Analysis of Drought in Jember Regency Based on Remote Sensing and Geography Information System

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Abstract. In 2019 the drought that occurred in the Jember Regency area was recorded as many as 39 times spread across 13 regions. The objective of this study is to produce a map of the potential for drought in the Jember Regency area using GIS (weight and score for parameter) and remote sensing techniques. This study used Landsat 8 imagery overlayed to obtain five parameters: rainfall, vegetation index, wetness index and brightness index, and soil texture. The validate of drought parameters that effect by taking multiple samples in the field. The final result for map of drought potential has three classes of drought potential. Low drought potential class with a region area of 45,923 ha, moderate drought potential class with an area of 201,109 ha, and high drought potential class with an area of 59,288 ha.

Keywords: Drought**,** GIS, Landsat

1 Introduction

Drought is a disaster that affects life and can threaten and disrupt human survival in the region [1]. The drought phenomenon is caused by the lack of groundwater supplies in one region due to the change from rainy to dry seasons [2]. This change in seasons results in a prolonged drought, and this condition will be more severe if an area naturally has a lower water availability rate [3]. These changes are characterized by extreme weather, rain patterns, changes in the growing season, increased temperatures, and sea levels. In Indonesia, the change from rainy to dry season can cause drought in several regions.

The delay in the rainy season in Indonesia in 2019 has caused parts of the region to experience a long drought. Maarif [4] revealed drought in Indonesia, mainly occurred on the island of Java-Madura because the island has serious danger and vulnerability compared to other islands. Jember Regency is one of the areas in East Java Province, has a land area of 3,293.34 Km2 consisting of thirty-one sub-districts and 248 villages/villages. The people of Jember Regency are mostly livelihoods as farmers. The evidenced by Jember Regency's agriculture area, which reaches 86.098.0 hectares and became the regency with the second-largest agricultural land area in East Java Province after Lamongan Regency [5]. The drought caused

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farmers in Jember Regency to experience crop failure. Concerning that, the drought that occurred in Jember Regency can disrupt the production of foodstuffs because Jember Regency is one of the leading suppliers of foodstuffs in East Java. In addition, the transfer of land functions on agricultural land affected by drought occurs into settlements and industries. Concerning that, areas of potential drought need to be predicted to reduce losses in areas. Drought impacts the agricultural and environmental sectors and the negative impact on the socio-economic sector that can disrupt political stability [6]. That shows the drought that occurred in Jember Regency has an impact on the agricultural and environmental sectors and causes the transfer of land functions such as rice fields and hills that switch functions into residential areas. So far, land drought distribution information in Jember Regency is only mapped after the drought occurs, based on drought disaster data. This needs to be done not only to identify the characteristics of drought, but also in order to map the spread of drought levels that occur in the Jember Regency area. Identification and mapping will be able to provide information to the community and government in anticipating and preparing for drought disasters in Jember Regency. This condition is interesting to be researched through the implementation of Remote Sensing and Geographic Information Systems, a technique in mapping science that can provide information related to phenomena that occur on earth [7], [8].

Attention to paying the impact of drought on life, it is essential to analyze the drought parameters in the Jember Regency area to determine the drought characteristics so that mapping can be done to the level of land drought in the Jember Regency area. Paying attention to several existing drought parameters, in this study, the parameters used to identify droughts that occurred in the Jember Regency area consisted of (1) rainfall, (2) vegetation index, (3) wetness index, (4) brightness index, and (5) soil texture.

2 Study Area and Data

2.1 Study Area

Astronomically Jember Regency is located at the position of 113º15'47" - 114º02'35" East Longitude and between 7º58'06" s/d 8º33'44" south latitude [5]. Administratively Jember Regency borders Bondowoso Regency and Probolinggo Regency to the North, Banyuwangi Regency to the east, the Indian Ocean to the south, and Lumajang Regency to the west. The topographic character of parts of Jember Regency in the southern part is a relatively fertile lowland for the development of food crops, while in the north, it is a hilly and mountainous area that is relatively good for the development of perennials and plantation crops. The division of the sub-districts of the Jember Regency is listed on the Jember Regency Administration Map in Figure 1.

2.2 Remote Sensing Data

This study uses primary data, which is superior data, namely Landsat 8 OLI/TIRS image. The data used is soil texture data, rainfall data in 2019, and lansat 8 OLI/TIRS image recorded in October 2019. Landsat 8 OLI/TIRS images can be obtained for free on the official website of USGS http://usgs.gov/. Landsat image 8 OLI/TIRS processed by pre-processing such as; radiometric correction, geometric correction, atmospheric correction, then cropping an image. The process of correcting Landsat 8 OLI/TIRS using bands 2 - 7. Radiometric correction is done

by converting pixel values into radians and reflectance values. Meanwhile, the atmospheric correction process uses the Dark Pixel Subtraction (DOS) method [9].

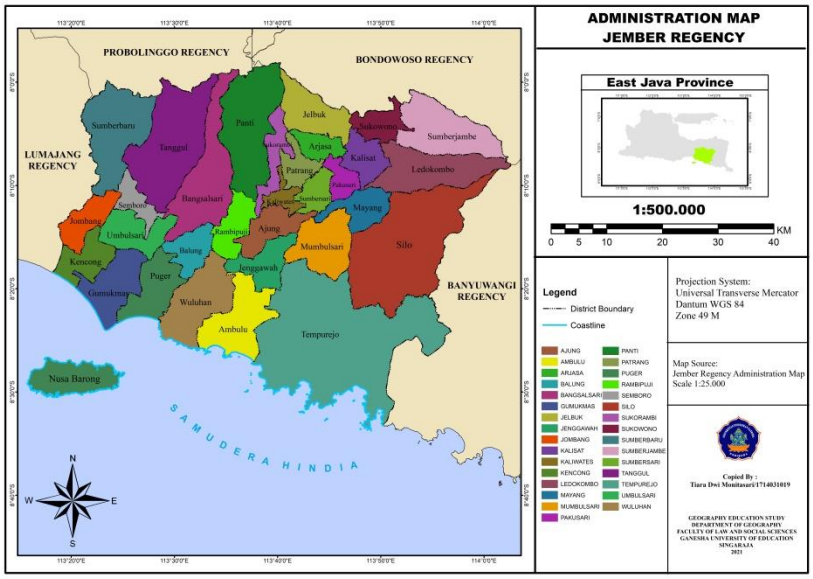


Fig. 1. Administration Map Jember Regency

3 Method

The research data that has been obtained is then processed using the NDVI and TCT methods. Normalize Difference Vegetation Index (NDVI) is used to find vegetation index values from image processing. Then the results are classified into 3 classes: low, medium, and high based on the Decree of the Ministry of Environment and Forestry of the Republic of Indonesia Number: P.12 / Menhut-II / 2012 [10]. NDVI (Normalized Difference Vegetation Index) Landsat 8 OLI/TIRS shown in equation (1).

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad \text{.....(1)}$$

NDVI values range from -1 to 1 where the closer to the number 1 greenish index, the higher and vice versa, the lower the number -1 greenish index [11].

Surface moisture can be interpreted using Tasseled Cap transformations that produce brightness and wetness indices [12]. Brightness and wetness values are used to analyze drought levels. Tasselled Cap transformation formula to produce the Brightness Index and Wetness Index shown in equation (2) and equation (3).

Brightness Index = (0.3561*b1)+(0.3972*b2)+(0.3904*b3)+(0.6966*b4)+(0.2286*b5)+ (0.1596*b7) ..... (2)

Wetness Index = (0.2626*b1)+(0.2141*b2)+(0.09266*b3)+(0.0656*b4)-(0.7629*b5)- (0.5388*b7) ..... (3)

Soil texture is obtained from the processing of Landsat 8 by doing the raster calculator process, which can then be produced a map of soil texture. While rainfall conditions in Jember Regency based on results obtained from https://dataonline.bmkg.go.id/ showed the average rainfall in 2019 ranged from 1000-2500 mm / year. From the data then made a rain map using interpolation methods with the help of tools IDW.

The process of processing data with the NDVI method produces a vegetation index, data processing with the Tasseled Cap transformation method will produce a wetness and brightness index. After processing Landsat imagery and obtaining the five drought indices, the weighting and scoring methods are used to analyze drought. The research flow can be seen in figure 2.

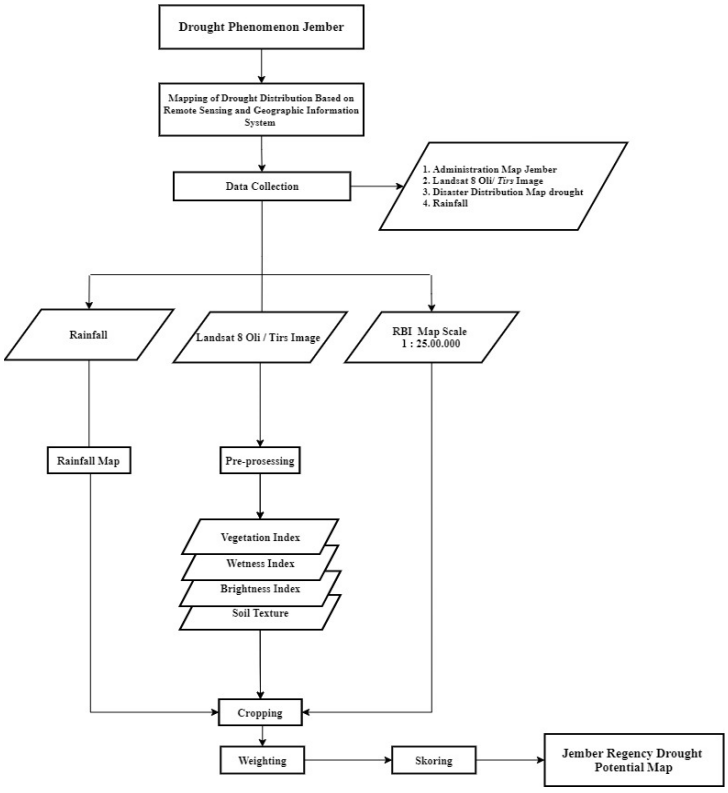


Fig. 2. Research Flowchart

Weighting and scoring are used to analyze potentially drought-stricken areas in Jember County. Variables that have been obtained will be discovered based on each class. The highest grade level will be given a grade of 5, and the lowest class level will be assigned a grade of 1. The classification of drought parameter scores can be seen in Table 1.

Table 1. Drought Index parameters Value

No.	Criteria	Sub-Criteria / Class	Classification	Score
1.	**Rainfall**	< 1500 (mm/tahun)	Low	4
		1500 – 2000 (mm/tahun)	Medium	3

No.	Criteria	Sub-Criteria / Class	Classification	Score
		2001 – 2500 (mm/tahun)	High	2
2.	**Vegetation Index**	-1 - -0.03	Non Vegetation	1
		-0.03 – 0.15	Very Low Vegetation	2
		0.15 – 0.25	Low Vegetation	3
		0.26 – 0.35	High	4
		0.35 – 1	Very High	5
3.	**Wetness Index**	Nilai Terkecil - -30	Very Drought	1
		-30 - -13	Drought	2
		-13 - 10	Medium Drought	3
		10 – 35	Wet	4
		35 – Nilai Terbesar	Wetness	5
4.	**Bgrihtness Index**	15.109 – 19.500	Very Low	1
		19.500 – 24.000	Low	2
		24. 000 – 28.500	Medium	3
		28.500 – 33.000	High	4
		33.000 – 103.697	Very High	5
5.	**Soil Texture**	Dusty Clay	Very Smooth	1
		Berliat Clay	smooth	2
		Clay, Sandy Clay	Medium	3
		Sandy Clay	Raough	4
		Clay Sand	Very Rough	5

Source: [12], [13]

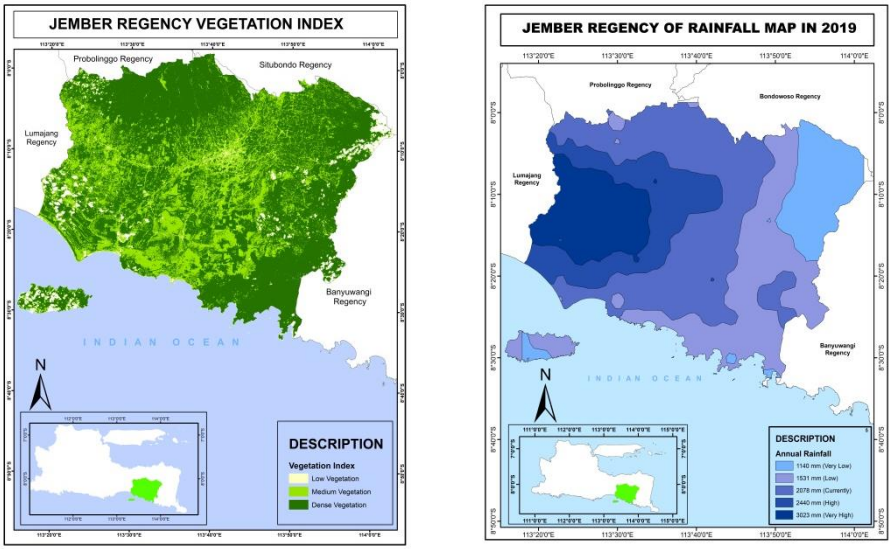
This potential drought research integrates between Remote Sensing techniques and Geographic Information Systems. Remote Sensing is used to interpreting the NDVI, Brightness Index and Wetness Index. While geographic information systems are used to combine, block and sabotage the parameters used.

4 Result and Discussion

The NDVI transformation process has a spectral value between -0.2608 to 0.5959. From these values, it can be known that the higher the value of NDVI, the higher the density of vegetation. According to spectral value, the vegetation class mentioned to Regulation of the Minister of Forestry of the Republic of Indonesia Number: P.12 / Menhut-Ii / 2012 [10]. Based on the processing of vegetation index, Figure 2a shows that the Jember Regency area is dominated by moderate levels of vegetation that are in the western, central, and southern regions because it is a lowland area. The level of high vegetation is in the Eastern region and partly in the northern part of Jember Regency. The area is a highland area that borders other districts. In comparison, the low-density level is in the central part, dominated by the city area.

Rainfall conditions in Jember Regency based on the results of an analysis of data obtained from https://dataonline.bmkg.go.id/ showed the average value of rainfall in 2019 was 1000 - 2500 mm / year. From the data then created a map of rainfall using interpolation methods using IDW tools. The results of making a rainfall map of Jember Regency can be seen in Figure

2b. From the results of the rainfall map, it can be known that the level of rainfall in the Jember Regency varies greatly. High rainfall levels are in the western region, the central region combined with moderate to low rainfall levels, and increasingly heading eastwards shows deficient rainfall levels.

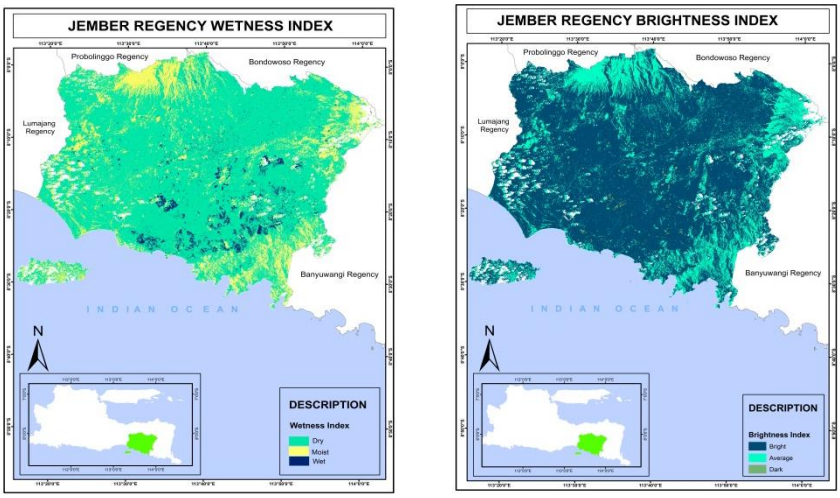


(a) (b)

Fig. 3. Result of (a) Vegetation Index Map and (b) Rainfall Map

The transformation of tasselled cap transformation processing results or TCT is the acquisition of wetness index and brightness index. In the Wetness Index, the spectral value obtained starts from 464.06 to 60.99. The spectral value is stated in the Regulation of the Minister of Forestry of the Republic of Indonesia Number: P.12 / Menhut -Ii / [10] to further analysis. The wetness index is used to assess or interpret the brightness level of an object. So it can be assumed that the lower the spectral value of the Brightness Index result, the darker the object will be. Conversely, if the spectral value produced by the Brightness Index of an object is higher then the object will be brighter (dry) [12], [14]. Figure 3a shows that the dominating classification is a dry classification that spreads throughout almost all areas of Jember County. While the classification of medium / humid is in the periphery, which is a highland area. As for the wet classification is very little and spreads at various points.

The transformation of the results of the TCT process also produces a Brightness Index with spectral values ranging from 14510 to 39525. Brightness Index processing results are divided into classes to simplify values to produce homogeneous regions [15]. The assumption used in this study is that the higher the brightness value of an object in the image and the dry object, the lower the object's brightness in the image and the object is water [12]. Figure 3b shows that the dominating classification is a sunny classification that spreads throughout almost all areas of the Jember Regency. There is a suburb of Jember Regency for the current classification whose dominated by highland and forest areas. As for the dark classification is at some point in the Jember Regency area.



(a) (b)

Fig. 4. Result of (a) Wetness Index Map and (b) Brightness Index Map

The texture transformation of the soil is obtained from the process of extraction of Landsat 8 OLI/TIRS images using bands 5 and 6. It was then identified using a raster calculator, resulting in classifying soil textures divided into five classes. In Figure.4 it can be seen that the classification of soil textures in Jember Regency varies greatly.

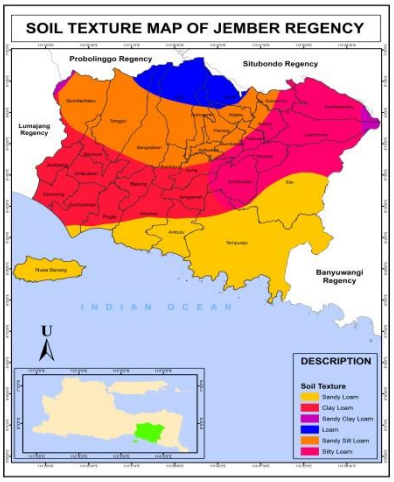


Fig. 5. Result of Soil Texture Map

After overlaying and weighting of rainfall parameters, vegetation index, wetness index, brightness index, and soil texture then obtained areas that have the potential for the drought that occur into three classes of drought potential in Jember Regency (Table 2). Areas experiencing low drought include Jombang, Kalisat, Ledokombo, Sukowono, and Sumber Baru. For the classification of drought levels are in the subdistrict of Ajung, Ambulu, Arjasa, Balung, Bangsalsari, Gumuk Mas, Jenggawah, Kencong Mayang, Mumbulsari, Pakusari, Panti, Rambipuji, Semboro, Sumbersari, Tanggul, Umbulsari, and Wuluhan. The classification of high

drought is found in the sub-districts of Jelbuk, Kaliwates, Patrang, Silo, Sukorambi, and Sumberjambe. The area that is the classification of drought in Jember Regency can be seen in Figure 5.

Table 2. Classification of Drought

Drought Classification	Count (ha)
Low	45,923
Medium	201,109
High	59,288

Source: Data Processing, 2021

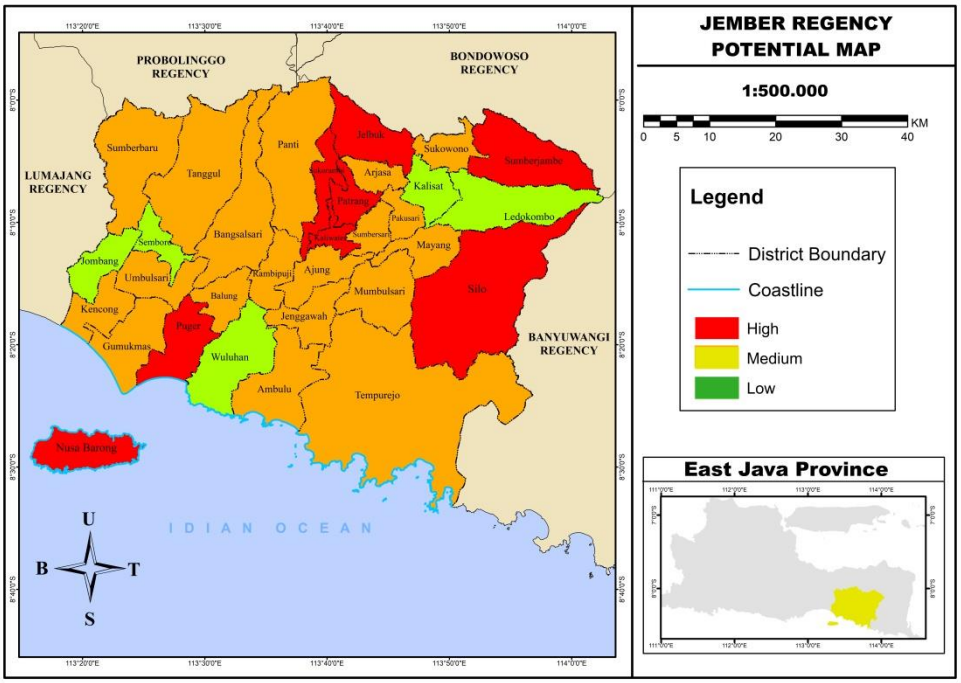


Fig. 6. Map of Drought Jember Regency

Based on the analysis conducted, the drought that occurred in the Jember Regency area was dominated by rice fields, settlements, and fields. In addition, the geomorphological influence in the Jember region will strengthen the impact of drought events supported by the conditions of the spread of vegetation in the rainy season [16]–[18]. Accordingly, the results obtained in connection with the conditions of drought through the overlay process differ from the analysis that was made at the land surface temperature through remote sensing imaging data [19], [20].

5 Conclusion

Drought potential in a region can be analyzed using several parameters, including rainfall and vegetation index obtained using the NDVI method, brightness and numbness index processed using the TCT method, and soil texture obtained from the Landsat image extraction process. From the processing results, the most significant drought potential is in the moderate drought class with an area of 201,109 ha, with a percentage reaching 50.20% of the total area of Brebes. The use of land that dominates in the potential area of drought is rice fields, settlements, and fields.

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