Utilization of Remote Sensing and GIS Applications for Detecting Vegetation Density and Land Surface Temperature Using Landsat 8 Imagery (Banyuwangi Regency Case Study in 2019)

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Abstract. This study aimed to determine the value of vegetation density and land surface temperature in Banyuwangi Regency in 2019. Vegetation, which forms the forest, is one of the components that affect the climate in an area (microclimate). Landsat 8 has been widely used to study vegetation density and land surface temperature. Vegetation density was obtained from the analysis of Landsat 8 imagery with GIS using the Normalized Dryness Vegetation Index (NDVI) method. NDVI utilizes the red and Infrared channels, and land surface temperature values take advantage of the thermal band radiation. The case study for this research is Banyuwangi Regency. The NDVI value obtained was in the range of 0.085666 to 0.644453. The surface temperature of the land itself is between 6.17 - 43.45 0C. The correlation of NDVI value with land surface temperature is 0.989637. This proves that the dense vegetation, the lower the land surface temperature.

Keywords: NDVI, LST, Landsat 8, GIS.

1. Introduction

Vegetation is a living process composed of vegetation that dominates an ecosystem, or, in increasingly narrow areas, an ecological niche. Vegetation is a form of forest is one of the components that affect the components of the microclimate [7].

The vegetation or land cover of an area will at least affect the surrounding air temperature. The soil surface that does not receive direct solar radiation due to the presence of vegetation on it will affect the absorption of sunlight [13]. Areas with high vegetation density will greatly affect the land surface temperature in the area where the temperature will be lower. Utilization of remote sensing imagery to analyze vegetation density and land surface temperature will greatly facilitate this research. Because remote sensing imagery is able to provide the latest spatial data and information very precisely and accurately for this research, especially with the wide area of research and time efficiency. Geographic Information System is a technology that becomes a tool in storing, manipulating, analyzing and displaying natural conditions with the help of attribute and spatial data so that it will be easier to carry out spatial analysis. Landsat 8 is widely used to analyze the level of vegetation density, land cover and surface temperature. A high vegetation index value can be interpreted if the area under study has a high level of greenery such as dense and dense forest areas, and vice versa if the

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vegetation index value is low it can be concluded that if the area studied has a low level of greenery, then the vegetation is sparse or not a vegetation object [2].

The NDVI vegetation index (normalized difference vegetation index) was used for this study because it was able to highlight aspects of vegetation density [5]. NDVI takes advantage of the reflectance of two Landsat 8 channels: visible red and near-infrared.

Surface temperature is the heat from sunlight hitting an area of the earth's surface (from a satellite's point of view, the surface is whatever it sees as it passes through the atmosphere to the ground, be it grass on lawns, roofs of buildings, or the leaves of a forest plant canopy). Surface temperatures were measured and analyzed using radiant radiation data on thermal waves from Landsat 8 imagery.

This study will focus on extracting the value of vegetation density and land surface temperature in Banyuwangi Regency by utilizing Landsat 8 satellite imagery, then correlation and regression analysis will be carried out to determine the relationship between the two objects.

2. Methods

2.1 Study Area

Banyuwangi is one of the easternmost districts on the island of Java and is located in the province of East Java, which is located at coordinates 7º 43'-8º 46' South Latitude and 113º 53' - 114º 38 East Longitude (Figure 1). In the east it is directly adjacent to the Bali Strait, the north is bordered by Situbondo Regency, the south is bordered by the Indian Ocean, and the west is bordered by two regencies, namely Jember Regency and Bondowoso Regency.

The flow chart below is the steps taken to support the research process that will be made, to support the research can run more directed and systematic. Furthermore, in Figure 2, the flow of this research can be seen.

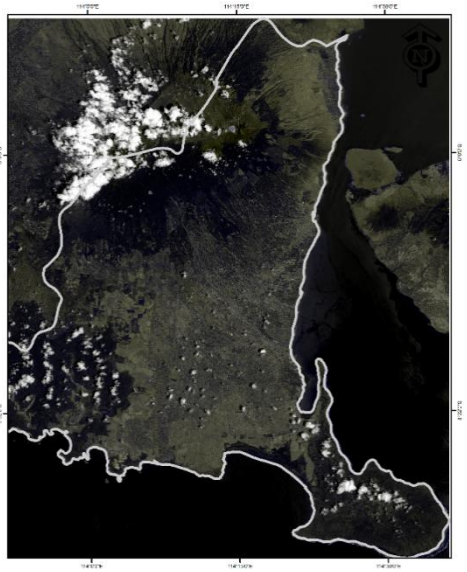


Fig 1. Study Map Area (Banyuwangi Regency)

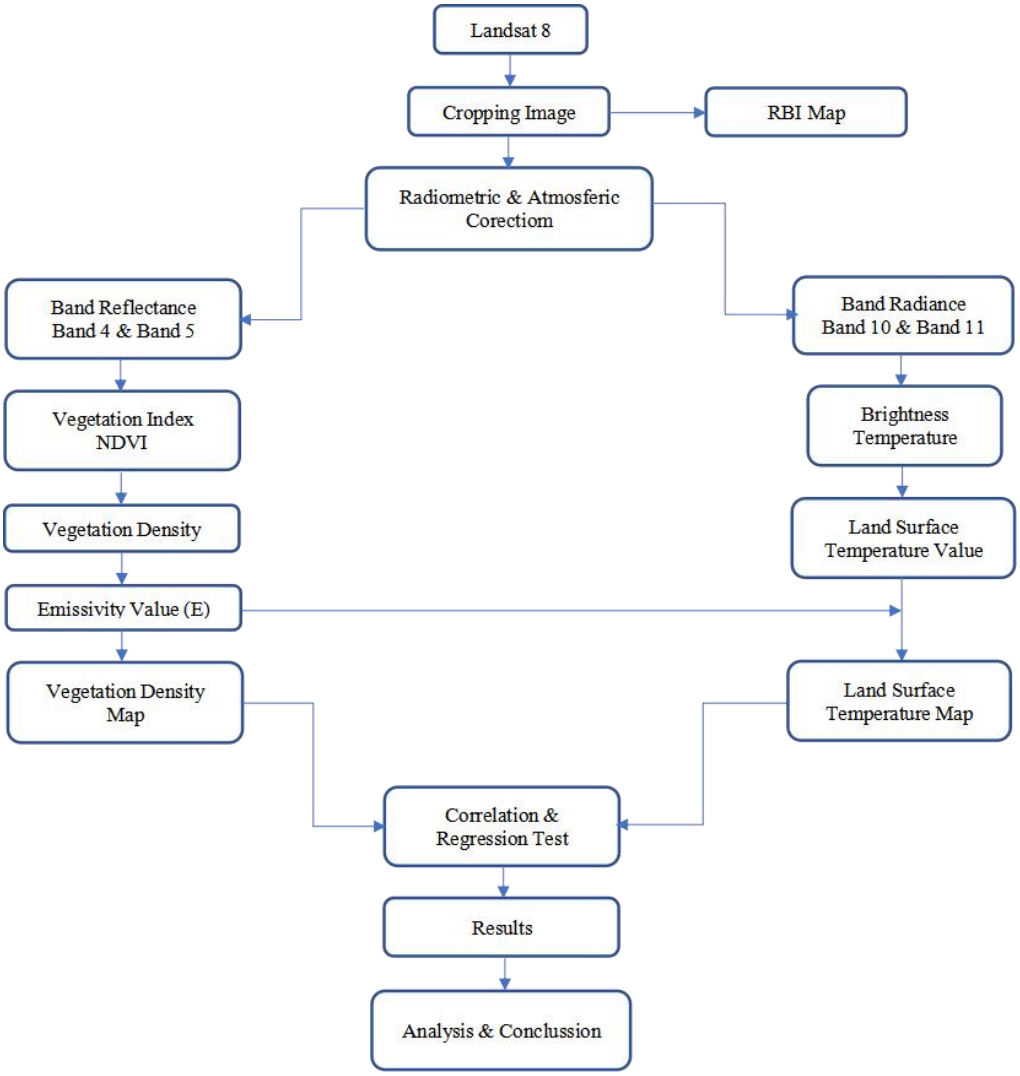


Fig 2. Work Flow Chart

2.2 Normalized Dryness Vegetation Index (NDVI)

Vegetation index NDVI (Normalized Difference Vegetation Index) is used to classify the level of vegetation density. NDVI describes the relationship between the amount of chlorophyll in leaves and the wavelength of the red band and near infrared band.

The vegetation index is a value obtained from the combination of several specific spectral bands from remote sensing images. The NDVI index value is obtained from the energy received by the remote sensing image sensor from the emission of vegetation objects to indicate the size of the vegetation and the amount of chlorophyll in the leaves with a

wavelength of red band and near infrared band. Plants emit and absorb unique waves so that this situation can be associated with the emission of waves from other objects so that it can be distinguished between vegetation and objects other than vegetation.

NDVI is calculated from reflectance measurements in the red (red) and near infrared (near infrared) bands with the following equation:

$$\text{NDVI} = \frac{\text{NIRband} - \text{Redband}}{\text{NIRband} + \text{Redband}} \quad (1)$$

Description: NDVI=NDVI value, ρ*nir* = Near infrared band reflectance, ρ*red* = Red band reflectance.

2.3 Land Surface Temperature (LST)

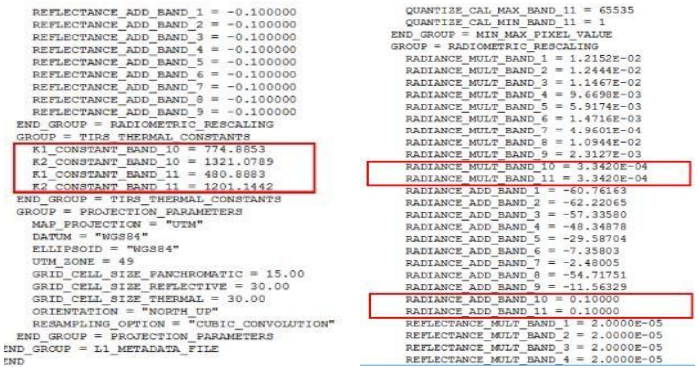
The analysis of land surface temperature (LST) from satellite image data was previously carried out in the data pre-processing stage, namely radiometric and atmospheric corrections. This stage aims to produce an analysis that can be accounted for. Determination of the surface temperature value (LST) is obtained using the radiative transfer equation.

$$L\lambda = ML \times Qcal + AL \quad (2)$$

Where Lλ is the value of the TOA spectral radiation, ML is the rescaling and thermal factor, Qcal is the amount of heat energy, and AL is the value of the thermal band constant. The result of the above calculation equation is the Radian value. The ML and AL values can be seen in the Landsat 8 image metadata (Figure 3a).

The spectral radian value is then converted to a brightness temperature value by referring to the metadata of each data set for each satellite image, the brightness temperature value can be used as a LST (Land Survey Temperature) reference. The resulting temperature is still in kelvins and will be directly converted to degrees Celsius. Conversion of spectral radiation values refers to equation 3.

$$T = \frac{k_2}{Ln/\frac{k1}{L\lambda}} + 1, -273{,}15 \quad (3)$$



(a) (b)

Fig 3. (a) Landsat 8 metadata (ML and AL values), (b) Landsat 8 metadata (K_1 & K_2 values)

Where T is the brightness temperature value in Kelvin units, K1 (Band 10) / K2 (Band 11) as the calibration constant obtained from the metadata, Lλ is the spectral radiation value from equation 1, and 273.15 is the reduction from Kelvin units to Celsius. The values of K1 and K2 can be seen in the metadata of the Landsat 8 image used (Figure 3b).

After getting the temperature value in Celsius units, then calculating the surface emissivity, which means the ability of objects on the earth's surface to emit radiation compared to black bodies at the same temperature. The emissivity value varies greatly depending on the type, intensity and shape of the object [4]. The emissivity value is calculated using the NDVI value with the equation:

$$e = 0.004\ PV + 0.986 \tag{4}$$

Then PV is the proportion of vegetation determined by the equation:

$$PV = ((NDVI - NDVImin) / (NDVImax - NDVImin))^2 \tag{5}$$

Where NDVI = Normalized vegetation difference index, NDVImin = minimum NDVI value, NDVImax = maximum NDVI value.

Land surface temperature is obtained from the calculation of temperature brightness (TB) which is corrected according to the emissivity values of different vegetation cover density classes. Calculation of ground surface temperature using the equation:

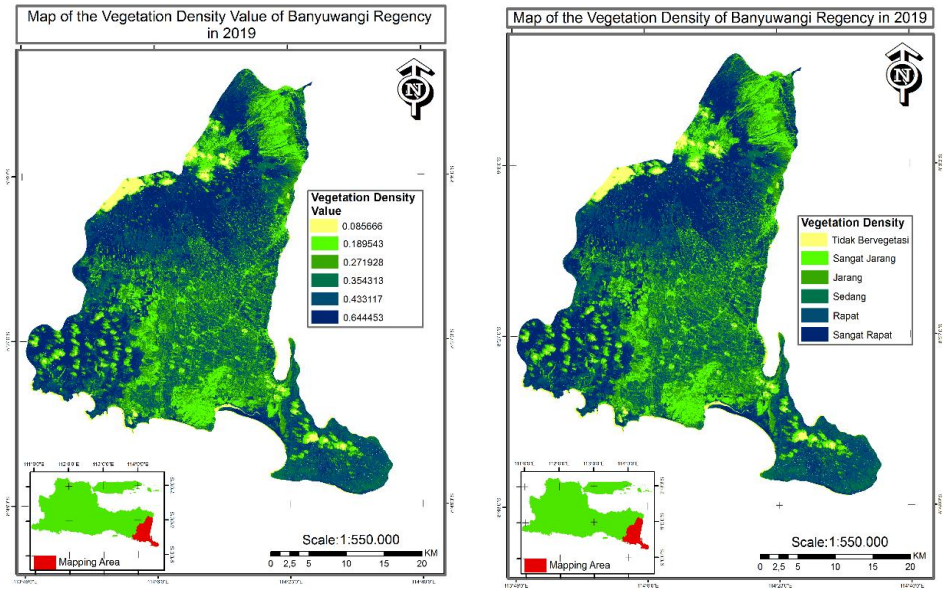
$$LST = \frac{TB}{(1+\left(\frac{TB}{C2}\right) x\ Ln\ (E))} \tag{6}$$

Where TB = Temperature Brightness = Central Wavelength Emitted Radiance (B10 = 10,8 and B11 = 12), and C2 = h x c/s (1,438 x -2 m K)

3. Result and Discussion

3.1 Vegetation Index Normalized Dryness Vegetation Index (NDVI)

The NDVI vegetation index has been proven to help in the extraction of vegetation information because in the process it will highlight aspects of vegetation density [5]. The results of the author's processing that has been carried out by the author of the distribution of vegetation density values using NDVI are produced in the range of 0.085666 to 0.644453



(Figure 4a).

(a) (b)

Fig 4. (a) NDVI Range Value and (b) Vegetation Density Map of Banyuwangi Regency in 2019

NDVI index value close to 1 can be concluded if the area is forest cover. The higher the NDVI vegetation index value, the higher the density and vice versa. This is very possible because the NDVI index focuses on the spectral results received by the image sensor on the canopy of vegetation, so the higher the canopy density, the greater the digital value (Faizal & Amran 2005). Furthermore, from the NDVI index, the authors conducted welding into 6 classes of vegetation density (Figure 4b) and (Table 1).

Table 1. NDVI Index Value

NDVI Index Value	Density Class	Square Area (km^2)	Percentage (%)
0.085666	Non-Vegetation	111,72	2,96
0.189543	Very rarely	484,66	12,88
0.271928	Rarely	633,28	16,8
0.354313	Currently	719,62	19,12
0.433117	Tightly	931,32	24,75
0.644453	Very Tightly	881,73	23,45

Source: Data Processing, 2022

The processed image with the NDVI index presented on the map can be seen that the vegetation density class is divided into 6 classes, namely the non-vegetated class, very rare, rare, medium, dense, and very dense. The reason the author classifies into 6 classes of vegetation density is for further analysis in the form of correlation analysis and linear regression between the NDVI value and the land surface temperature value which is grouped into 6 classes.

The area of vegetation density in Banyuwangi Regency is dominated by vegetation density with dense classes, where with this dense class the area is 931.32 km2 or 24.75% and the least area is the area that is not vegetated, namely 111.72 km2 or 2.96 % of the total area of vegetation density in Banyuwangi Regency, which is 3762.3 km2 based on the data processed by the author. Furthermore, very rare area is 484.66 km2 or 12.88%, rare area is 633.28 km2 or 16.8%, medium area is 719.62 km2 or 19.12%, very dense area is 881.73 km2 or 23.45%.

3.2 Land Surface Temperature (LST)

The result of processing land surface temperature in Banyuwangi Regency from the extraction of Landsat 8 satellite imagery, the highest temperature is 43.450C and the lowest temperature is 6.170C with the distribution shown in (Figure 5). Furthermore, the authors classify the land surface temperature into 6 classes (table 2), which are adjusted to the vegetation density class to facilitate the process of correlation analysis and regression analysis.

The widest area from the results of the author's processing and analysis is in the temperature range of 250C - 300C with an area of 1674.81 km2 or 43.37% of the total temperature area and for the lowest area it is in the temperature range of 100C - 15 0C with an area of 52.25 km2. or 1.48% of the total area. Furthermore, for temperature prone to 150C – 200C with an area of 96.69 km2 or 2.73%, vulnerable temperature 200C - 250C with an area of 1262.27 km2 or 35.7%, temperature range 300C - 350C with an area of 393.81 km2 or 11.14%, and 35-40 < 0C with an area of 82.662 km2 or 2.34%.

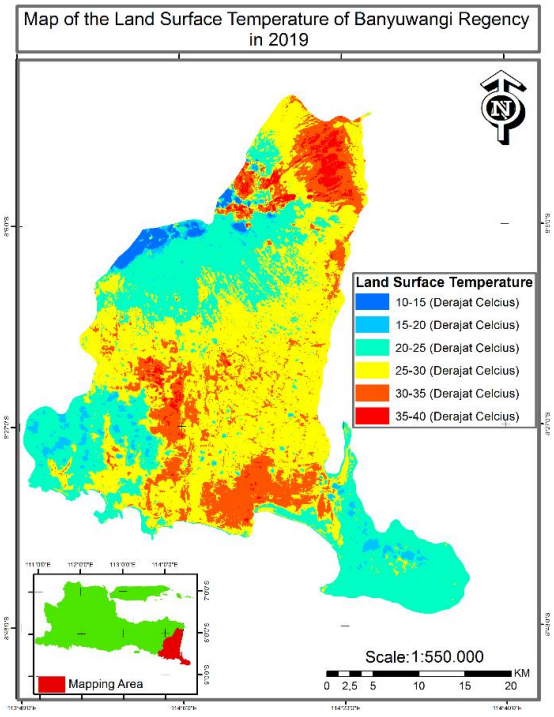


Fig 5. Map of Land Surface Temperature in Banyuwangi Regency in 2019

Table 2. Land Surface Temperature

LST Range Value	Square (km^2)	Percentage (%)
10 – 15 ^{0}C	52,25	1,48
15 – 20 ^{0}C	96,69	2,73
20 – 25 ^{0}C	1262,27	35,7
25 – 30 ^{0}C	1674,81	43,37
30 – 35 ^{0}C	393,81	11,14
35 – 40< ^{0}C	82,662	2,34

Source: Data Processing, 2022

3.3 Correlation and Regression Analysis of Vegetation Density With Land Surface Temperature

Correlation and regression analysis was conducted to determine the relationship between land surface temperature and vegetation density (NDVI vegetation index) from the processed data. The results of the correlation analysis between the land surface temperature value and the NDVI value are presented in Figure 6 and the results of the regression analysis are shown in Figure 7.

	Vegetation Index	*LST*
Vegetation Index	1	
LST	0.989637	1

Fig 6. Correlation Vegetation Index and LST

Seen from the results of the correlation processed by excel between the density index (NDVI) and soil surface temperature of 0.989637, it can be analyzed whether the vegetation density and land surface temperature in Banyuwangi Regency have a significant inverse relationship. Furthermore, from the linear regression graph generated between the NDVI Index and the land surface temperature, it gets R2 = 0.9794 so it can be concluded that the relationship between the two is significant as well. It can also be seen that the lower the ground surface temperature, the higher and wider the area of vegetation density and the higher the land surface temperature, the lower and less vegetation density area. This phenomenon indicates the importance of vegetation cover as one of the factors that can reduce land surface temperature. The smaller the NDVI index value or vegetation density, the higher the temperature.

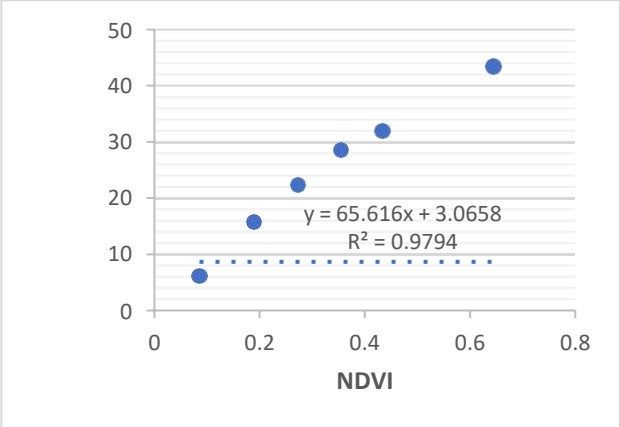


Fig 7. Linear Regression Graph of Land Surface Temperature with NDVI

4. Conclusion

The vegetation density in Banyuwangi Regency is in the range of 0.085666 to 0.644453, thus indicating that the area is covered in vegetation. The higher the vegetation index from the NDVI, the higher the vegetation density and vice versa. The land surface temperature in Banyuwangi Regency is in the range of 6.170C to 43.450C. The correlation between land surface temperature and NDVI is 0.989637. This shows that the value of surface temperature and vegetation density in Banyuwangi Regency has a significant inverse relationship, where low temperatures can be found in areas with high density and large area and high temperatures are found in areas with low density and small area. This phenomenon indicates the importance of vegetation cover as one of the factors that can reduce land surface temperature.

5. References

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