between 2015 and 2019

Year	Temperature					(%)
	18-21°C	21-24°C	24-27°C	27-30°C	30-34°C	
2015	0,3	1,7	60,3	22,4	15,0	100
2019	1,3	4,0	13,8	44,2	36,7	100

DEM Results

From the SRTM DEM data cropping results, the lowest elevation data of Bandung City can be obtained, which is 660 masl with the coordinates of 6 ° 57'48.49 "S; 107 ° 41'38.69 "E. The highest elevation of the city of Bandung is 1076 masl with the coordinates 6 ° 50'23.88 "S; 107 ° 35'48.66 "E. The average elevation of the city of Bandung is 722 masl. The surface temperature of Bandung City in 2015 and 2019 was elevated to 660 masl which was 26.1 ° C and 26.8 ° C. There was an increase of 0.7 ° C which could be due to changes in land cover types or a reduction in vegetation density (Khandelwal et al, 2018). Visualization of the object from the surface temperature according to the date the image was recorded was performed to see changes in conditions at these coordinates. Figures 3a and 3b show the results of visualizing surface temperature data to google earth.

3a) 3b)

Figure 3a:Visualisation LST in 2015 b) in 2019

The results of the visualization show that there is no change in the coordinated land cover, but the increase in LST could be caused by fine clouds, the direction of sunlight, and soil moisture (Susanti et al., 2019). Surface temperatures in 2015 and 2019 at an elevation of 1076 masl can be seen in Figure 4.

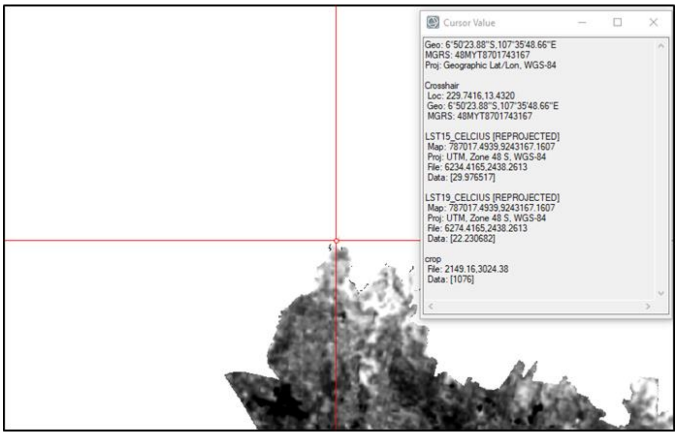


Figure 4: LST value at highest elevation

At the highest elevation, the temperature in 2015 was 29.9 ° C, while in 2019 it was 22.3 ° C and there was a decrease of 7.6 ° C. Visualization of surface temperature objects in 2015 and 2019 at the highest elevation in Bandung can be seen in Figure 5a and 5b.

5a)

5b)

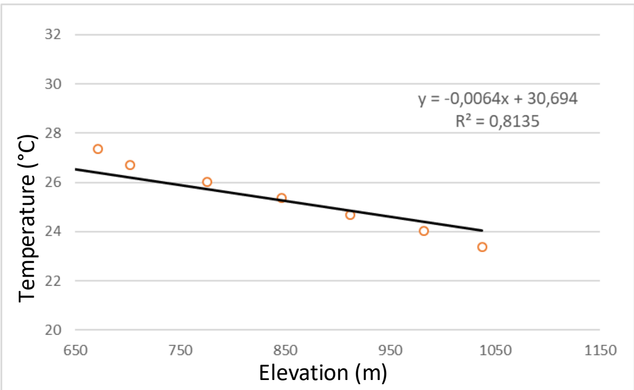
Correlation Between LST and Elevation

The results of surface temperature from LST were correlated with elevation data using the Pearson Correlation Product and the results show in table 2;

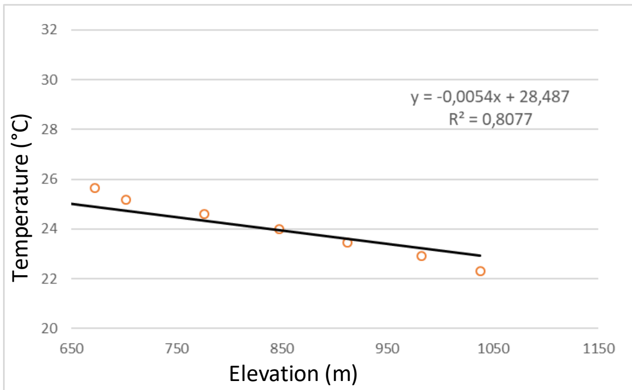
Table 2: The correlation of LST and elevation in 2015 and 2019

LST and Elevation in 2015	LST and Elevation in 2019
-0,90194	-0,898741819

Based on Table 2, the value of the correlation between surface temperature and height data is negative, which means the correlation between two variables, namely surface temperature, and elevation data runs in the opposite direction. The correlation between LST 2015 and elevation data is -0.90194. In 2019 LST, the correlation value is -0.898741819. Regression analysis was also conducted to see the linear relationship and how big the coefficient of determination (R2) is. Figure 6a shows the regression analysis for the elevation and LST data in 2015 and Figure 6b in 2019.



6a)



6b)

Figure 6: Regression analysis of the LST and elevation in 2015(a) in 2019 (b)

Based on Figure 3, the effect of the determination coefficient from LST in 2015, and elevation data is 0.8135 or 81% with the equation y = -0.0064x + 30.694. In Figure 4.9, the effect of the determination coefficient from LST in 2019, and the elevation data is 0.8077 or 80% with the equation y = -0.0054x + 28.847. This value is the square of the Pearson Correlation Product value, the interpretation of the value of the correlation coefficient can be categorized as variable surface temperature and elevation data including at a very strong level of relationship (Sugiyono, 2004). Besides, the same thing happened in the research of Khandelwal et al. (2018) that there is a strong linear relationship between the average LST data and the elevation data. Khandelwal et al also revealed that the effect of elevation changes is very important to consider related to the spatial distribution of LSTs such as urban studies for the Urban Heat Island (UHI), climate change studies, and evapotranspiration studies.

Variation LST Value and Meteorological Station

Table 3: Temperature in LST and Meteorological Station

Met. Station 2015(°C)			Met. Station 2019(°C)			LST 2015(°C)			LST 2019(°C)		
Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
18	31	23,6	18	30,8	23,2	21	34	26	22	34	28

From the daily temperature data of meteorological stations taken on the same day when recording the image. 2015 has a difference with the results of LST processing for a minimum temperature of 3° C, a maximum temperature of 3° C, and an average temperature of 2.4° C, for 2019 the difference in minimum temperature is 5° C, a maximum temperature of 3.2° C and an average temperature of 4.8° C. From these results, it can be seen that the LST value calculated with the temperature value of the meteorological station is different, this is because the temperature data obtained from the meteorological station is climate temperature data while the one generated from the Landsat 8 satellite imagery is ground surface temperature data. Climate data itself is weather data where the observation of the degree of heat and cold in the atmosphere while the ground surface temperature is defined as the average surface temperature within the scope of a pixel with various surface types (Faridah and Krisbiantoro, 2014).

4. CONCLUSION

Surface temperature in Bandung between 2015 and 2019 showed that there had been an increase in the minimum temperature at 1 ° C and 2 ° C at the average temperature. The correlation between LST and elevation data showed negative results which means that the higher one location then its surface temperature would be lower. Both correlation had a strong relationship with results is 0.8135 for 2015 and in 2019 is 0.8077.

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