Spatial Mapping of Drought Areas in Banyuwangi Regency Using Landsat 8 Satellite Imagery Case Study 2023

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Abstract. Drought is a natural disaster that often occurs in tropical regions, especially in Indonesia, so it is very important to map it as a reference for disaster mitigation. The purpose of this study is to spatially analyse the drought that occurred in Banyuwangi Regency in 2023. The results of vegetation index and surface temperature of Landsat 8 Oli/Tirs imagery are used as a reference for analysis in mapping the distribution of drought-prone areas. The area or population of this study is the entire area of Banyuwangi Regency. The results of the drought-prone areas are classified into 3 classes, namely the humid drought class with an area of 1480386.6 hectares (ha), the moderate drought class with an area of 162374.9 ha, and the high drought class with an area of 65838.6 ha. The results of the mapping of high drought-prone areas are located in Wongsorejo district because it is dominated by dry grasslands and minimal rainfall.

Keywords: Drought, LST, Landsat 8 Oli.

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1. Introduction

Drought is a type of disaster that occurs frequently in almost all parts of Indonesia. Drought itself is caused by the hydrological conditions of an area where there is an imbalance between water demand and water availability. The availability of water in an area decreases over a long period of time due to reduced rainfall intensity. Drought is generally defined as an area with reduced water availability over a prolonged period due to reduced rainfall intensity [1]. The intensity and extent of drought varies from year to year [2].

The dry season in Indonesia is getting longer and earlier every year, due to the increasing phenomenon of global warming and the effects of the El Nino phenomenon. These conditions and symptoms affect the duration and extent of the area affected by drought [3]. The effects of drought include reduced water availability, reduced food production and land/forest fires. It will therefore be very important to monitor and predict the occurrence of drought in order to minimise its effects [4].

A widely used method is Land Surface Temperature (LST). This method is widely used because it is considered to be more efficient and simpler than direct measurements at ground level [5]. In research conducted by [6], LST using the SWA-S model with vegetation extraction and water vapour index gave significantly different results due to the emissivity value. Under these conditions, different emissivity values are more evenly distributed or more methods are used with land surface temperature results that can be compared from different topographies of the research site, so that more accurate results can be obtained in the future. This research requires remote sensing imagery as a data provider, and the image data used in this research is Landsat 8 OLI/TIRS Image.

The location of this research is Banyuwangi Regency. Banyuwangi was chosen because it is one of the regencies in Indonesia with a drought emergency in 2023 [7]. In addition, Banyuwangi Regency was chosen because rainfall data is easily available so that it is very supportive of this research to validate the results of drought identification.

This research will specialise in the extraction of land surface temperature values as a reference to obtain information on the extent and distribution of drought-prone areas in Banyuwangi Regency by utilising Landsat 8 OLI/TIRS satellite imagery.

2 Method

2.1 Study Area

Banyuwangi is one of the regencies at the eastern end of the island of Java. The regency is located at 7º 43' - 8º 46' N and 113º 53' - 114º 38' E, in the province of East Java (Figure 1). The district is bordered by the Bali Strait to the east, Situbondo regency to the north, the Indian Ocean to the south, and Jember and Bondowoso regency to the west. Banyuwangi's topography varies considerably, with the western and northern regions being mountainous and the southern part dominated by lowlands. These differences affect the region's location and land cover characteristics, which in turn affect soil moisture.

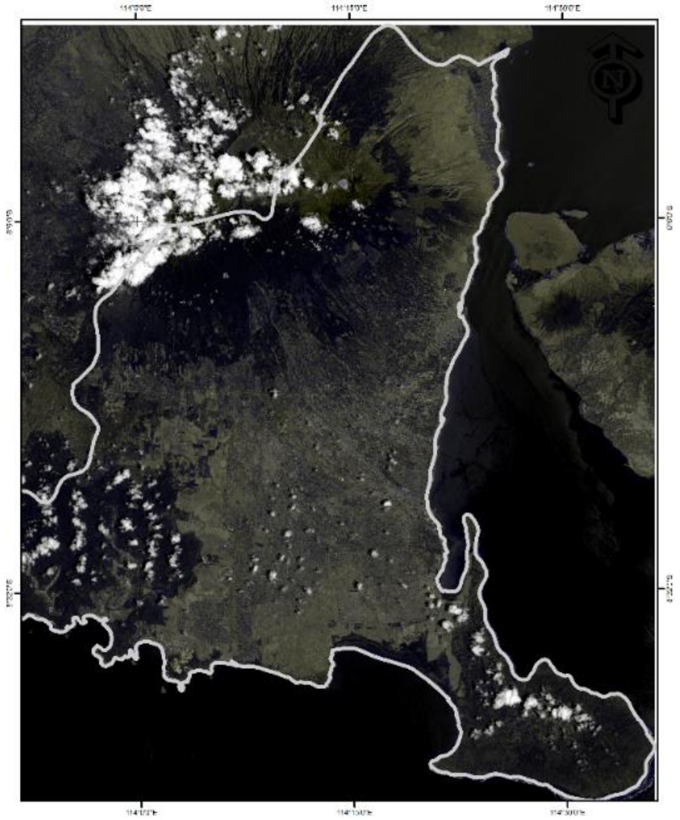

Figure 1. Research location

Figure 2 shows the research flowchart, which shows the steps taken to support the research process to be carried out, so that the research can be more structured and systematic.

Figure 2. Research Flowchart

2.2 Normalized Dryness Vegetation Index (NDVI)

Vegetation density class is obtained from the Vegetation Index (NDVI). Extraction of the vegetation index is obtained from the relationship between chlorophyll content in leaves with wavelengths recorded in the red and near infrared channels, or energy received by remote sensing image sensors from the reflection of vegetation objects. Plants have special characteristics when receiving and emitting electromagnetic waves compared to other objects on the Earth's surface. In the process, Landsat 8 OLI imagery is pre-processed, namely radiometric and atmospheric correction, because the downloaded data is Collection 2 Level 1 data. NDVI is calculated from reflectance measurements in the red and near infrared bands using the following formula:

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

Description: NDVI = NDVI value, ρnir = Near infrared band reflectance, ρred = Red band reflectance.

2.3 *Land Surface Temperature* (LST)

Land surface temperature was obtained through extraction of Landsat 8 OLI satellite imagery downloaded from the official USGS website [8]. The determination of the value (LST) was obtained using the radiative transfer equation.

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

Lλ denotes the TOA spectral radiation value, ML is the temperature and rescaling factor, Qcal is the thermal energy, and AL is the constant value in the thermal channel. The result of the equation and explanation above is the radian value.

The previously obtained radiant value is converted into the Brightness Temperature (BT) value [9]. The conversion of spectral irradiance values refers to equation 3.

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

T is the Brightness Temperature (BT) value in Kelvin units, K2 (channel 11) / K1 (channel 10) as a constant, calibration is obtained from metadata, Lλ is the spectral irradiance value using Equation 1, - 273.15 is the process of converting temperature values from Kelvin to Celsius units. The K1 and K2 values are obtained from Landsat 8 OLI image metadata.

Emissivity values are also needed to obtain LST values, where emissivity is the ability of objects at the Earth's surface to emit radiation compared to dark objects at the same temperature. Emissivity values vary greatly depending on the type, intensity and shape of the object (Beg 2018). The emissivity value is obtained from the NDVI value using the equation:

$$e = 0.004\ \text{PV} + 0.986 \qquad (4)$$

then the proportion of vegetation (PV) is determined by the equation:

$$PV = ((NDVI - NDVImin) / (NDVImax - NDVImin))2 \qquad (5)$$

Land surface temperature (LST) is obtained by calculating the brightness temperature divided by the emissivity value of different vegetation cover density classes. The LST value is obtained using the following equation:

$$LST = \frac{BT}{(1 + \left(\frac{\lambda BT}{c2}\right) x Ln(E))} \qquad (6)$$

BT= *Brightnes Temperature* dalam ℃, λ = *Central Wavelenght Emited Radiance* (B10 = 10,8 dan B11 = 12), dan C2 = h x c/s (1.438 x -2 m K)

3. Results and Discussion

3.1 Normalized Difference Vegetation Index (NDVI)

NDVI has proven to be effective in extracting vegetation information, as it highlights the aspect of vegetation density [10]. The author's analysis of vegetation density distribution using NDVI produced values ranging from -0.618371 to 0.838208, as shown in Figure 3.

NDVI values close to 1 indicate forested areas, with higher NDVI values corresponding to greater vegetation density, and lower values indicating less dense areas. This is because the NDVI index captures the spectral information received by the image sensor from the vegetation canopy, meaning that the denser the canopy, the higher the digital value [11]. Based on the NDVI index, the author categorized the data into six classes of vegetation density (Figure 3 and Table 1).

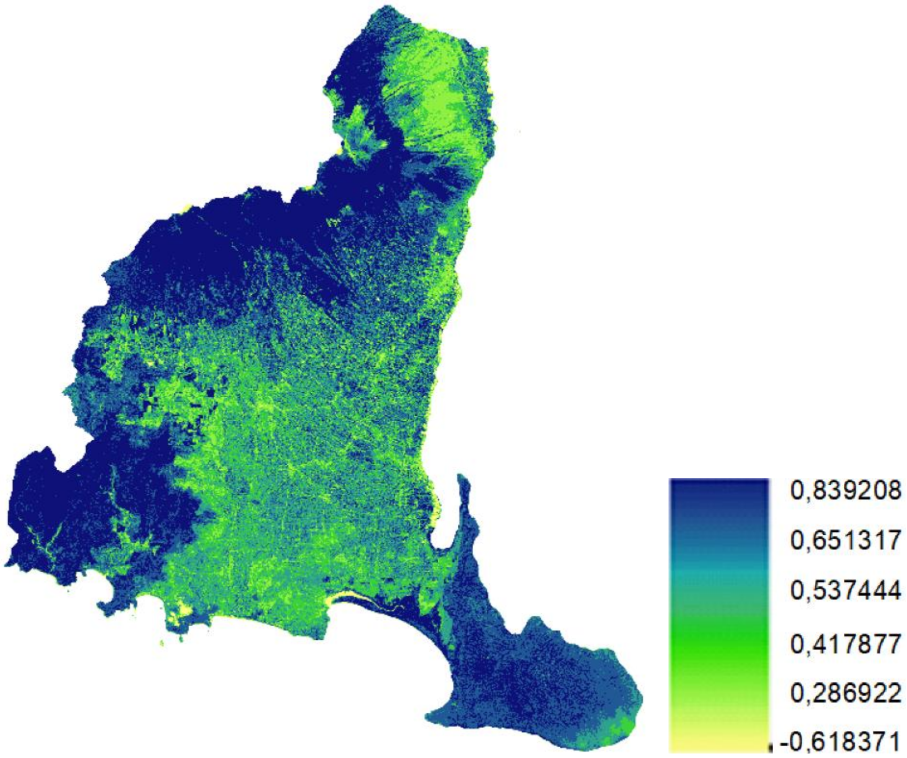

Figure 3. Distribution of NDVI values in Banyuwangi Regency in 2023

The Vegetation Index (NDVI) in Figure 3, shows that the vegetation density class is grouped into 6 classes, including the classes of no vegetation, very sparse, sparse, medium, dense, and very dense. The area of vegetation density in Banyuwangi Regency is dominated by very dense class vegetation density with an area of 114493.2 hectares (Ha) or 31.8% and the least area is the area of non-vegetated area which is 2536.8 Ha or 0.7% of the total area of vegetation density of Banyuwangi Regency which is 360574.1 Ha based on the author's processed data. Furthermore, the area of very sparse area is 27954.5 Ha or 7.8%, the area of sparse area is 55978.6 Ha or 15.5%, the area of moderate area is 71169.5 Ha or 19.7%.

Table 1. Vegetation Index Value (NDVI)

Value NDVI	Density Class	An Area (Ha)	Presentation (%)
-0,618371	Non-vegetated	2536,8	0,7
0,286922	Very rarely	27954,5	7,8
0,417877	Rarely	55978,6	15,5
0,537444	Moderate	71169,5	19,7
0,651317	Tight	88441,5	24,5
0,839208	Very tight	114493,2	31,8

Source: [8]

3.2 Land Surface Temperature (LST)

Land surface temperature (LST) of Banyuwangi Regency from the extraction of Landsat 8 OLI satellite imagery, obtained the highest temperature of 46.4 0C and the lowest temperature of 10.06 0C with the distribution shown in (Figure 4).

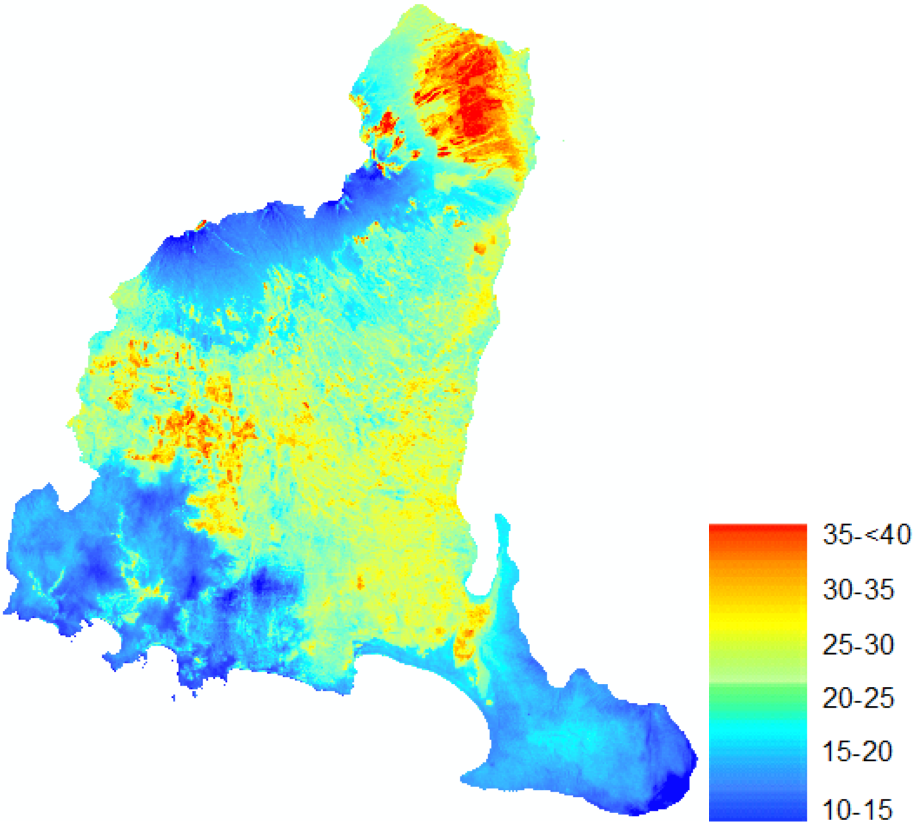

Figure 4. Land Surface Temperature (LST) Banyuwangi Regency 2023

Table 2. LST

Range of LST Values	An Area (Ha)	Presentation (%)
10 – 15 ^{0}C	43228,9	11,48
15 – 20 ^{0}C	94986,2	25,24
20 – 25 ^{0}C	88558,5	23,53
25 – 30 ^{0}C	89333,6	23,74
30 – 35 ^{0}C	44385,6	11,79
35 – 40< ^{0}C	15752	4,18

Source: [8]

Based on table 2, the largest area is found in the temperature range of 15-200 with an area of 94986.2 Hectares (Ha) or 25.24% of the total and for the area with the lowest temperature is in the temperature range of 35 - <40 ^{0}C with an area of 15752 Ha or 4.1% of the total area. Next in sequence is from the temperature range of 25 - 30 ^{0}C with an area of 89333.6 Ha or 23.74%, temperature range of 20 - 25 ^{0}C with an area of 88558.5 Ha or 23.53%, temperature range of 30 - 35 ^{0}C with an area of 44385.6 Ha or 11.79%, and 10-15^{0}C with an area of 43228.9 Ha or 11.49%.

3.2 Mapping Drought Prone Areas

Spatial analysis was used to produce a map of drought-prone areas. The mapping of drought-prone areas is obtained from Land Surface Temperature (LST) analysis. The mapping of drought-prone areas is divided into 3 categories: wet areas, moderately drought-prone areas and highly drought-prone areas. The following are the results of the mapping of drought-prone areas generated from the LST analysis (Figure 5).

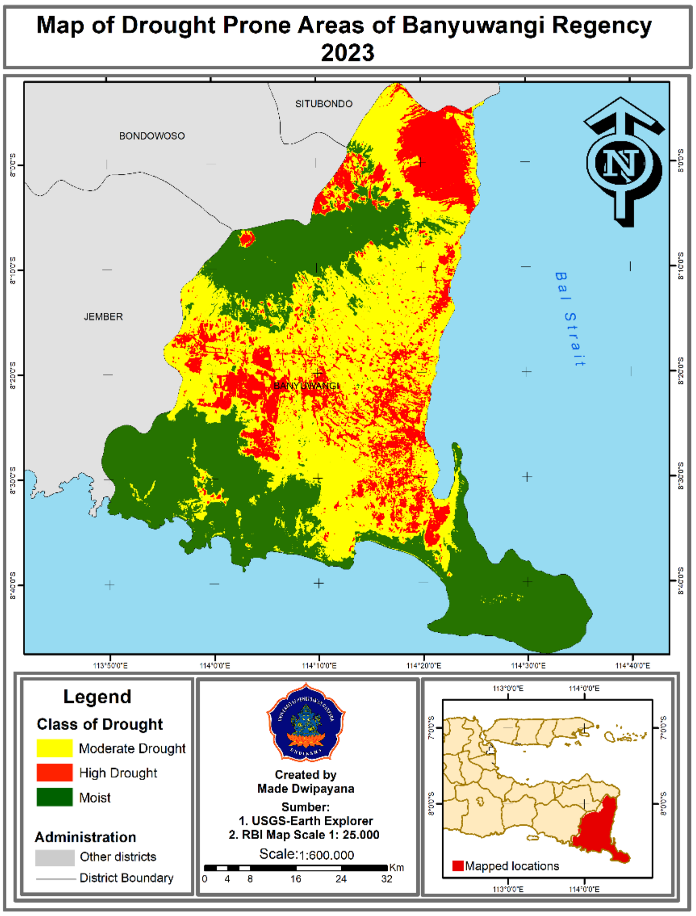

Figure 5. Map of Drought Prone Areas of Banyuwangi Regency in 2023

Table 3. Drought Prone Areas

Drought Prone Class	An Area(Ha)	Presentation (%)
Moist	148036,6	39,34
Moderate Drought	162374,9	43,15
High Drought	65838,6	17,5

Source: [8]

Table 3 shows the area of each drought zone. Moderate drought zones have the largest area of 162374.9 hectares (ha) or 43.16%, followed by humid zones with an area of 148036.6 ha or 39.34% and high drought zones with the smallest area of 65838.6 ha or 17.5%.

4. Conclusion

The vegetation index value of Banyuwangi Regency is between the range of -0.618371 to 0.839208, from the vegetation index value it can be known if the area is a vegetation cover with varying density. High NDVI vegetation index values indicate high vegetation density and low vegetation index values indicate low vegetation density. The LST values were obtained in the range of 10.060C to 46.40C. The results of mapping the drought-prone areas of Banyuwangi Regency in 2023 resulted in 3 classes. Areas with humid categories have an area of 148036.6 Ha, areas with moderate drought categories 162374.9 Ha are the highest area and areas with high drought categories have an area of 65838.6 Ha and are the areas with the lowest area. This condition shows that the drought area in the Regency is quite high, this is seen because the moderate to high drought areas have a very high area that exceeds 50%. So that it can be used as a reference to urge people in Banyuwangi Regency to always be alert to the danger of drought which is quite high.

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