Monitoring Peat Soil Water Content in Oil Palm Plantations for Sustainable Agriculture Using Satellite Imagery

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The development of oil palm plantations in Indonesia is speedy. The percentage of Oil Palm Land Cover based on Ministry of Agriculture data in 2019 was 16.38 million hectares. Some oil palm plantations in Indonesia are located on sub-optimal land, especially peat land. Developing peatlands for oil palm cultivation requires soil drainage to support optimal plant growth and production. Peat soil drainage affects soil water content. In the long term, soil drainage causes several impacts on the soil layer above the groundwater table, including decreasing groundwater levels, increasing aeration, carbon release, and lowering the surface of peat soil (subsidence) (Szajdak & Szatylowicz, 2010). Excessive drainage of peat soil causes the soil to dry out, and irreversible dryness (hydrophobicity) will appear (Brandyk et al., 2002). In conditions of low soil water levels, the lower leaves of oil palms begin to dry out. Apart from that, the water content of peat soil has a significant influence on palm oil production. A decrease in the groundwater level depth of more than 70 cm affected the incline average weight of oil palm bunches (Winarna, 2015).

One method to optimize palm oil production is land monitoring. The typical method for monitoring soil water content is taking soil samples and then analyzing them using the gravimetric method. The results of measuring soil water content using the gravimetric method cannot be done in real-time. Currently, technological developments are speedy. Calculation of soil water content can be done through the use of sensors. Nugroho et al. (2023) developed a Soil Moisture Content Monitoring System (SMC) for Precision Measurement of Soil Moisture in Sub-Optimal Land for Palm Oil Plantation. The soil Moisture Content (SMC) was designed to consist of sensors for soil moisture content and soil temperature placed in the soil at three different depths in spodosols. This system is excellent and able to detect soil water levels real-time. Observation of water content using gravimetric methods and sensors has spatial limitations. Both methods are suitable for spot observation, so another method that can be used for wide-scale and fast observations is needed.

Current technological developments, especially in remote sensing, make it possible to carry out monitoring on a wide scale. Utilizing satellite image data for monitoring soil water content is possible and has great potential for development (Peng et al., 2021); however, this technology still needs to be implemented in the palm oil industry. The research was conducted in the Labuhan Batu area of North Sumatra Province. The treatment used in this research is an area with a groundwater level of 35-50 cm, 60-75cm, and 80-95 cm. The characteristic of the peat in the research area is hemosaprist maturity peatland with more than 3 meters of depth. The satellite image used was Landsat 8. Observations were carried out during the transition season and rainy season. Interim results show that the extracted pixel values converted into TDVI values showed a strong relationship (R transition season: 0.675 and R rainy season: 0.968) and were negative with soil water content. This negative relationship could be seen from the opposite pattern between TDVI values and actual soil water content. The higher the TDVI value, the lower the actual water content in the field. This pattern occurred both in the transition season and the rainy season. TDVI values were generally higher in the rainy season than in the transition season. Based on the results of simple linear regression calculations, the formula that can be used for upscaling soil water content values during the transition season is y = - 203963x + 567.04. The formula for upscaling in the rainy season is y = -219907x + 562.89.

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