Drought Analysis By Using Standardized Precipitation Index (SPI) and Normalized Difference Vegetation Index (NDVI) at Bekasi Regency in 2018

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Abstract. Drought problem is a routine problem occurring in several regions in Indonesia. Bekasi Regency is one of the regions impacted by drought every year. Such threat of drought occurring due to influence of climate is unavoidable. Nevertheless its impact can be minimized if we know the drought pattern of such a region. Meteorologically, drought monitoring can be conducted with various methods. One of the methods used is by knowing the SPI (Standardized Precipitation Index). SPI method is the rainfall unit occurring under normal condition in such a time scale. Beside meteorologically monitoring, it can also be monitored based on the spread of vegetation influencing the availability of water supply which can be seen from the NDVI (Normalized Difference Vegetation Index) value. The purpose of this research is to find the relation between the SPI (Standardized Precipitation Index) value and the NDVI (Normalized Difference Vegetation Index) value. The result of this research shows that there is a close relation between a region having such a high SPI value and NDVI value. But in a region having a low NDVI value, several regions have high SPI values.

1. Introduction

Drought is a natural disaster caused by rain deficit within a certain period of time, which causes water availability not adequate for human being activity and environment (Surmaini, 2016). In other side, water is one of natural resources existing on earth. Besides, water has a very important function for the life of human beings and other living creatures (Regulation of the Government of the Republic of Indonesia No.82 of 2001).

The Standardized Precipitation Index (SPI) is one of the methods to analyse a drought index in a region developed by McKee et al in 1993. SPI was designed to quantitatively identify a rain deficit with various time scale (Saidah, 2017)

Population change increases followed by an increase of human necessities every year. Indirectly it can cause a change of land use (Adiwicaksono, 2014). In Indonesia, the rate of change of land use is very significant, especially forests and green areas. The depletion occurring in Java until the year of 2001 is 90,5%, Sumatera 59%, Nusa Tenggara 74,9%, Sulawesi 49,6%, Kalimantan 38,8%, and in Indonesia is averagely 54,4% (Chandrawidjaja, 2006)
Draught is one of disasters which significantly influences vegetation density, wherever it is, especially in a region where draught frequently occurs. One of the indicators which can be used to identify draught level is by seeing the difference vegetation index is normal. Which method that has been accepted in various regions with different ecological condition, Ji and Peter (2003 in Khosravi, 2017).

The Head of Emergency and Logistics Section of the Local Region Disaster Handling Agency (BPBD) of Bekasi, Rasyid on the 26th day of August 2018 stated that there are draughts in 4 district in Bekasi Regency, namely Cikarang Selatan, Serang Baru, Bojong Bangu and Cibarusah. And even before, in 2014, there are 7 districts experiencing draughts, namely Cikarang Tengah District, Serang Baru, Cikarang Selatan, Cikarang Utara, Babelan, Bojongamangu, and Cibarusah Districts. There were no previous researches, which discussing the relation between the Standardized Precipitation Index (SPI) and the normal difference vegetation index (NDVI) whereas in Bekasi by limiting the draught level in the said region. The purpose of this research is to see the relation pattern between the Standardized Precipitation Index (SPI) and the normal difference vegetation index from 2011 - 2018 in Bekasi.

2. Research Material and Method

The research region is Bekasi Regency, located at Coordinate of 106° 48' 28" East Longitude 107° 27' 29" and 6° 10' 6" South Latitude. The area of Bekasi Regency Region is 1,884,37 Km² comprising 23 regencies. Bekasi is a low land region with its southern part of mostly hilly, its location height is between 0 - 115 meters and its slope is 0 - 250 meters, Bekasi Regency, located in Northern Part of West Java Province with majority of its regions become low land, 72% of Bekasi Regency are existing in the height of 0-25 meters above sea level.

![The Map of Bekasi Regency](image)

**Figure 1.** The Map of Bekasi Regency
In this research, the data used is Landsat satellite image 8 from the year 2014 until 2018. The data of Landsat 8 will be conducted with certain algorithm processes to determine the Normalized Difference Vegetation Index (NDVI) value in Bekasi Regency. Further data is the rainfall data of Bekasi city for 9 years, from 2010 to 2018, which will be analysed to find the value of Standardized Precipitation Index (SPI). From the two values of NDVI and SPI, the relation between the two will be seen in the region distribution in Bekasi Regency, as illustrated in the thinking flow below.

![Diagram of Research Mindset]

**Figure 2. The Research Mindset**

There are a lot of drought index calculation methods including Surface Water Supply Index (WSI), Palmer Drought Severity Index (PDSI), Standardized Precipitation Index (SPI), Deciles Method, Percent of Normal Index (PNI) Method, Run Method etc. This drought index is made depending on the research region, user, process, input and output and until now there is no hydrology drought index which prevails universally (Hatmoko 2012 in Saidah et al, 2017).

Rainfall Index Standardization (SPI) is one of the methods used to analyse drought. This method is developed in 1993 by Mc Kee. The purpose of this method is to know and monitor drought (Muliawan et al 2013 in Febrina 2017). According to Bordi et al (2009) SPI method is mostly used because it can give such a reliable comparison and is relatively easy to use in various conditions and climate locations (Febrina, 2017).

The value in SPI shows the condition compared to rainfall at average. If the SPI value is positive it means that it shows bigger than the rainfall at average. If the SPI value is negative, it shows that it is
less than the rainfall at average. Based on the SPI value, drought and wet level can be categorized as follows:

| Class              | SPI       | Class              | SPI       |
|--------------------|-----------|--------------------|-----------|
| Slight drought     | -0.8 to -0.5 | Exceptional wet    | >2        |
| Medium drought     | -1.3 to -0.8 | Too severe wet condition | 1.6 to 2 |
| Severe drought     | -1.6 to -1.3 | Severe wet condition | 1.3 to 1.6 |
| Too severe drought | -2.6 to -1.6 | Medium wet condition | 0.8 to 1.3 |
| Exceptional drought| < -2       | Slight normal      | 0.5 to 0.8 |
|                    |           | Normal             | -0.5 to 0.5 |

The SPI received by the world climate organization as a reference of drought index to describe drought (Khosravi et al, 2017) obtained from Eq 1:

\[
SPI = \frac{P_i - \bar{P}}{\sigma} \quad S = \sqrt{\frac{\Sigma (P_i - \bar{P})^2}{n}}
\]

where

- \(P_i\) = The rainfall of the given period
- \(\sigma\) = the standard deviation
- \(\bar{P}\) = the average of the period of the rainfall
- \(n\) = the number of data in a single period

The vegetation index most generally used is the Normal Difference Vegetation Index (NDVI). Its vegetation index value is based on the difference between the maximum radiation absorption in the red row as the result of chlorophyll pigment and the maximum reflection nearby the infrared spectrum channel / NIR as the result of cellular structure. (Tucker, 1979 in Khosravi). Formulation of NDVI is as follows Eq 2:

\[
NDVI = \frac{NIR - RED}{NIR + RED}
\]

where

- \(NIR\) = The Reflection of the light in NIR band
- \(RED\) = The Reflection of the light in Red band

In this formula, NIR is near infrared band, R is red band. Its domain is variable from -1 to +1. When vegetation is so good and dense, this index is close to +1 and decreases in case of vegetation destruction. To obtain this index, we have used ENVI software.

3. Result and Discussion
The Normalized Difference Vegetation Index at average in Bekasi Regency is -0.14289 to 0.260494. From these values they show the health level of plants (vegetation) in Bekasi Regency.
The result of this research shows that the value of Standardized Rainfall Index (SPI) is ranging between -0.7 to 0.75, in which the SPI value shows the drought level of the research region. The lesser value the drier region it is, and vice versa, the bigger value it is, the more and more water source it is.

From the two results between NDVI and SPI it was found that a region with high vegetation density (in the middle) has the smallest SPI value -0.192 (is being in drought condition). Whereas a region with the highest SPI value in the southwest region, which has no dense vegetation.

**Figure 3.** The Map of Bekasi SPI Index
Figure 4. The Map of Bekasi NDVI Index 2014

Figure 5. The Map of bekasi NDVI Index 2015
Figure 6. The Map of Bekasi NDVI Index 2016

Figure 7. The Map of Bekasi NDVI Index 2017
Figure 8. The Map of Bekasi NDVI Index 2018

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