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Identification of land drought potential in Blora district using NDVI and NDWI methods

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Abstract. The plumbing system is an inseparable part of a multi-storey building. Drought is one of the routine disasters occurring in Indonesia. The occurrence of a prolonged disaster caused by the absence of countermeasures and good handling from the government. One of the causes of the drought is seasonal change. Blora district is one of the districts in Central Java that suffers severe drought other than other areas in Central Java which has two seasons: dry season and rainy season. The turn of the season resulted in a long drought in the Blora area. The purpose of this research is to identify the possibility of drought in Blora district by looking at several variables of drought index that is, vegetation index, wetness index and rainfall. To measure the vegetation index using NDVI (Normalized Difference Vegetation Index) method and for measure the wetness index using NDWI (Normalized Difference Water Index) method. The results of this research suggest that there is a relationship between vegetation index, wetness index and rainfall. When the value of wetness index increases then the vegetation index gets more solid. Like the data obtained in April 2016, the vegetation index in Blora District is -0.118 due to the dry season and the minimum rainfall that month.

1 Introduction

Drought is one of the disasters that occur due to the impact of seasonal circulation or global climate drift. Indonesia itself is a country that has a tropical climate that is very sensitive to the anomaly climate El-Nino South Oscillation, which is this climate is the cause of drought [1]. According to BMKG, El-Nino is a condition used to describe the increase of temperature on the ocean of the Pacific Ocean, which occurs on the equatorial surfaces of the central and eastern parts. Where the impact is the reduction of the amount of rainfall in Indonesian territory [2]. In addition to the El-Nino phenomenon, the threats resulting from drought are also caused by several physical factors such as, weight, drought, and land cover [3].The cause of drought apart from physical factors and El-Nino phenomena is the factor of water utilization in human life. This is because humans sometimes use water excessively like water use for irrigation process in the wrong way [4].

This research was conducted in Blora district. This is because Blora district is an area that already runs integrated farming system, which is this system can help increase farmer's

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income and assist in agriculture aspect to be more productive in producing various agricultural products [5].The drought in Blora district is occurs because of the long drought climate and its soil layer which is difficult to absorb water, since the soil in Blora district is limestone [6]. Head of the Regional Disaster Management Agency (BPBD) Blora, Sri Rahayu, said that from the data obtained there are 161 villages in Blora district [7] and 16 drought-stricken sub-districts, of which only 16 sub-districts did not request clean water, one of it is Kradenan sub-district [8].

From the problems above, the researcher assumes that Blora district is an area that has run a integrated farming system or mix farming, which is this agriculture is very useful to help increase income for farmers, so they not only get income from one kind of agriculture product but also can earn income from the various agricultural products. But because Blora district is one of the districts in Central Java that has high possibility to experience drought disaster [9], then it's probably will be very disturbing to the farmers later in running the integrated agricultural system.

Therefore, this research was conducted to assist BPBD of Blora District to be able to identify the possibility of drought disaster in Blora district that happened outside prediction and can disrupt the activity of farmers in running their integrated agriculture. The methods used for the identification of this possibility are NDVI and NDWI methods.

The research titled "Analysis of the Distribution of Vegetation with Sentinel Satellite Imagery Using the NDVI and Segmentation Methods" conducted in Demak district explained that the pattern of vegetation distribution in Demak district with NDVI and Segmentation is evenly distributed throughout the region with different areas in each region. The result varies in vegetation density. The indicator used in the vegetation analysis is divided into two, namely the quantitative parameter which discusses the number of individual organisms per unit of space. As for the second parameter is a qualitative parameter that shows the relative distribution of species of organisms in the community [10].

The next research titled "Utilization of Geographic Information System Application (GIS) and Remote Sensing for Drought Prone Area Mapping in Sukabumi District" its shows that with NDVI method obtained conclusion assisted application of geographic information system to analyze surface conditions such as land use and vegetation index in the form of NDVI with using secondary data in the form of Landsat 8 satellite guitar with OLI sensor. The results showed areas with drought-prone areas of Ciemas and Ciracap sub-district. And for Warungkiara sub-district, Cicurug sub-district, Parungkuda sub-district have low drought [11].

The concept of drought index is determined by the value describing the drought characteristics referring to Effendy (2011), there are meteorological element parameters and other elements such as water source, soil, vegetation, and population [10].Therefore, the NDVI method is used because it utilizes the physical phenomenon of the reflection of light waves derived from foliage [11].In addition, the vegetation index (NDVI) itself has been used in numerous studies globally for drought mapping, desertification and deforestation [12].

The formula of NDVI is as follows equation I.

$$NDVI=(NIR-R)/(NIR+R) \qquad (I)$$

Information:
NIR : Near Infrared channel spectral value
R : The channel's spectral value Red

The NDVI-based Vegetation Index equation has values starting from -1 (non-vegetation) to 1 (vegetation) [13]. The lack of the NDVI method is that data processing does not have a long history of satellite data. Therefore, this study tried to combine NDVI method with NDWI method. This NDWI value is a combination of NDVI which is widely used for plant identification where Wavelength 860 nm to 1240 nm [14].The NDWI method is a method that used in determining the wetness index value with the NIR and Green channels. If the value of a NDWI is high then the vegetation in the area is very solid and otherwise if the NDWI value is low, then the area vegetation is rare or low. Therefore, the NDVI and NDWI methods are closely related in managing an image [15].The advantage of this method is that it has high resolution and good spatial coverage.

The formula of NDWI is as follows equation II.

$$NDWI=(Green-NIR)/(Green+NIR) \quad (II)$$

Information:
NIR: Near Infrared channel spectral value
Green: Green channel spectral value

This research besides using the NDVI and NDWI methods and uses Landsat 8 satellite imagery with OLI sensor as a measuring instrument to see the result of vegetation index which a parameter is to measure the drought level and wetness level in Blora district.

2 Material and Methods

2.1 Research Data

This research method consists of several stages, namely (1) problem analysis, (2) data collection, (3) literature study, (4) results and testing of research, and (5) conclusion (Figure 1).

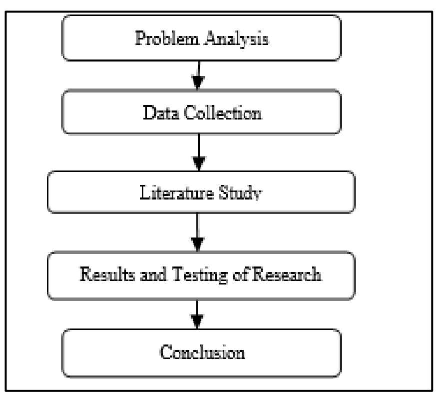


Fig. 1. Research Stages

For the above research, the stages will be explained as follows:

- Problem analysis is done to know the problem first to be faced and how we provide a solution to the problem.
- Data collection includes image recording of Landsat 8 satellite with OLI sensors in the Blora district for identifying potential drought using Landsat data.
- Literature study is an activity to provide relevant research references to support the data in this study.
- Results and Testing is a step to see a comparison of the result of drought potential indication with statistical data that has been obtained previously.
- Conclusions include the results of research that has been presented and will be written in the report of this research

2.1.1 Vegetation Indeks

The vegetation index is an index that is used to calculate values based on the difference in reflectance on the visible channel and near infrared [11].In this case vegetation index involves some combination of spectral bands.

2.1.2 Landsat 8 OLI Sensor

Drought can be grouped into several types, namely hydrological drought, meteorological drought, agricultural drought, and socioeconomic drought. Hydrologically, drought occurs due to minimal rainfall below normal long enough to cause sea level elevates/rises. While in agriculture, drought occurs due to the absence of water content as a supplier of energy for plants [16].

Seeing from the drought occurs, information is needed to answer what is the causes of it. This information will help the community to know the potential of drought disaster, such as which areas are most vulnerable. So that can be done precautions.

The project to acquire satellite earth images is called a Landsat program. Currently we know Landsat 8 which was launched on February 11, 2013.The parameters used in this research were taken from Landsat 8 satellite imagery data to identifying the potential of drought disaster through vegetation index and wetness index in Blora district [17].

2.1.3 Standardized Precipitation Index (SPI)Method

This method is a useful method for researching rainfall that has deviation in one period. This method uses the classification done to classify the intensity of the drought, as well as the criteria for the occurrence of drought in a certain time scale. Drought in the SPI occurs when the SPI is worth -1 or less and the drought will end if the SPI is positive [18].

Table 1. SPI Classification

SPI value	Classification
≥2.00	Very, very wet
1.50 s.d 1.99	Really wet
1.00 s.d 1.49	Pretty wet
- 0.99 s.d 0.99	Near normal
-1.00 s.d 1.49	Fairly dry
-1.50 s.d -1.99	Very dry
≤ -2.00	Very dry

2.2 Rainfall Data

Based on climate in Blora district during the last three years, it can be seen that Blora district is in tropical climate which has two seasons that is dry season (April / May - September / October) and rainy season (October / November-April / May). Rainfall data for the last three years can be seen in Table 2.

Table 2. The average Rainfall Last 3 Years

Month	**Average rainfall for the last 3 years in Blora Regency**												
	Bogorejo	**Banjarejo**	**Jiken**	**Japah**	**Kunduran**	**Randublatung**	**Jati**	**Sambong**	**Jepon**	**Kota Blora**	**Cepu**	**Ngawen**	**Kardenan**
Jan	232	300	291	111	256	217	289	198	158	266	12	173	185
Feb	145	175	197	50	179	73	134	258	96	212	15	170	207
March	129	176	118	78	154	83	103	236	195	173	15	162	86
Apr	178	214	227	103	212	177	234	180	169	250	13	174	156
May	177	45	37	29	63	6	17	44	93	52	4	105	53
June	84	29	94	21	47	12	86	58	109	54	5	72	75
July	31	22	33	41	31	105	31	34	40	67	4	90	91
Aug	31	7	15	32	19	21	19	47	9	4	2	70	20
Sep	16	26	53	95	114	44	47	32	43	42	3	99	118
Oct	32	44	92	42	78	128	89	98	46	69	4	106	99
Nov	121	210	88	127	165	220	188	138	218	261	7	176	143
Dec	169	256	230	203	192	248	246	223	183	236	12	197	259
Sum	1343	1506	1477	933	1511	1334	1483	1546	1359	1687	97	1593	1492

3 Results and Discussion

3.1 Drought Index with SPI Calculations

This analysis involves 13 rain stations spread evenly throughout Blora District with the duration of the last 3 years recorded in 2014, 2015, and 2016 (Table 3). The rainfall data obtained is taken from BPS and Bappeda of Blora District. The results obtained show the level of drought that ever happened in Blora District. Almost all stations have entered very dry conditions with different frequency of drought. Table 3 gives the drought index values that occurred in Blora district over the last 3 years.

Table 3. The drought index values that occurred in Blora district over the last 3 years

Area	Year					
	2014	**Kat**	**2015**	**Kat**	**2016**	**Kat**
Bojonegoro	-0.72	N	1.41	CB	-0.7	N
Banjarejo	0.29	N	-1.34	CK	1.06	CB
Jiken	0.19	N	-1.31	CK	1.12	CB
Japah	1.05	CB	-1.34	CK	0.29	MN
Kunduran	-0.19	N	-1.12	CK	-1.31	CK
Randublatung	-0.2	N	-0.24	MN	-1.58	SK
Jati	0.17	MN	-1.3	CK	1.13	CB
Sambong	-0.58	MN	-0.83	MN	1.41	CB
Jepon	-1.38	CK	0.43	MN	0.95	MN
Kota Blora	-0.43	N	-0.95	MN	-1.5	CB
Cepu	-1.08	CK	-0.25	MN	1.33	CB
Ngaweb	-0.06	N	-1.19	CK	1.25	CB
Kradenan	-0.6	N	-0.82	MN	1.41	CB
Indeks Kekeringan	-1.38	CK	-1.34	CK	-1.58	SK

Drought index value in the period 2014 the largest occurred in Jepon sub-district followed by Cepu. Then in 2015, the largest drought index occurred in the sub-district of Japah followed by Banjarejo, Jiken, Kunduran, Jati, and Ngawen. Then in 2015, the largest drought index occurred in the sub-district of Japah then followed by Banjarejo, Jiken, Kunduran, Jati, and Ngawen see Figure 2.

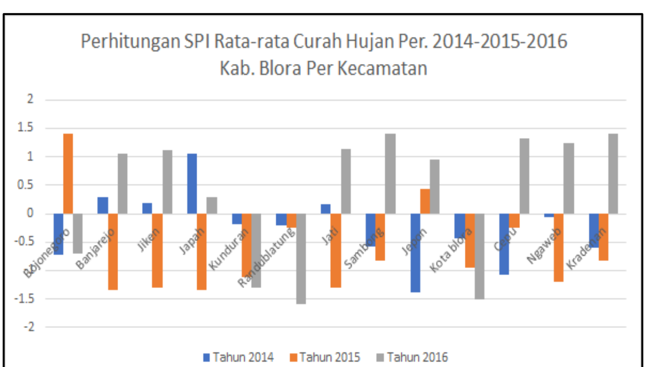


Fig. 2. SPI Calculation Chart

3.2 Analysis of NDVI Vegetation Index

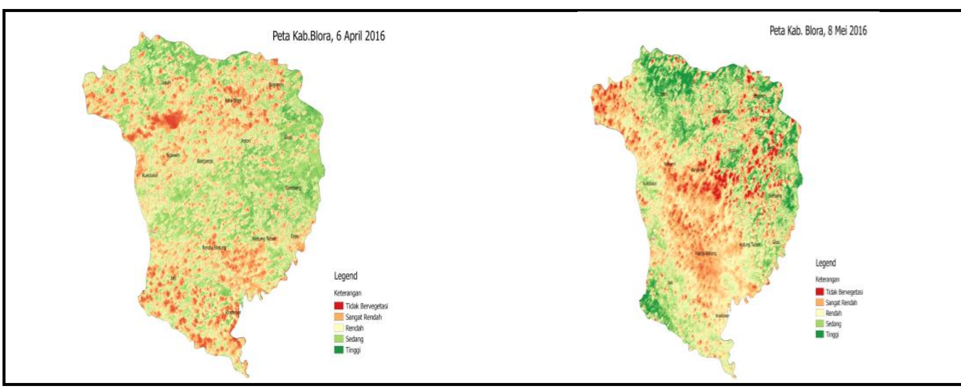
NDVI transformation (Normalized Difference Vegetation Index) in this research is used to know the index of drought. NDVI is excellent for areas with vegetation densities. The NDVI scale has a range value from -1 to 1 where the value 1 indicates a vegetation-rich area, a value of 0 indicating a slightly vegetation area and a value of -1 indicating a low vegetation area or none at all. The vegetation index is derived from waves captured by red band and NIR band (Near Infared) wherein the red band is band 4 (0.636 - 0.673) and the band NIR is band 5 (0.851-0.879) in Landsat 8.

The negative NDVI represents the type of surface without vegetation, water bodies, or clouds [19]. The following is a classification of values from NDVI [20].

Table 4. Classification of NDVI

Class	NDVI Score	Green Level
	-1 < NDVI < -0.03	Not Vegetable
	-0.03 < NDVI < 0.15	Very low
	0.15 < NDVI < 0.25	Low
	0.25 < NDVI < 0.35	Moderate
	0.35 < NDVI < 1	Higher

The object of this research is the area with the vegetation having high water absorption capacity, which has high water absorbing ability. So, the lowest value from NDVI shows areas of low vegetation density, as seen in Figures 3 and 4.



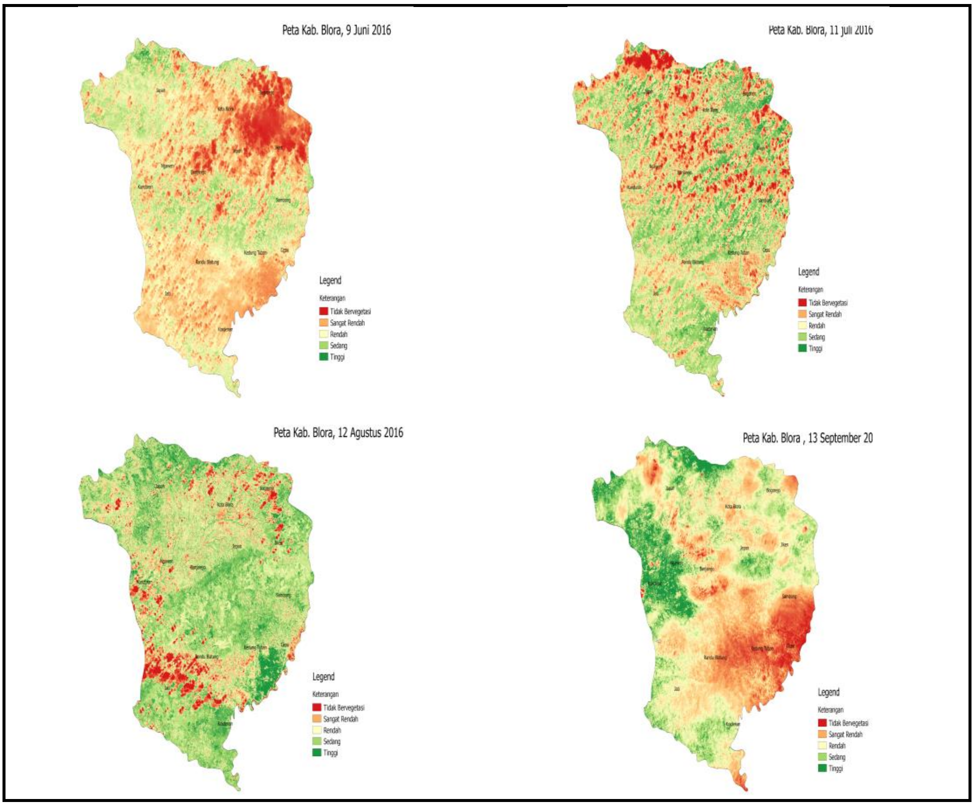


Fig. 3. Distribution of Vegetation During the dry season in Kab. Blora th.2016 (April-September)

It can be seen in Figure 3 if the vegetation index of Blora District varies considerably from April 2016 to September 2016.In April 2016 the lowest vegetation index or vegetation classification had an average value -0.0118 and for the high vegetation index had an average value 0.622.While in May 2016, the lowest vegetation index or non-vegetated had an average value -0.251 and possessed a high vegetation index level with an average value 0.732.

Then in June 2016, the lowest vegetation index with very low NDVI vegetation classification had an average value of 0.025 and the highest vegetation index with an average 0.599. Furthermore, in July 2016, the lowest vegetation index was in a very low classification with an average value 0.0604 and for the highest vegetation index the average value was 0.47.Then for the month of August, the lowest index of vegetation again came in very low classification with the average value 0.104 and the highest vegetation index with an average 0.481.The last one in September, the lowest vegetation index was in a very low classification with an average value 0.09467 and the highest vegetation index value 0.389.

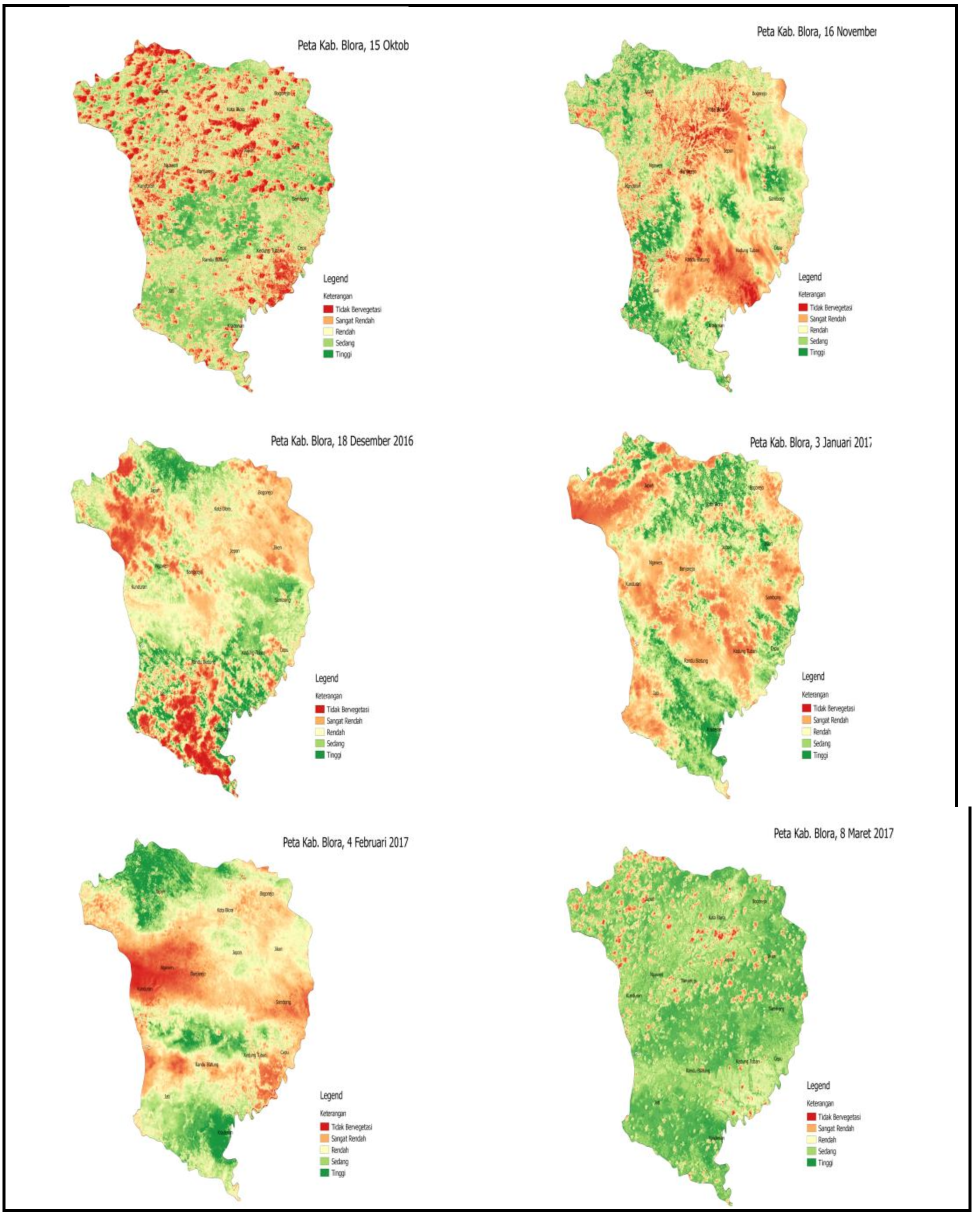


Fig. 4. Vegetation Distribution During the rainy season in Kab. Blora th.2016-2017 (October-March)

Then in Figure 4 can be seen also in October 2016 until March 2017 has a varied vegetation index as well, as in Figure 3. Beginning with October, the lowest average vegetation index is worth 0.106 with its classification including very low vegetation and the highest vegetation index averaging 0.553. For November, the lowest vegetation index was in a very low class 0.0906 and its highest vegetation index value was an average 0.495. Then in December, the lowest vegetation index was in very low grade with the value 0.0437 and the highest with the value 0.425, then in the month of January 2017 the lowest value entered in the classification no vegetate with the average value-0.0279 decreased vegetation and the highest vegetation index has an average value 0.489. While for the month of February 2017, the lowest vegetation index was in very low grade with the value 0.125 and the highest index with the value 0.348 which entered in the classification of moderate vegetation. And the last for March 2017, the highest vegetation index was in non-vegetated classification with a value -0.218 and the highest index had an average value 0.464.

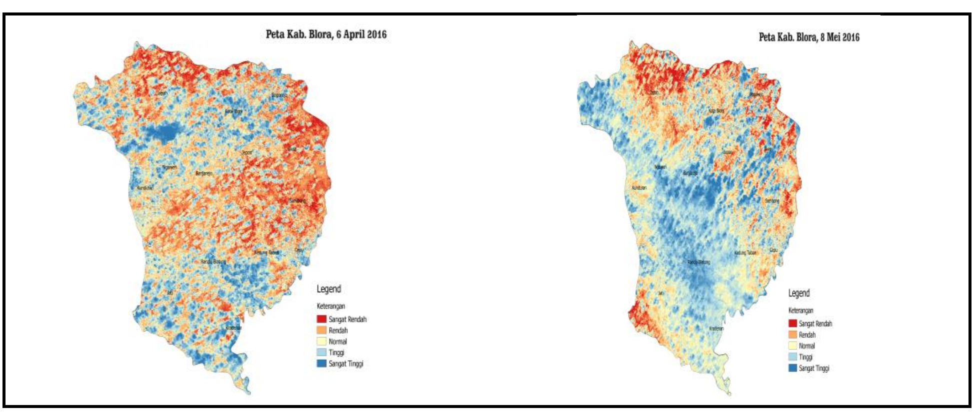
3.3 Analysis of NDWI wetness index

Normalized Difference Water Index (NDWI) analysis in this research is useful tool to determine whether there is a relationship between wetness with drought. This research uses the assumption that the lower spectral value of the wetness index transformation of an object means that the object is getting dry. The NDWI scale has a range value from -2 to more than 1 where the values of -2 to -1 are very low, -1 to -0.33 low, and so on as shown in Table 5. The wetness index are derived from waves captured by green band / band green and NIR band (Near Infared) where the green band is band 3 (0.533 - 0.590) and the band NIR is band 5 (0.851-0.879) in Landsat 8. A positive NDWI describes a very wet surface type, it could be a body of water, or a cloud. The following is a classification of values from NDWI according to Gao, (1996) [21].

Table 5. NDWI Classification

Class	NDWI Score	Wetness Level
	-2 < NDWI < -1	Very Low
	-1 <NDWI < -0,33	Low
	-0,33 < NDWI < 0,33	Normal
	0,33 < NDWI < 1	High
	< 1	Very High

Then from the NDWI classification, calculation is done by NDWI calculation formula, then the transformation result from NDWI wetness index analysis can be seen in Figure 5 and 6.



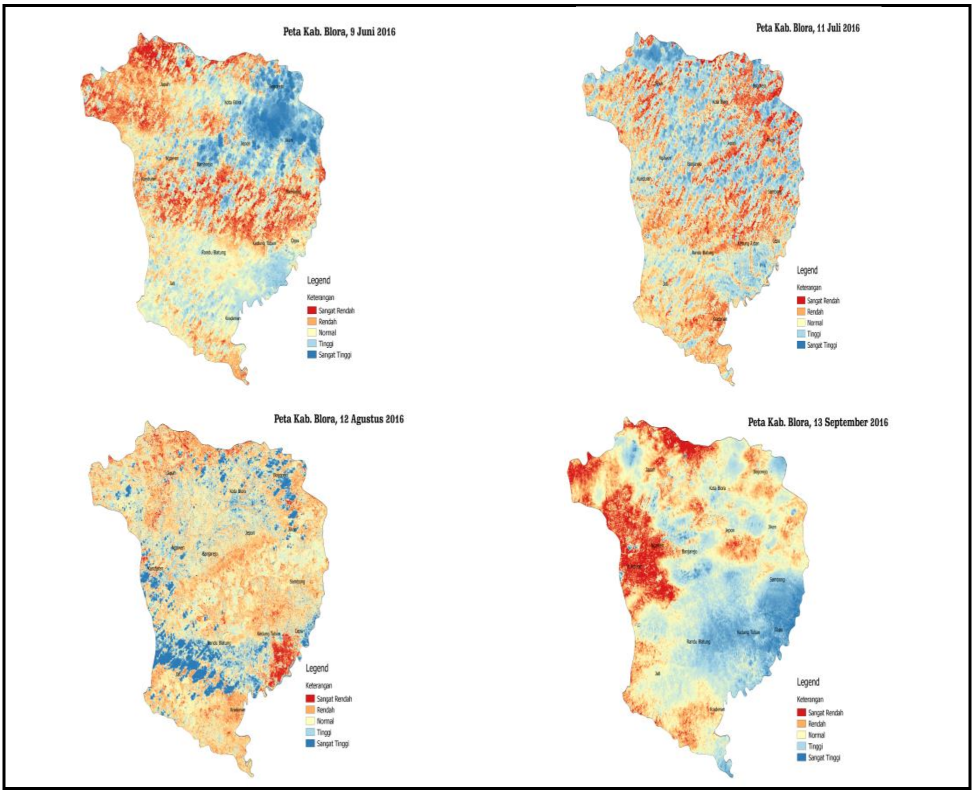
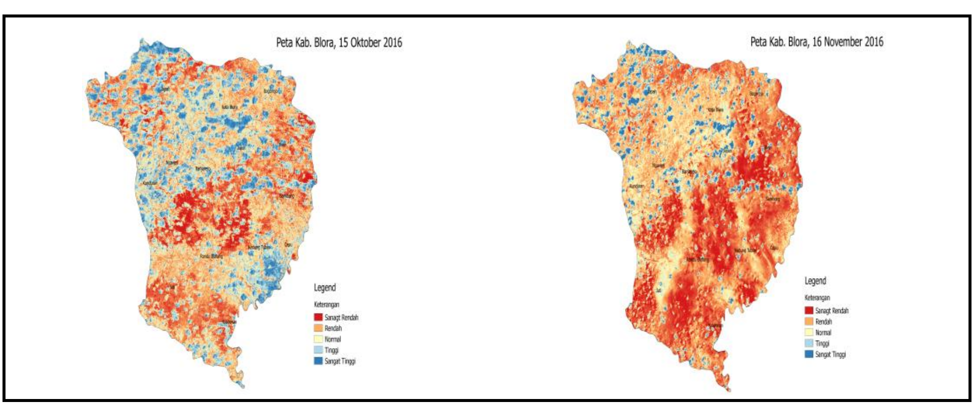


Fig. 5. Wetness Index Kab. Blora 2016 (April - September)

From Figure 5 it can be seen that the wetness index in Blora District from April 2016 to September 2016 varies, probably because the clouds so its look wet and so forth. Beginning in April 2016, the index of wetness has an average value -0.07 which goes into the normal classification. Then in May 2016, the index of wetness entered the normal classification with the average value of wetness is normal. For the month of June 2016, the wetness index went into a low classification with a average value -0.40, then in July 2016, its index of wetness had an average value -0.65 and it belong to a low classification. For the month of June 2016, the wetness index went into a low classification with a average value -0.40, then in July 2016, its index of wetness had an average value -0.65 and it belong to a low classification.



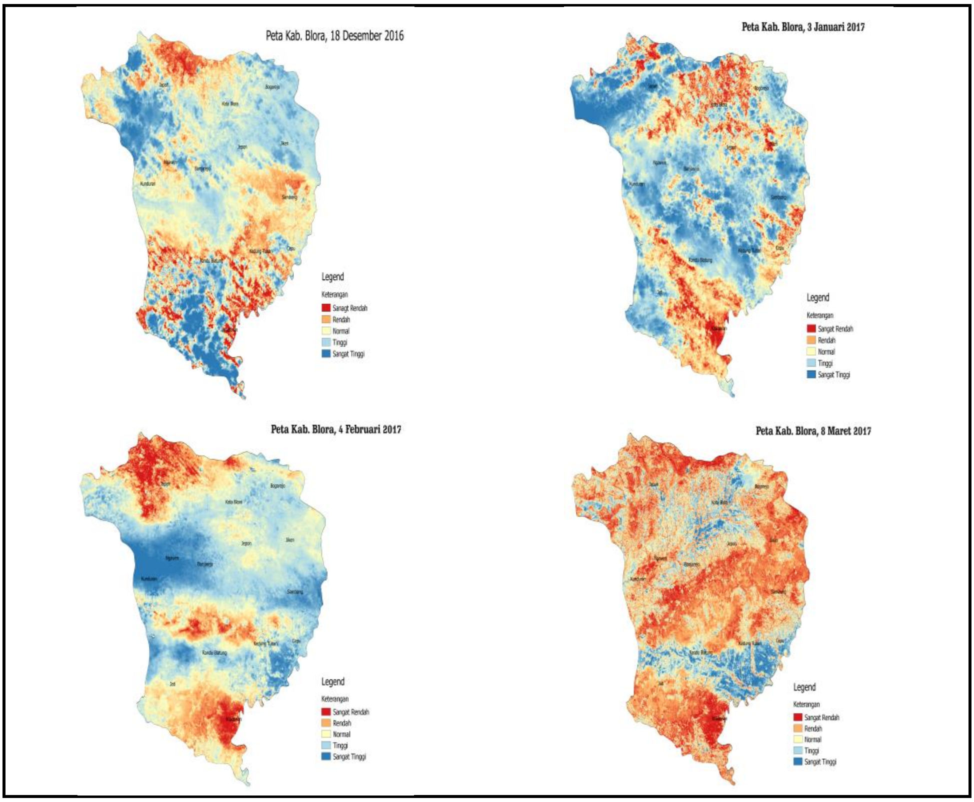


Fig. 6. Wetness Index Kab. Blora 2016-2017 (October 2016 - March 2017)

In Figure 6, the wetness index of Blora district in every month is also different, but because this month is wet months so maybe it was wet because it was going rain. October 2016 shows a wet index with an average value 0.03 and it goes into a high classification. Then for November 2016, its wetness index went into a high classification with an average value 0.13.Then for December 2016, the wetness index is worth 0.18 and included in the high classification. In January 2017, the index of wetness went into a very high classification with an average value 1.2.After that in February 2017 the index of wetness went into high classification with an average value 0.32, and for March 2017, had a normal wet index with an average value -0.31.

3.4 NDVI, NDWI and Rainfall Relation

Parameters to measure a drought index include temperature, rainfall, vegetation, soil moisture and storage of water. According to Cris (1984), the wetness index of the NDWI method is used to calculate the wetness of land in an area with parameters where the higher the wetness index value the closer the vegetation index.

This research discusses the level of land drought in Blora District, because Blora district has a lot of land that can be used for rice fields, yard, forest and so forth. The land that owned by Blora district can be classified according to its usefulness like in Table 5.

Table 5. Table of land classification in Blora, Source Blora BPS

Description	Unit	2015	2016
Wide	Ha	45.993.20	
Ricefield	Ha	17.004.18	45.948.19
Yard	Ha	26.188. 52	17.049.32
Moor	Ha	26.188.52	26.188.37
Forest	Ha	90.416. 52	90.416. 52
Etc	Ha	2456.40	2.456.39

Then the next analysis is in December, where the wetness index is 1.2 with the classification is very high. From these results can be concluded, if the vegetation index would have a high value is 0.425 and the lowest vegetation index is less than negative, proved the lowest value is 0.0437. This is also supported by the percentage of rainfall in December which amounted to 176.79%, because December is a wet month with high rainfall more than 100mm.To know the classification of the existing rainfall, can be seen in Table 6.

Table 6. Drought Rate Classification [18]

Rainfall from normal conditions	Drought Level
78-85	Dry
50-70	Very Dry
<50	Very Very Dry

4 Conclusion

The value of a drought index is measured by temperature indicator, wetness index, vegetation, rainfall, soil moisture and water storage. In this research, the three methods used to find out the drought index in Blora District are NDVI method used to measure vegetation index, then NDWI method used to measure wetness index of a land and rainfall from SPI data. The conclusions obtained from this research are: (a) The lowest value of vegetation index in Blora district is -0.118 in April 2016; (b) The highest of wetness index score in Blora district is 1.2 in December 2016; (c) The lowest rainfall was in August with a presentation of 48.92% and the highest rainfall was in November with a presentation of 269.76%. So, a region is categorized as experiencing drought if the wetness value is low. Thus, it will cause a low vegetation index affected by the minimal rainfall that occurs in the area. Otherwise, then the high rainfall and the soil absorption of water will determine the wetness index that affects the vegetation of a plant. From the statement above can be categorized if Blora district including drought potential region in April and August, besides included in dry months, the result obtained in vegetation index and rainfall data, the highest drought and the lowest rainfall occurred in April and August. Therefore, the researcher gave suggestions to BPBD of Blora District to be able to do counseling and to prepare things to reduce the potential of drought in Blora District during those months. Then for further research it would be better to include real data or field conditions data so it can compare the results of the satellite imagery used and the actual field conditions, and for future research it can include any districts data that potentially occur drought.

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