

PAPER • OPEN ACCESS

The Spread Of Dry Area Based On TVDI Index (*Temperature Vegetation Dryness Index*)

To cite this article: A Aisyah *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **311** 012006

View the [article online](#) for updates and enhancements.

The Spread Of Dry Area Based On TVDI Index (*Temperature Vegetation Dryness Index*)

A Aisyah, E Kusratmoko, A Wibowo

Dept of Geography, Universitas Indonesia, Jl. Margonda Raya, Depok 16424, Indonesia

E-mail: amalia.aisyah@ui.ac.id

Abstract. This research explains the use of Remote Sensing to know which areas are dry that are connected by the morphological characteristics in the Sukaresmi district. The purpose of this research is to see the spread of the dry areas in Sukaresmi district which are vulnerable towards drought when the dry season comes using the Remote Sensing application. The Landsat image 8 OLI was used throughout July-September 2013 and between June-August 2017. One of the methods that used in Remote Sensing is triangulation. This method is known as TVDI (Temperature Vegetation Dryness Index) which consists of NDVI (Normalized Difference Vegetation Index), LST (Land Surface Temperature) with the algorithm formula of $(LST - LST_{min}) / (a + b * NDVI - LST_{min})$ that used in determining the dry areas in Sukaresmi district. The relation between the spatial pattern of the dry areas and the morphological characteristics of an area analyzed statistically. This research concludes that the spatial pattern of the dry areas in Sukaresmi district based on the TVDI method reached the highest rate of drought in September 2013 with 163.26 ha, and the drought in June 2017 with a whopping 336.43 ha. The drought areas usually concentrated on the morphological characteristics of the soil of the inhabitants, rice fields, and inclination of the slopes.

1. Introduction

Indonesia is one country out of many that located on the Equator line which has two seasons dry and rainy season. The two seasons makes Indonesia's climate to be rather hot, making it vulnerable to towards drought. Indonesia's climate is also affected by the changes that happen on the surface temperature of both the Indian Ocean and Pacific Ocean [1]. Drought is the lack of water supply availability that needs to meet the needs of life, agriculture, economic activities, and environment [2]. It classified as a hydrological and meteorological disaster. It can define in general as a temporary water supply or humidity reduction-significantly below the normal or expected volume for a specified period. Drought is one of many kinds of hydrometeorological disaster which mainly caused by rainfall. Similar researches of the hydrometeorological disaster had been done in Cibanteng Village of Sukaresmi District discussing loss risk caused by a landslide [3,4,5].

In the case of drought relief, it is necessary to map the dry areas. In order to do that, *Remote Sensing* is one out of many methods that have been used to assist in performing drought mapping, where in many cases it has been used to either scan or predict drought [6]. A *triangulation* method that has been developed by Carlson *et al.* (1995) is one that benefits the use of *Remote Sensing* application. *Triangulation* method (or known as TVDI—*Temperature Vegetation Dryness Index*) that consists of NDVI (*Normalized Difference Vegetation Index*) and LST (*Land Surface Temperature*).



Cianjur regency is one of the regencies in West Java Province. The total area of Cianjur Regency is 350,148 km² with a population of 2,235,418 in 2014. The main livelihood in Cianjur Regency is in the agricultural sector, as much as 52% of the labor absorbed by contributing 42.8% of Cianjur Regency GRDP. Administratively, Cianjur Regency has 32 sub-districts which are generally bordered by Bogor Regency on the north and Sukabumi Regency on the west [7]. One of the districts of Cianjur that was hit by drought is Sukaresmi District. In daily news *pojokjabar.com* on September 27, 2017, stated that the dryness in Sukaresmi resulted in 5 hectares of rice fields cannot be flooded water. Drought disaster in Cianjur Regency has an impact on the availability of water to meet the needs of the community. One of the affected needs by the drought disaster is the fulfillment of water for domestic use and irrigation on agricultural land.

The purpose of this research is to know the distribution of dryness area in Sukaresmi district, Cianjur Regency based on TVDI index value in 2013 and 2017. So it can be determined which areas in Sukaresmi sub-district that always experience drought and identify the relation of drought region with a physical characteristic of Sukaresmi sub-district, Cianjur Regency. Selection of the year 2013 and 2017 based on the ENSO index for the year under normal conditions. The aims of the research to identify dry areas in Sukaresmi district under normal conditions.

2. Methodology

2.1 Data

In this research, secondary data from various sources. In addition to secondary data, there are also primary data that had taken on 26-28 March, namely, the soil texture of Sukaresmi (Table 1).

Table 1. Source Data

No	Data	Kinds of Data	Source
1	Dryness Index TVDI	June-August 2013 & July September 2017	https://earthexplorer.usgs.gov/
2	Soil Texture	Soil Texture Map on a scale 1:50.000	Research Center and Agroclimate
3	Landuse of Cianjur Regency	Landuse Type Scale 1:25.000	Badan Informasi Geospasial (BIG)
4	Elevation and Slope	SHP Contour Cianjur Regency	Badan Informasi Geospasial (BIG)

2.2 TVDI (Temperature Vegetation Dryness Index)

This method explains the relationship between Land Surface temperature (LST) and vegetation index (NDVI). The triangulation referred to in this method is the result of the *scatterplot* formation of the two parameters of the triangle. The edges on the scatterplot illustrate the range of ground surface temperature variations. At the upper limit (warm edge) indicates soil conditions without moisture or dryness, while at the bottom (wet edge) indicates very wet soil. From these two parameters, the soil moisture index can determine from the ratio of the distance of a point on the scatterplot to the wet edge (A) with the distance between edges (B) called the Temperature Vegetation Dryness Index (TVDI) [8]. TVDI is a dry or non-humidity index, where the maximum value of TVDI = 1 indicates dry pixels and wet pixels indicated by TVDI values close to 0.

2.2.1 Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST)

Normalized Difference Vegetation Index (NDVI) is used to determine vegetation density; vegetation index is the greenish value of vegetation, vegetation index obtained by the process of comparison between brightness level of the red light channel (red) and infrared light channel close to the formula:

$$NDVI = \frac{\text{Near Infrared Band} - \text{red Band}}{\text{Near Infrared Band} + \text{red Band}} \quad (1)$$

Ministry of Agriculture regulation 2008 divides the class of NDVI values into three classes, i.e., rarely (-1.0-0.32), moderate (0.32-0.42), and dense (0.42-1.0).

Satellite image data on Landsat 8 can produce LST. It obtained from the correction of band 6 (TIR) with wavelength 10.40-12.50 μm . Band 6. Satellite image data obtained cannot directly process its digital number, but must undergo several conversion steps in advance to get the actual surface temperature value. The algorithm used is Mono-window Brightness Temperature [9], as follows:

- Determining the object's spectral radian value in the image of its digital pixel value by using the equation [9].

$$L_{\lambda} = L_{\min \lambda} + \frac{L_{\max \lambda} - L_{\min \lambda}}{Q_{\text{calmax}}} \times Q_{\text{cal}} \quad (2)$$

(L_{λ} : Spectral Radian; $L_{\max}(\lambda)$: Maximum Spectral Radian; $L_{\min}(\lambda)$: Minimum Spectral Radian; Q_{cal} : Digital Number; and Q_{calmax} : Maximum Value of Digital Number)

- Spectral Radian value conversion into Kelvin:

$$Tb = \frac{K_2}{\ln\left(\frac{K_1}{L_{\lambda}} + 1\right)} \quad (3)$$

(Tb : Satellite Brightness Temperature (K); K_1 : Radian Spectral Constanta Calibration; K_2 : Absolute Temperature Constanta Calibration (K); and L_{λ} : Spectral Radian)

- Temperature Conversion from Kelvin into Celsius

$$T_{\text{Celcius}} = T_{\text{Kelvin}} - 273$$

2.2.2 TVDI Index Value Calculation

After getting the result of the vegetation index value and land surface temperature, calculate the value of dryness index. TDVI can be calculated using NDVI and T_s (Land Surface Temperature) obtained from satellites by using the formula:

$$TVDI = \frac{(T_s - T_{s \min})}{(a + b \text{NDVI} - T_{s \min})} \quad (4)$$

(T_s : Land Surface Temperature ($^{\circ}\text{C}$); $T_{s \min}$: Minimum Land Surface Temperature ($^{\circ}\text{C}$); NDVI: Normalized Difference Vegetation Index; a, b: Regression Constanta T_s and NDVI hot edge triangle) After TVDI obtained, classify it into three classes of dryness according to the Ministry of Agriculture regulation 2008 is Normal/Wet (-1.0-0.32), Rather Dry (0.32-0.42) and Dry (0.42-1.0).

2.3 Statistic Data Process

Statistical data processing by conducting a chi-square correlation test between the degree of dryness with physical characteristics (soil use, soil texture, altitude, and slope) to see whether there is a relationship between the two, also to observe the adjacency of the relationship between physical characteristics with the level of drought based on the value of Contingency Coefficient.

3 Result and Discussion

3.1 Dry Area according to TVDI Index

Dry areas in July 2013 located in the villages of Cibadak, Cikanyere, Ciwalen, Kawung Luwuk, Pakuon, and Sukaresmi. In August 2013 there are dry areas located in Cibadak, Cikanyere, Ciwalen, Kawung luwuk, Kubang, Pakuon, Rawa Belut, and Sukaresmi villages. In September 2013 there were dry areas located in Cibadak, Cikanyere, Ciwalen, Kawung Luwuk, Kubang, Pakuon, Rawa Belut, and Sukaresmi villages. Table 2 is the region of overall dryness by 2013.

Table 2. Dry Area in Sukaresmi District in 2013

Dryness Level	TVDI Value	Area (Ha)		
		July	August	September
Normal (Wet)	0 – 0,82	9.367	8.952	8.702
Rather Dry	0,82 – 0,92	109	461	668
Dry	0,92 – 1	58	119	164

Dry areas in June 2017 located in Cibadak Village, Cikanyere, Ciwalen, Kawung Luwuk, Kubang, Pakuon, Sukamahi, and Sukaesmi. In July 2017 there was a dry area located at Cibadak Village, Cikanyere, Ciwalen, Kawung Luwuk, and Pakuon. In August 2017 there was a dry area located in the Village Cibadak, Cikanyere, Ciwalen, Kawung Luwuk, and Pakuon. Table 3 is an overall dryness region by 2017.

Table 3. Dryness Area in Sukaesmi District in 2017

Dryness Level	TVDI Value	Area (Ha)		
		June	July	August
Normal (Wet)	0 – 0,82	8.152	8.711	8.619
Rather Dry	0,82 – 0,92	1045	729	804
Dry	0,92 – 1	336	95	111

Figure 1 is a map of the dry area in Sukaesmi District showing the region which always has a high index. Thus the area is always dry and indicates areas with low indexes or areas that are always normal (wet). On drought area map in Kecamatan Sukaesmi, can be seen the dry and somewhat dry region. Dry areas in Sukaesmi District located in the villages of Cibadak, Cikanyere, Ciwalen, Kawung Luwuk, Kubang, Pakuon, and Sukaesmi. The dominant drought areas found in five villages namely, Cibadak, Cikanyere, Ciwalen, Kawung Luwuk, and Pakuon (Table 4).

Table 4. Drought Area in Sukaesmi District

No	Dryness Level	Area (Ha)
1	Normal (Wet)	8.319
2	Rather Dry	1.084
3	Dry	131

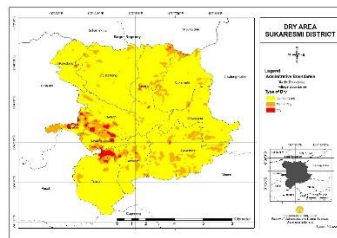


Figure 1. Dryness Area in Sukaesmi District

3.2 Relation of Drought Areas with Physical Characteristics

Table 5 explained dryness areas based on land use. From the table, it can see dryness areas with the broadest dry classification found on the use of settlement land with an area of 96 ha. The dryness area due to the use of land in the form of settlements of vegetation index values, or NDVI values located in the classification of vegetation with rare density and high surface temperature. Resulting in dryness based on TVDI index. The area of dryness with the widest dry classification after the use of land in the form of rice fields with 27 Ha.

Table 5. Area of Dryness Table Based on Landuse

Landuse/Dryness Level	Forests (Ha)	Plantation (Ha)	Rice Fields (Ha)	Settlement (Ha)	Shrubs (Ha)	Moor/Field (Ha)	Vacant Land (Ha)
Normal (Wet)	568	2.993	2.007	195	1.497	1.038	8
Rather Dry	0	330	460	200	7	87	9
Dry	0	12	27	96	0	1	0

Table 6 is a table of the area of dryness based on slope. Table the dryness area with the widest dry classification lies on a slope of 3-8% with an area of 85 Ha. Dryness with the widest dry classification subsequently lies on a slope of 0-3% with an area of 31 ha. So it can be seen that dryness areas are on a flat slope.

Table 6. Dryness Areas with Slope

Slope/Dryness Level	0% - 3% (Ha)	3 – 8% (Ha)	8 – 15% (Ha)	15 – 30% (Ha)	30 – 45% (Ha)	45 - 65% (Ha)	> 65% (Ha)
Normal (Wet)	266	783	2.086	3.395	1.136	493	145
Rather Dry	122	397	329	211	39	2	0
Dry	31	85	12	2	1	0	0

Table 7 is a table of the area of dryness based on altitude. In Table 7, the dryness area with the widest dry classification located at an altitude of 500 - 1000 masl with an area of 127 Ha and a level of 250 - 500 masl with an area of 3 Ha.

Table 7. Dryness Areas with Elevation

Elevation (Masl)/Dryness Level	< 250 (ha)	200 – 500 (ha)	500 – 1000 (ha)	> 1000 (ha)
Normal (Wet)	0	1,393	6,521	390
Rather Dry	9	150	924	16
Dry	0	3	128	0

Table 8 explains of dryness areas based on soil texture. The dryness area with the widest dry classification lies in a soil texture of silty loam with an area of 128 ha. While the area of dryness with dry classification on the soil texture of sandy-silty loam, which is equal to 3 ha. The dryness because the soil texture of silt loam is the dominant soil texture in Sukaresmi District. The dominant dryness areas are on the soil texture of silt loam.

Table 8. Drought Areas with Soil Texture

Soil Texture/ Dryness Level	Silty Loam (ha)	Sandy Silt Loam (ha)
Normal (Wet)	6,209	2,093
Rather Dry	935	164
Dry	128	3

The physical characteristics that are most affected by dryness are land use which has a value of *Contingency Coefficient* the biggest than any other physical characteristic that is 0.360. The slope has a second effect after the soil usage, with the value of *Contingency Coefficient* 0.259. Furthermore, the third physical characteristic that affects dryness is the elevation of a slope with the value *Coefficient, Phi* 0.120. The weakest physical characteristics affecting dryness is the soil texture with a *Contingency Coefficient* value of 0.114. The closeness of the relationship between the level of drought with physical characteristics based on the value of *Contingency Coefficient* that is, the use of soil, the slope, altitude, and soil texture. The dryness area because the land use has a direct effect on the vegetation index where the use of settlement land and rice fields has greater drought potential compared to the land use of others. While steepness of a slope, the more sloping a slope is, the greater the potential for drought. The dryness area due to the steeping slopes used in the form of settlements and rice fields.

4 Conclusion

From the research results, it concluded that the highest dryness (in 2013) occurred in September with 163 Ha, while in July 2013 with 58 Ha. The highest dryness (in 2017) occurred in June with 336 Ha, while the lowest occurred in July with 95 Ha. In 2013 or 2017 the lowest dryness occurs in July. Areas that always experience dryness in Sukaresmi district found in the village of Cibadak, Cikanyere, Ciwalen. Kawung Luwuk, and Pakuon.

Dryness associated with physical characteristics, i.e., land use, slope, ground texture, and altitude. Physical characteristics of Sukaresmi district with the most association related to dryness are land use and slope. The use of settlements and rice fields has greater dryness potential compared to other land

uses. The dryness area due to the rare vegetation index density and high surface temperatures. The other hand, on the steepness of the slopes, the steeper it is then the potential for dryness is more significant. The dryness area due to the territory of steep slopes used for land use in the form of settlements and rice fields.

The suggestion in this research is the verification and validation of TVDI models on dry areas are required to research to determine the accuracy level of the model.

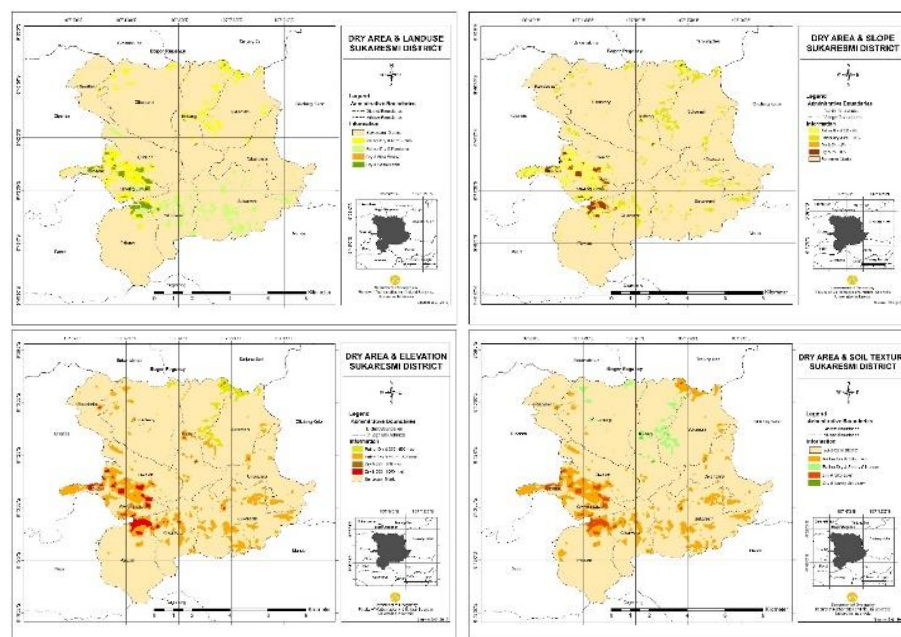


Figure 2. Dryness Area with Landuse, Slope, Elevation, and Soil Texture

Acknowledgment

The authors are deeply grateful to Research and Public Service Directorate, Universitas of Indonesia for support of the research grant Hibah PITTA year 2018 with contract number 2220/UN2.R3.1/HKP.05.00/2018

References

- [1] Aldrian, E 2008 *Meteorology Laut Indonesia* Badan Meteorologi dan Geofisika Jakarta
- [2] Policy Number 24 the Year 2007 on Disaster Management
- [3] Adiningsih, E.S 2014 *Tinjauan Metode Deteksi Parameter Kekeringan Berbasis Data Penginderaan Jauh* Pusat Teknologi dan Data Penginderaan Jauh LAPAN
- [4] Kusratmoko, E., Wibowo, A., Cholid, S., and Pin, T.G 2017 *Participatory three-dimensional mapping for the preparation of landslide disaster risk reduction program* In AIP Conference Proceedings 2017 July 25 Vol. **1857** No.1 p.110001 AIP Publishing
- [5] Puspita, D., Susilowati, M.H. D., and Kusratmoko, E. *Karakteristik Permukiman pada Wilayah Rawan Tanah Longsor di Desa Cibanteng, Cianjur, Jawa Barat* Majalah Geografi Indonesia **28**(2) pp 140-152
- [6] Ulfa, F., Kusratmoko, E., and Wibowo, A. *Risiko Kerugian Akibat Longsor di Desa Cibanteng, Kecamatan Sukaresmi, Kabupaten Cianjur, Jawa Barat.* Majalah Geografi Indonesia **29**(2):139-48
- [7] Badan Pusat Statistik Kabupaten Cianjur 2015 *Kabupaten Cianjur Dalam Angka 2015* Badan Pusat Statistik Kabupaten Cianjur Cianjur
- [8] Sandholt, I., Rasmussen, K., & Andersen, J 2002 *A Simple Interpretation of the Surface Temperature/Vegetation Index Space for Assessment of Surface Moisture Status* Remote Sensing of Environment **79** pp 213– 224
- [9] USGS 2013 Using the USGS Landsat 8 Product http://landsat.usgs.gov/Landsat8_Using_Product