Hydrometeorological hazard prediction in the kuto bodri river region central java based on normalized difference vegetation index (ndvi) analysis

Y Basuki*, Widjonarko
Departemen of Urban and Regional Planning, Faculty of Engineering, Diponegoro University, Indonesia.
*yudibasuki@lecturer.undip.ac.id

Abstract. The objective of this paper is to predict drought as a hydrometeorological hazard to anticipate the lack of water in Kuto Bodri River Region. The method based on Normalized Difference Vegetation Index (NDVI) analysis. Drought assessment based on the assumption of photosynthetic. If photosynthesis goes well, it indicates that enough water is available to support the process. The data is using Landsat 8 image from March to October 2018. The results show that the potential of drought occurs in the Kuto Bodri River Area in the September-April period. The NDVI value in the period shows a low number, the pattern of distribution of NDVI with a low value is quite even and even in the upstream region which in fact is a forest area NDVI value shows a minus number, meaning photosynthesis does not run well and indicates the availability of water is minimal. The potential drought threat in the Kuto Bodri WS began in June 2018 to October 2018 and occur in the downstream area, especially in the type of paddy fields. Based on this result it is necessary to make policy to anticipate and overcome this hazard such as sosialization in farmer community.

1. Introduction
The development of the area in the north coast of Central Java (especially in the river basin system) is characterized by an increase in population and the physical development of space indicated to contribute to the vulnerability of natural disasters, both in the form of geological, volcanological and hydrometeorological natural disasters. Geological natural disasters are triggered by the condition of geological structures in an area, while volcanological disasters are triggered by volcanic activities. Hydrometeorological disasters are triggered by the conditions of the hydrological and climate systems, where both systems will be strongly associated with land cover.

Hydrometeorological disasters can be defined as a disaster event triggered by hydrological factors (rainfall, evaporation, transpiration), climate factors and oceanography factors. Hydrometeorological disasters include floods, droughts, hurricanes, landslides, heat waves and cold waves [8] [9] [10] [12]. In this research, the hydrometeorological disaster will be focused on the occurrence of droughts and floods.

The types of hydrometeorological disasters as mentioned above vary greatly depending on the duration of the time and scale of the disaster. For example, floods due to hydrometeorological influences can be classified based on the length of the flood event, genetic depth, frequency of flood events, rainfall flow sub-districts and patterns of flood events. Likewise, drought can be grouped based on the duration of the drought, the coverage of drought areas, and the pattern of drought events.
Hydrometeorological disasters have a very significant impact and have the potential to cause substantial loss of life and material. The impact of hydrometeorological disasters can be direct or indirect by humans. Types of disaster impacts can be environmental impacts, economic impacts and social impacts [4][12].

The empirical occurrence of hydrometeorological natural disasters in Central Java Province is inseparable from the condition of land cover that occurs in the upstream and downstream areas of the watershed system in Central Java. Hydrometeorological disasters, especially drought, could not be separated from the reduced ability of upstream areas to absorb water, regardless of the dynamics of changes in vegetation land cover to non-vegetation. The reduced ability to absorb water has an impact on the potential availability of ground water. Reduced potential for groundwater availability will impact on potential drought [2][3]. Another factor that has the potential to influence the drought is rainfall, the higher the intensity of the rain, the lower the potential for drought, and vice versa.

Based on these problems, it is important to conduct a study to map the potential of drought as a result of land cover changes and climate characteristics in the river area in North Central Java, especially in the Kuto Bodri river region, which in fact is a river area with minimal infrastructure for disaster mitigation drought. This study will explore the relationship between potential drought based on land cover data in the river area, using Landsat 8 images. This study aims to assess the potential for drought hazards in the Kuto Bodri River region based on landsat 8 spatio temporal data.

2. Methods

2.1. Location and Time of Research

Research on the drought potential potential is carried out in the Kutobodri River Region located in the Kendal Regency area. The Kuto Bodri River Region is a river area whose management authority is the responsibility of the Central Java Provincial Government. The Kuto Bodri River area consists of 11 watersheds namely: Kuto River, Damar River, Bulanan / Penin River, Blukar River, Bodri River, Buntu River, Kendal River, Blorong River, Aji River, Pesanggrahan River, and Plumbon River. Research Activities carried out in the period December 2017 to December 2018.

2.2. Types and Data Sources

The research on the potential of the Kuto Bodri WS drought hazard using Landsat ETM 8 images in Central Java Province path / row: 120/065, spatial resolution of 30 x 30 m. The data used is monthly Landsat data from March 2018 to October 2018. The selection of the time period is based on cloud cover found in satellite images. The period of January-February and November-December initial cover is more than 20%, so it was decided to only use images with the most minimal cloud cover. Image data obtained through the USGS website, the acquisition process was carried out in July 2019. The process of processing image data using the ArcGIS 10.x application.

2.3. Research methods

The assessment of the level of vulnerability of hydrometeorological disasters in this case is drought will use the image combination process to produce a color combination that will represent the potential for drought in an area. The process of utilizing satellite image data in the assessment of potential drought has been carried out by various researchers. The satellite imagery used uses landsat imagery using near infrared color channels and green channels, as well as infrared shortwaves [5].

This study uses a descriptive method for the results of interpretation of Landsat imagery 8. The process of interpreting Landsat 8 images and the NDVI analysis process uses geographic information system software. The research process begins with pre-processing Landsat 8 image data includes geometric correction stages and image cutting according to the boundaries of the Kuto Bodri river area. Data from the cutting image is used for NDVI analysis and identification of land cover with a guided classification method. The results of the assessment of the Normalized Difference Vegetation Index (NDVI) are overlaid with the results of land cover classification. NDVI analysis was used to obtain the distribution value of vegetation density at Kuto Bodri WS. NDVI describes the sensitivity to
photosynthetic activity by chlorophyll so that the NDVI value can be used to classify vegetation conditions. The condition of the vegetation will greatly affect the reflection of near infrared waves and red wave emission. The healthier the vegetation, the more it will reflect radiation near infrared wavelength compared to the red wavelength, and vice versa. The health condition of vegetation is a representation of sufficient water availability, so that the reflection of the near infrared wavelength will be able to describe the condition of water availability in an area. Based on this, the NDVI value can be used to assess potential drought hazards in an area [2]. Research conducted shows that NDVI is very sensitive to photosynthesis [4] [1] [12]. The mathematical model used to calculate the NDVI value is as follows [7].

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NDVI = \frac{\text{Near Infrared Channel (Band 5)} - \text{Infrared Channel (Band 4)}}{\text{Near Infrared Channel (Band 5)} + \text{Infrared Channel (Band 4)}}
\]

NDVI has a range of values from -1.0 to 1.0. Non-vegetation objects (buildings), clouds, and water have NDVI values less than zero. The vegetation object has an NDVI value in the range 0.1 to 0.7. If the NDVI value is higher than the range of values from 0.1 to 0.7, the health of vegetation is getting better [4][5][6]. The research process showed in the following figure 1.

![NDVI Analysis Process at Kuto Bodri WS](image-url)
3. Results and Discussion

3.1. The NDVI value for Kuto Bodri WS

The NDVI value for Kuto Bodri WS varies from March 2018 to October 2018. NDVI values range from -0.2 to 0.6 from the period March 2018 to June 2018. The NDVI value decreases from July to October 2018 which its range from -0.04 to 0.4. This decrease in NDVI value indicates a decrease in photosynthetic activity [4] [1]. The reduction in photosynthesis cannot be separated from the availability of water as one of the important elements of photosynthesis. The decrease in water availability can be seen from the monthly rainfall in Kendal Regency which decreased in the period June to November 2018 (BMKG, 2019) and began to increase again in December 2018. To provide a clearer picture of the characteristics of the monthly NDVI at the Kuto Bodri WS can be followed in the following figure 2 and 3.

Figure 2. Monthly NDVI Pattern Chart
Based on Figure 2 and 3, it showed that there is one relationship between the decrease in NDVI and the decrease in monthly rainfall in the Kuto Bodri WS. Decreasing monthly rainfall will automatically affect the health of vegetation. Decreased health of vegetation affects the reflection of the more dominant infrared wave light [4] [11][12]. This condition is also an instrument that illustrates the drought potential of the Kuto Bodri WS occurring in the period May to October.

3.2. NDVI on various land cover
By using data from land cover classification and overlapping process for NDVI values, the NDVI value of various land cover can be known. The main focus of the NDVI assessment on land cover is focused on vegetation land cover at the Kuto Bodri WS. The description of the overlapping results between NDVI values and land cover in the Kuto Bodri WS can be followed in the following table 1.

Table 1 Value of NDVI on Cover of Vegetation Land at Kuto Bodri WS

| No. | Land Cover         | Type NDVI   | Area Character |
|-----|--------------------|-------------|----------------|
| 1   | Padi Field         | 0.08 – 0.20 | Downstream     |
| 2   | Forest             | 0.35 - 0.54 | Upper          |
| 3   | Plantation         | 0.41 – 0.60 | Central        |
| 4   | Dryland Agriculture| 0.18 – 0.27 | Central        |

Based on the table 1, it is clear that the threat of Kuto Bodri WS drought occurred in paddy fields. This condition is inseparable that rice plants are a type of plant that requires a lot of water for photosynthetic activities, so farmers will ensure the availability of water to start the planting process. In terms of geographical distribution, forest land cover provides a fairly high reflection of NDVI value and illustrates that the upstream area has relatively no significant threat to the potential drought hazard [1][2][7] [13].

4. Conclusion
Based on the results of the analysis of NDVI values in the period March 2018 to October 2018 the potential drought threat in the Kuto Bodri WS began in June 2018 to October 2018. The potential threat of drought is very potential to occur in the downstream area, especially in the type of paddy fields that require availability water that is adequate for photosynthesis.
The upstream area with forest land cover has a lower potential drought threat compared to the downstream region. The high condition of the upstream region with topographical and higher rainfall and water requirements in forest plants that are relatively lower than the rice fields make the potential threat of drought to be lower. To be able to provide better results accuracy, research on NDVI with a longer period of time will produce more accurate results. A longer period of time can be used for the comparison process between the same month in different years. This comparison will be able to produce a more complete drought pattern and is expected to be used to predict the potential for drought in an area based on the time period.

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Reference
[1] Anja Klisch and Clement Atzberger 2016 Operational Drought Monitoring in Kenya Using MODIS NDVI Time Series Remote Sens vol 8 p 267
[2] Aparicio N, Villegas D, Araus JL, Casadesús J and Royo C 2002 Relationship between growth traits and spectral vegetation indices in durum wheat Crop Sci vol 42 pp 1547-1555
[3] Memon, Ahktar Ali, Sher Muhammad, Said Rahman and Mateeul Haq 2015 Flood Monitoring and Damage Assessment Using Water Indices: A case Study of Pakistan Flood-2012 The Egyptian Journal of Remote Sensing and Space Sciences vol 18 pp 99-106
[4] Mishra AK and Singh VP 2010 A review of drought concepts J. Hydrol vol 391 pp 202–216.
[5] NASA 2000 *handout Measuring Vegetation/measuring_vegetation_2* (earth observation)
[6] Rembold F Atzberger C Savin I and Rojas O 2013 Using low resolution satellite imagery for yield prediction and yield anomaly detection Remote Sens vol 5 pp 1704–1733.
[7] Sruthi S and Mohamed Aslam 2015 Agricultural Drought Analysis Using the NDVI and Land Surface Temperature Data; a Case Study of Raichur District Aquatic Procedia vol 4 pp 1258-1264
[8] Svoboda M 2000 An introduction to the drought monitor Drought Network News vol 12 p 80
[9] Thenkabail P S 2005 *Remote Sensing of Water Resources, Disasters, and Urban Studies* (CRC Press: Boca Raton, FL, USA).
[10] UNISDR, 2009, *Terminology of Hydrological Disasters* (UNISDR)
[11] Xu H 2006 Modification of Normalized Difference Water Index (NDWI) to Enhance Open Water Features in Remotely Sensed Imagery, International Journal of Remote Sensing vol 14 pp 3025-3033
[12] Wilhite D and Buchanan-Smith M 2005 *Drought as a natural hazard: Understanding the natural and social context* In Drought and Water Crises: Science, Technology, and Management Issues; (CRC Press: Boca Raton, FL, USA, pp. 3–29).
[13] Zavaleta ES, Thomas BD, Chiariello NR, Asner GP and Shaw MR 2003 Plants reverse warming effect on ecosystem water balance. PNAS vol 17 pp 1892-1893.