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Research Highlights

An Ongoing Approach for Drought Detection in Sumatra, Indonesia

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Drought has been considered a major threat to human beings as it affects various aspects of human life, including food production. Water plays an important role for plant growth and production, and thus limited availability of water would result in inhibited growth and reduced yield. A change in the ecosystem comprises three classes: (i) seasonal change, caused by the changes in temperature and rainfall per year that influences plant phenology with different vegetation types, (ii) gradual change, a change of mean annual rainfall or land cover, (iii) abrupt trend change, a change driven by human activities or natural disasters (Verbesselt, Hyndman, Newnham, & Culvenor, 2010; Vogelmann, Xian, Homer, & Tolk, 2012). A natural disaster such as long-term drought is classified as gradual change since it results in changes over some years. The detection of gradual change on vegetation in an area of the Sumatra Island, Indonesia is higlighted in this article. The key to plant survival is the transpiration process that transports water from the roots to the leaves via the circulatory system comprising the xylem and phloem. Plant cells require sufficient water to maintain turgidity. Inability to maintain turgor pressure will result in the plant becoming flaccid. For example, rice paddy, requires a substantial amount of water to maintain its growth and yield, thus, water stress would significantly reduce its growth and yield. Water stress on plants could be identified by changes in its physical appearance. Current studies are focusing on finding an effective and efficient way for drought detection and monitoring by utilizing remote sensing technology.

The Indonesia Agency for Meteorology, Climatology, and Geophysics (BMKG) predicts drought conditions in all areas within Indonesia. The BMKG has a WMO-recommended tool with Standardized Precipitation Index (SPI) method showing an index calculated based on the probability of the recorded amount of rainfall; negative index values for drought, and positive for wet conditions (Nurhayati, et al. 2018). The SPI can be utilized to monitor climate conditions on a range of time intervals (monthly, three monthly, seasonal, annual). Together with remote sensing technology, data generated from SPI can be further used to detect and monitor drought.

The posssibilities of using remote sensing to observe changes on land cover and LAI (leaf area index) of vegetation is explored. By using MODIS EVI Satellite Images with Breaks For Additive Season and Trend (BFAST) time series analysis, the possibility of drought can be detected. The BFAST is a method that can be used by operating Rstudio and R (http://bfast.r-forge.rproject.org/). It detects either significant or gradual changes in global range in time series with magnitude and direction. It combines the decomposition of a time series into trend, seasonal, and the remaining component (Aulia, Setiawan, & Fatikhunnada, 2016).

The BFAST time series can be detected from changes occurring in the trend component that indicates gradual change and break. These changes occurred in 2015 at -1.65 inches and it was analysed as the most serious drought. Unusual strong El Nino and land clearance were the factors cited for the prolonged dry weather in 2015 in Sumatra, Indonesia.

The affected vegetation experienced water stress. Furthermore, based on the images acquired from MODIS Land Cover Type Product (MCD12Q1), there were several land use changes from 2004 to 2013. Vegetation areas were converted into building and housing areas which became one of the main factors for water scarcity in Sumatra, Indonesia. Various stakeholders in Indonesia, namely the Ministry of Agriculture, Directorate of Water Resources, Local Authorities and the National Board for Disaster Management, who are responsible for drought early-warning have been putting a lot of effort in building up a communication system to inform the general public about this solution. They do it by providing information that can be accessed through the website (http://cews.bmkg.go.id/). Although, this is a very good initiative, some aspects still need to be improved. An example is the quality and speed of information dissemination to the public. Water consumption by the public plays an important role in the management of drought. The National Committee of Water and River Basin Management, which consists of the Directorate General for Water Resources, National Met Service, Directorate of Groundwater and Earth, and related NGOs, conduct meetings on a regular basis to make recommendations to the policy-makers at the national level on appropriate programs to be undertaken in water resources issues, including drought. Rainfall intensity will continue to increase throughout the 21st century in some regions, while some places will receive lesser precipitation (IPCC 2007). Remote sensing technology has a huge potential in application and utilization for drought detection and monitoring. BFAST is now available to estimate the time and number of abrupt changes within time series in case of drought. It can be used to analyze across different time series (e.g. Landsat, MODIS) where the data satellite can be acquired freely. Therefore, this proposed analysis is applicable in other similar settings, especially in countries that either do not have sufficient data collection points (weather stations) or lack consistent data collection. Despite the sweeping benefits, this proposed analysis also has some limitations, such as cloud cover issues on the image acquired by the satelite, availability of satellite observational data and resolution of the data. While it has some limitations that need to be addressed, BFAST nonetheless does offer a potential to help stakeholders and policy-makers to better detect and monitor droughts so that they can make well-informed decisions on crop rotation, grain stock-piling and prudent water management.

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