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Detection of drought area using greening index and wetness index in Sukaresmi Subdistrict, Regency Cianjur, West Java

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Abstract. Drought is a natural disaster that reduces the supply of water in the atmosphere or on the ground, causing plants cannot grow normally. Drought is causing the decrease of plantation and harvest area, productivity, and quality of agricultural products. Sukaresmi Subdistrict, Cianjur Regency is depending on agricultural sector and has the risk of loss from drought. This research aims to detect spatial and temporal of drought areas and to analyze drought areas according to the physical condition of the land (altitude, slope, soil type, and land use) in Sukaresmi Subdistrict. This research uses Landsat 8 OLI imagery data from July-September 2013 and June-August 2017 analyzed by Normalization of Differences Vegetation Index (NDVI) and Tasseled Cap Transformation (TCT). Overlay of the moderate, high, and very high drought classes in the same year will generate drought areas that overlap each year. Drought areas during 2013 and 2017 are 726 hectares or 8% of the total Sukaresmi Subdistrict area, dominates the Kawang Luwuk Village and Cibadak Village in the western part of Sukaresmi Subdistrict. Mostly, drought areas located in paddy field land use (322.18 hectares); brown latosol soil type (447.85 hectares); and altitude of 500-1000 msl (624.1 hectares).

1. Introduction
Drought is defined as a temporarily decreased water supplies until below normal, both in the atmosphere and on the surface [1]. The lack of availability of water can interfere with the plant growth process and caused decreasing of planting area, harvest, productivity also the agricultural product quality [2]. Mitigation strategies and drought disaster management plan especially the for preventive action needs to carry out continuously to prevent more significant loss, one of the action is providing information about drought-inclined areas and spatially and temporally prediction about drought symptoms [3]. Normalized Difference Vegetation Index Method (NDVI) is one of the methods with vegetation index approach which used in various research on global scale vegetation mapping for drought, desertification, and deforestation [4]. According to Hartono in Raharjo (2010), NDVI is a combination between comparison technique and image reduction technique which generated vegetation density index of an object. Tasseled Cap Transformation Method (TCT) is a satellite image processing method that is combining band one until band 5 and band 7 of TM Landsat which produce humidity index [5].

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This research aims to map the distribution of dry areas in Sukaresmi Subdistrict on a normal year, or the area is not experiencing climate anomalies during the year 2013 (normal year) and the year 2017 (weak La Nina). The results of dry areas distribution in Sukaresmi Subdistrict will be further analyzed to find out the connection between dry areas vastness with the physical condition of land that consists height, slope, soil type, slope, and land utilization. The reason of area study in Sukaresmi Subdistrict, Regency Cianjur is for complete information on the hydrometeorological disaster [6,7,8].

2. Methodology

2.1 Data Collection

The data used to generate the vegetation density index and a soil moisture index is an image from Landsat 8 OLI satellite. Data of physical land condition is a tabular data sourced from the related institute. Field survey of this research was conducted on 26-30 March 2018 through random sampling technique based on dry areas distribution. Soil samples are processed in the laboratory of soil mechanics of the National Institute of science and technology from April 17 to May 3, 2018, to produce data on soil texture.

2.2 Data Processing

Vegetation Density Index

The density of the vegetation derived from the value of NDVI (Normalized Difference Vegetation Index) for Landsat 8 OIL is:

\[
NDVI = \frac{\text{Band 5} - \text{Band 4}}{\text{Band 5} + \text{Band 4}}
\]  

The Vegetation density index from NDVI has a range of values from -1 to 1, where the negative values are describing the condition of clearing (open ground) or the area which vegetation density is very low whereas the value of 1 indicated land with very high vegetation density [2].

Soil Moisture Index

Humidity index Algorithm that developed by Hasan using Landsat 8 OLI for mapping land cover or other classification projects are as follows [9]:

\[
\text{Wetness Index} = (0.1511 \text{ Band2}) + (0.1973 \text{ Band3}) + (0.3283 \text{ Band4}) + (0.3407 \text{ Band 5}) - (0.7117 \text{ Band6}) - (0.4559 \text{ Band7})
\]

Negative soil moisture index shows a low level of soil moisture, while soil moisture with positive values indicates higher soil moisture [2].

The Dry Areas distributions

Overlay Method used for overlapping between vegetation density index maps with soil moisture index map on land without habitation usage in every month. Then the results will be analyzed with the actual rate of drought determination matrix (table 1).

| The Level of Dryness | Surface Soil Moisture Level | Verdure Level/ Vegetation Density |
|----------------------|-----------------------------|----------------------------------|
| Very high            | 1.1                         | Very low (1)                     |
|                      | 2.1                         | Low (2)                          |
|                      | 3.1                         | High (4)                         |
|                      | 4.1                         | Very high (5)                    |
| High                 | 2.2                         | Medium (3)                       |
|                      | 3.2                         | High (4)                         |
|                      | 4.2                         | Very high (5)                    |
| Moderate             | 2.3                         | Low (2)                          |
|                      | 3.3                         | Medium (3)                       |
|                      | 4.3                         | High (4)                         |
| Not dry              | 2.4                         | Very high (5)                    |
|                      | 3.4                         | Medium (3)                       |
|                      | 4.4                         | High (4)                         |
|                      | 5.1                         | Very high (5)                    |

Reference: [2]
2.3 Analysis
The overlay method is used to find out the distribution of dry areas in Sukaresmi Subdistrict and will be analyzed descriptively to know the distribution of dry areas that occurred spatially and temporally. The afterward statistical analysis will be performed to see the connection between the dry area vastness with the physical land condition through One Way Analysis of Variance (ANOVA).

3. Result and Discussion
3.1 Distribution of Dry Areas
Figure 1 shows that the area of potential moderate dry, high dry, and very high dry tend to increase from July through September of 2013. Afterward using methods of overlay (intersection) on the map of the distribution of dry areas in July, August, and September to produce overlapping dry region in the year 2013. The total dry area of the year 2013 can be seen in table 2. The results from the calculation of table 2 shows that the area is the dry year 2013 in Sukaresmi Subdistrict is 1,933 hectares or 21.38% from the total area of Sukaresmi Subdistrict. The village that has the largest dry area is Sukaresmi Village with 348 hectares. Figure 2 shows that total area with moderate potential dry and potential high dry are fluctuating in which the area increased from June to July 2017 and decreased from July to August 2017. As for the results of overlay methods (intersection) on the distribution of dry area on June, July, and August to produce an overlapping dry area in the year 2017. The total dry area of the year 2017 can be seen in table 2. Based on table 2, in the year 2017 Sukaresmi Subdistrict has a dry area of 1,189 hectares or 13.15% of the total area of Sukaresmi Subdistrict. The largest dry area located at Sukaresmi village in Sukaresmi Subdistrict with an area of 176 Ha.

3.2 Distribution of Dry Areas from 2013 until 2017
Distribution of dry areas in the year 2013 and 2017 is processed using overlay method (intersection) to generate overlapping dry areas in Sukaresmi Subdistrict. The dry area in Sukaresmi Subdistrict is 726 hectares or 8.03% of the total area of Sukaresmi. The dry areas for every village it can see in tabel 2. Based on tabel 2 that the village with the most extensive dry area in Sukaresmi subdistrict is Cikayere village with 107 hectares and Sukaresmi village with 103 hectares dry area. Meanwhile, the village that has smallest dry area is Rawabelut village with only 23 hectares the distribution showed in figure 3.

Distribution of dry areas in Sukaresmi Subdistrict associated with the physical condition of land by statistical analysis to explain whether there are or not differences of the average dry area with the physical condition of land that consist of topography, soil type, and land use.

3.2.1 The Relationship between Dry Area and Topography.
The physical condition of topography land described into two parts namely the height and the slopes. The Anova test generates a significant value of 0.008 that is lower than the specified alpha value of 0.05. Thus there are differences on dry area average in which dry area on 500-1,000 msl altitudes (high hills) is higher compared with 200-500 msl altitude (hills), also with an altitude higher than 1,000 msl (mountain). In the meantime, to find the relationship between the dry areas and the slopes, overlay method is used on the dry areas in Sukaresmi Subdistrict with five classes the slopes: 0-8%, 8-15%, 15-25%, 25-40%, and >40%. The results of the ANOVA test is a significant value of 0.063 which is smaller compared to the specified alpha value of 0.05. Thus there is no significant difference in the average of the dry area on the particular level of slopes in Sukaresmi Subdistrict.
Figure 1. The potential dry areas in Sukaresmi Subdistrict, the year 2013.
Figure 2. The potential dry areas in Sukaresmi Subdistrict, the year 2017.
3.2.2 The Relationship between Dry Area and Soil Type.
The results of the ANOVA test are lower the significant value compared to alpha value, 0.002 < 0.005. Thus it is concluded that there are significant differences in dry areas average from 4 types of soil. Consecutively the dry area difference started from the largest until the smallest type of soil as follows: brown latosol, association of reddish brown latosols and brown latosols, reddish dark brown latosols, complex of grey regosols and lithosols, association between greyish grey alluvial and brownish grey alluvial, association of grey alluvial and greyish brown alluvial soils. The physical nature of the soil, in which each different soil texture will affect the ability of the soil to keep and delivers water, also to keep and provide nutrients to various plants. Based on that matter, this research is trying to verify soil texture in dry areas. Laboratory results show that a fraction of dust with a range of values between 50% to 80% dominates the soil samples on dry areas in Sukaresmi Subdistrict. It is supported by soil type that is in the Sukaresmi Subdistrict which is dominated by brown latosol which has the texture of dust to clay. The texture of the dusty soil, loam, and clay are generally capable of holding the water or keep the soil moisture quite well compared to the sand texture [10]. Cover/land usage affected a variety of physical condition of soil and hydrological functions about soil moisture [11]. On the research of drought undertaken by Suseno discovered that brown latosol soil type had a texture from dust to clay thus has an excellent ability to store the water and has a low dry level. However, drought can be occurred on brown latosol soil because of the influence of the soil usage, for example, paddy field in the harvest season; the farmer deliberately lets the soil become dry [12].

3.2.3 The relationship between dry areas and land usage.
Anova test resulted in lower significant value compared to the specified alpha; 0.004 < 0.05 conclusively that there are differences is average of dry area based on land usage. Turkey test result is an order of average differences of dry areas based on land use, consecutively from highest until lowest are as follows: paddy fields, crops field, fields, shrubs, and forest.
4. Conclusion
Distribution of dry areas Sukaresmi Subdistrict dominates with dry areas more than 50 hectares distribution dominate the west area of the subdistrict on the year 2013 and 2017. Land physical conditions such as altitude, soil type, land usage have a significant average in a total of dry area. The largest dry areas located in high hills land with 500-1,000 msl altitude, with the brownish latosol soil type that has dusty to clay texture and also has land usage of the paddy field type.

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