THE FUNCTION OF NDWI AND NDTI IN DIFFERENTIATING THE CHARACTERISTICS OF WATER AREAS BASED ON SENTINEL 2 IMAGERY

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ABSTRACT

The use of remote sensing technology with satellite imagery data as the main medium has been widely used in analyzing data obtained using tools without direct contact with the object, phenomenon, or area under study. One of the satellite image data that can be accessed free of charge and officially is the Sentinel-2 MSI (Multi-Spectral Instrument) image data, which is data developed by the European Space Agency (ESA). Sentinel-2A image data used in this study is divided into 2 data levels, namely Level 1C and Level 2A. Recording data on the Sentinel-2A imagery used in this study uses a variety of different seasonal data, including the transitional season from the dry season to the rainy season in October 2018, the rainy season in November 2020, and the dry season in April 2022. NDWI is used to analyze water areas and non-aquatic while NDTI is used to analyze water turbidity. The results of the analysis show that the NDWI values in 2018 and 2020 range from the lowest value of -0.82 to the highest value of 0.79. The results of the analysis in 2022 show that the NDWI value is in the range of the lowest value of -0.87 and the highest value of 0.99. The results of the NDTI value analysis in 2018 ranged from the lowest value range of -0.51 and the highest value of 0.45. The results of the NDTI value analysis in 2020 range from the lowest value of -0.62 to the highest value of 0.43. The results of the NDTI analysis in 2022 range from the lowest value of -0.72 to the highest value of 0.43.

Keywords : NDTI, NDWI, Remote Sensing, Sentinel-2A

ABSTRAK

Penggunaan teknologi penginderaan jauh dengan data citra satelit sebagai media utama telah banyak digunakan dalam menganalisis data yang diperoleh menggunakan alat tanpa kontak langsung dengan objek, fenomena, atau area yang sedang dipelajari. Salah satu data citra satelit yang dapat diakses secara gratis dan resmi adalah data citra Sentinel-2 MSI (Multi-Spectral Instrument), yang merupakan data yang dikembangkan oleh Badan Antariksa Eropa (ESA). Data citra Sentinel-2A yang digunakan dalam penelitian ini terbagi menjadi 2 level data, yaitu Level 1C dan Level 2A. Perekaman data pada citra Sentinel-2A yang digunakan dalam penelitian ini menggunakan berbagai data musiman yang berbeda, termasuk musim peralihan dari musim kemarau ke musim hujan pada Oktober 2018, musim hujan pada November 2020, dan musim kemarau pada April 2022. NDWI digunakan untuk menganalisis area perairan dan non-perairan, sedangkan NDTI digunakan untuk menganalisis kekeruhan air. Hasil analisis menunjukkan bahwa nilai NDWI pada tahun 2018 dan 2020 berkisar dari nilai terendah -0,82 hingga nilai tertinggi 0,79. Hasil analisis pada tahun 2022 menunjukkan bahwa nilai NDWI berada dalam rentang nilai terendah -0,87 dan nilai tertinggi 0,99. Hasil analisis nilai NDTI pada tahun 2018 berkisar dari rentang nilai terendah -0,51 hingga nilai tertinggi 0,45. Hasil analisis nilai NDTI pada tahun 2020 berkisar dari nilai terendah -0,62 hingga nilai tertinggi 0,43. Hasil analisis NDTI pada tahun 2022 berkisar dari nilai terendah -0,72 hingga nilai tertinggi 0,43.

Kata kunci: NDTI, NDWI, Penginderaan Jauh, Sentinel-2A

1. 1. Introduction

Remote sensing is a science to obtain information about objects, phenomena or areas through analysis of data obtained using tools without making direct contact with the object, phenomenon or area under study (Virdis et al., 2022). Remote sensing technology has been widely used to obtain information from field samples with large area boundaries (Subiyanto et al., 2018). Field sampling in a large area can cause a lot of effort, a lot of time and a lot of costs in the process, so that an alternative solution to this problem has been developed through the presence of remote sensing technology (Bonansea et al., 2019).

Sentinel-2 Image Data MSI (MultiSpectral Instrument) is data developed by the European Space Agency (ESA) which provides good data contribution and continuity for users to monitor waters, soil, and vegetation (Syam'ani, 2021). The mission of the Sentinel-2 launch is to present data with high spatial resolution with multiple spectral bands, providing open data access with a short data re-recording time so that the currently available data is sufficient for use (Pałas & Zawadzki, 2020). Sentinel-2 satellite data offers a valuable scientific tool for investigating aquatic ecosystems. This capability lies in its ability to monitor and map water quality parameters within both nearshore and inland water bodies (Solovey, 2020).

Sentinel-2A image data used in this study is divided into 2 data levels, namely Level 1C and Level 2A. The Level-1C product is a data product that has been radiometrically corrected, but not atmospherically corrected. The Level-2A product provides atmospherically corrected data recording results, derived from the related Level-1C product, so the Level-2A product is radiometrically and atmospherically corrected data (Uwe et al., 2013). The research focused on several mainland areas in Bali Province which include regencies of Karangasem, Bangli, Gianyar, Klungkung, Denpasar and several areas in South Badung. The water areas in the form of beaches and sea are focused on the eastern region of Bali Province.

The recording data on the Sentinel-2A imagery data used in the study used different seasonal data variations, including the transitional season from the dry season to the rainy season in October 2018, the rainy season in November 2020 and the dry season in April 2022. It is hoped that this difference in seasons will be able to provides a different picture of the differences in the resulting NDWI and NDTI values so that the factors that cause these differences in values can be analyzed further.

2. Materials and Method

The Sentinel-2A satellite captures imagery with varying spatial resolutions: 10 meters (Bands 2, 3, 4, and 8), 20 meters (Bands 5, 6, 7, 8A, 11, and 12), and 60 meters (Bands 1, 9, and 10). Resampling techniques might be necessary to address geometric distortions present in the raw (Roy et al., 2016).

Atmospheric correction is a technique employed to eliminate atmospheric influence on remotely sensed data. This process strives to preserve both the spatial resolution of the data and the original order of spectral channels within the image for subsequent analysis (Rumora et al., 2020). In this study, atmospheric correction is focused on Level-1C data, where the input image level-1C (upper atmospheric reflection) is converted into a level-2A product (lower atmospheric reflection).

The NDTI value indicates the level of turbidity of the object. The greater the NDTI value, the higher the turbidity of the water (Rahman et al., 2021). NDTI is a formula made by (Lacaux et al., 2007) using the red channel (RED) and the green channel (GREEN). In the Sentinel-2A image data, the red channel is shown in Band 4 and the green channel is shown in Band 3. The form of the NDTI equation in the SNAP application is as follows:

$$NDTI = \frac{RED-GREEN}{RED+GREEN} \quad (1)$$

NDWI is an index that describes the body of water of an object. NDWI2 in the SNAP application uses a formula developed by (Xu, 2006), where in NDWI calculations it uses a green channel (GREEN) and a short infrared channel (SWIR). In the Sentinel-2A image data, the green channel is shown in Band 3 and the short infrared channel is shown in Band 12. According to (Sukojo & Prayoga, 2018), the level of drought vulnerability will be lower if the resulting NDWI value is higher. The level of drought vulnerability will be higher if the resulting NDWI value is lower. The form of the NDWI2 equation in the SNAP application is as follows:

$$NDWI = \frac{GREEN-SWIR}{GREEN+SWIR} \quad (2)$$

3. Results and Discussion

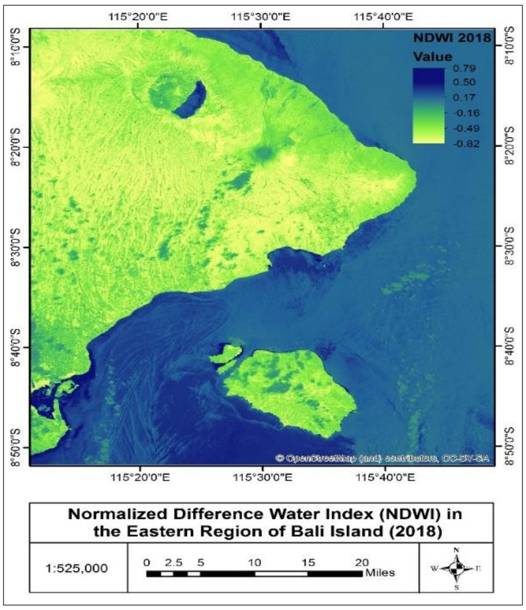

Figure 1. NDWI Value in the Eastern Region of Bali Island (2018)

The data for 2018 is data from the Sentinel-2A Level 1C satellite imagery on October 10th, 2018, which is the month of transition from the dry season to the rainy season. The results of the analysis show that the NDWI values range from the lowest value of -0.82 to the highest value of 0.79. The classification of non-water body areas is shown in yellow and light green which indicates that the area is a land area which is a residential area along with the types of vegetation that exist. Medium wettability classification is shown in light blue and high wettability classification is shown in dark blue. Moderate wetness and high wetness are the coastal and ocean areas as well as Lake Batur in the study area. Cloud cover which is in the process of recording direct image data is classified as a non-water body class. The distribution of cloud cover in the 2018 recording data is on the central side in land areas and the southeast and south sides in water areas.

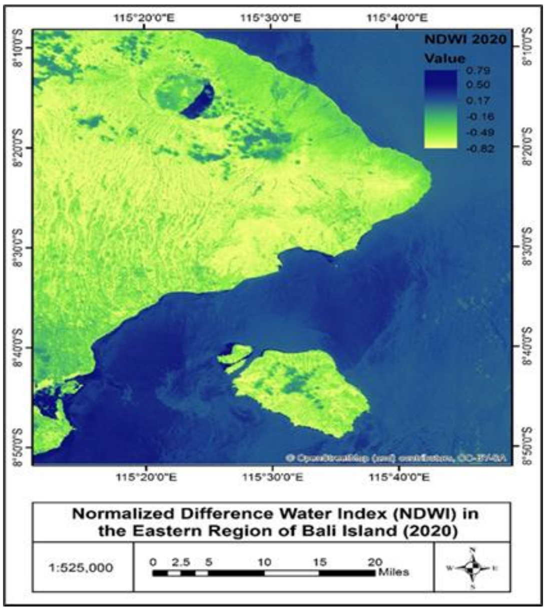

Figure 2. NDWI Value in the Eastern Region of Bali Island (2020)

The data for 2020 is data from the Sentinel-2A Level 1C satellite imagery on November 8th, 2020, which is the rainy season. The results of the analysis show that the NDWI values range from the lowest value of -0.82 to the highest value of 0.79. The classification of non-water body areas is shown in yellow and light green which indicates that the area is a land area which is a residential area along with the types of vegetation that exist. Medium wettability classification is shown in light blue and high wettability classification is shown in dark blue. Moderate wetness and high wetness are the coastal and ocean areas as well as Lake Batur in the study area. Cloud cover which is in the process of recording direct image data is classified as a non-water body class. The distribution of cloud cover in the 2020 recording data is on the north and south sides in land areas and the southeast side in water areas.

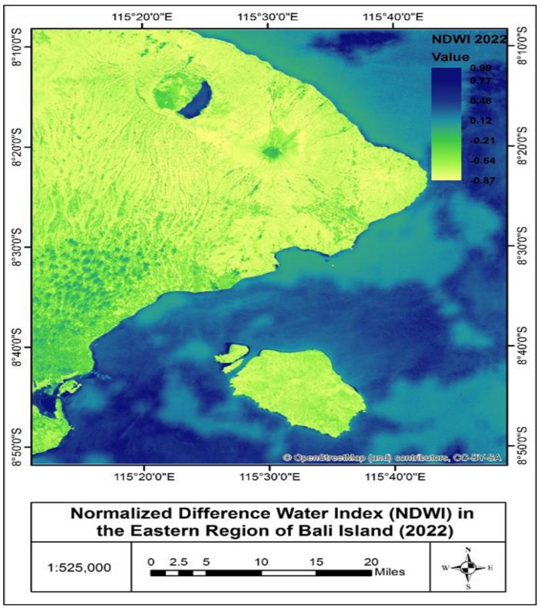

Figure 3. NDWI Value in the Eastern Region of Bali Island (2022)

The data for 2022 is data from the Sentinel-2A Level 2A satellite imagery recorded on April 27th 2022, which is the dry season. The results of the analysis show that the NDWI value ranges from the lowest value of -0.87 to the highest value of 0.99. The classification of non-water body areas is shown in yellow and light green which indicates that the area is a land area which is a residential area along with the types of vegetation that exist. Medium wettability classification is shown in light blue and high wettability classification is shown in dark blue. Moderate wetness and high wetness are the coastal and ocean areas as well as Lake Batur in the study area. Cloud cover which is in the process of recording direct image data is classified as a non-water body class. The spread of cloud cover in the 2022 recording data is on the south side in the mainland.

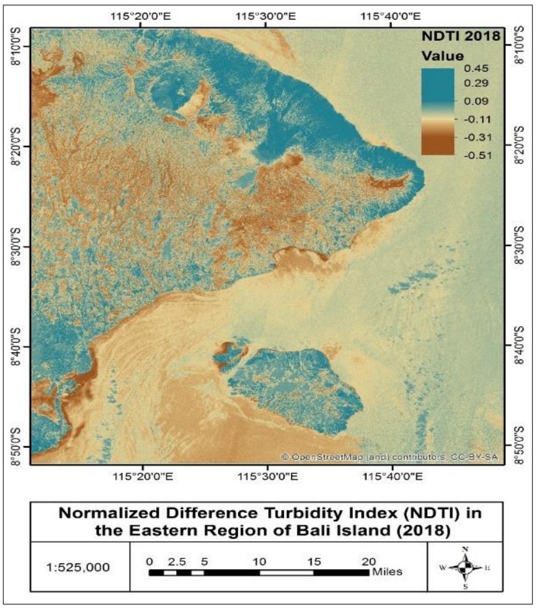

Figure 4. NDTI Value in the Eastern Region of Bali Island (2018)

The data for 2018 is data from the Sentinel-2A Level 1C satellite imagery on October 10th, 2018, which is the month of transition from the dry season to the rainy season. The results of the analysis show that the NDTI value ranges from the lowest value of -0.51 to the highest value of 0.45. The highest NDTI analysis results were in the northern part of the mainland which is the Kubu District in Karangasem Regency. The area is an irrigation area for agricultural activities. Irrigation water for agricultural activities is considered turbid because the water is mixed with existing soil particles. The highest turbidity values were also found at several existing river estuary points. The lowest turbidity values are in several land areas and the southern part of the water area in the form of beaches and seas. Turbidity affects the value of water fertility where the lower the turbidity value, the lower the productivity of the waters.

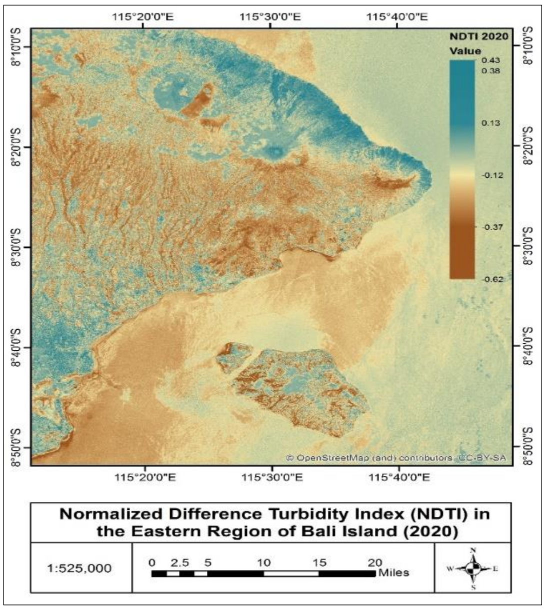

Figure 5. NDTI Value in the Eastern Region of Bali Island (2020)

The data for 2020 is data from the Sentinel-2A Level 1C satellite imagery on November 8th, 2020, which is the rainy season. The results of the analysis show that the NDTI value ranges from the lowest value of -0.62 to the highest value of 0.43. The highest NDTI analysis results were in the northern part of the mainland which is the Kubu District in Karangasem Regency. The area is an irrigation area for agricultural activities. Irrigation water for agricultural activities is considered turbid because the water is mixed with existing soil particles. The highest turbidity values were also found at several existing river estuary points. The lowest turbidity values are in several land areas and the southern part of the water area in the form of beaches and seas. Turbidity affects the value of water fertility where the lower the turbidity value, the lower the productivity of the waters.

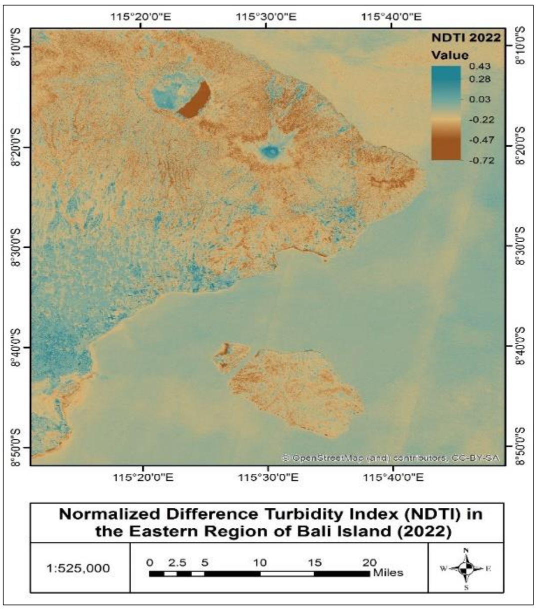

Figure 6. NDTI Value in the Eastern Region of Bali Island (2022)

The data for 2022 is data from the Sentinel-2A Level 2A satellite imagery recorded on April 27th 2022, which is the dry season. The results of the analysis show that the NDTI value ranges from the lowest value of -0.72 to the highest value of 0.43. Turbidity values are found at several points in the coastal waters and the southern part of the ocean. Identification of turbidity values in water areas does not only come from suspended material, but can be influenced by several factors including the distribution of phytoplankton biomass in a waters which can be seen from the distribution of chlorophyll-a. Chlorophyll-a is an indicator that can measure the value of water fertility, where chlorophyll-a has a role in carrying out photosynthesis. The intensity of light will increase the growth of phytoplankton, so that the more fertile the phytoplankton eats the higher the chlorophyll value. In a study conducted by (Suhendar et al., 2020), it showed that the relationship between turbidity and chlorophyll had a positive relationship with the existing turbidity concentration values.

4. Conclusions and Recommendations

Based on the results of the analysis, it can be concluded that NDWI can correctly identify differences between water areas and non-water areas. This is shown by the results of the classification of non-water body areas shown in yellow and light green which indicate that the area is a land area which is a residential area along with the types of vegetation that exist. Medium wettability classification is shown in light blue and high wettability classification is shown in dark blue. Moderate wetness and high wetness are the coastal and ocean areas as well as Lake Batur in the study area. The NDWI typically spans values between -1 and 1. For the observation years we examined (2018, 2020, and 2022), NDWI values ranged from -0.82 to 0.79 in both 2018 and 2020, while 2022 exhibited a broader range of -0.87 to 0.99.

The NDTI analysis results also show accuracy in analyzing water turbidity results. This is shown by the differences in the seasons being analyzed, resulting in different characteristics of water turbidity. In the 2018 and 2020 analysis results, the highest NDTI analysis results are in the northern part of the mainland, which is Kubu District in Karangasem Regency. The area is an irrigation area for agricultural activities. Irrigation water for agricultural activities is considered turbid because the water is mixed with existing soil particles. The highest turbidity values were also found at several existing river estuary points, where in 2018 was the transition season from dry to rainy and 2020 was the rainy season. The results of the 2022 analysis during the dry season show that turbidity values are found at several points in the southern coastal and oceanic waters. The intensity of light will increase the growth of phytoplankton, so that the more fertile the phytoplankton eats the higher the chlorophyll value in the water area.

Suggestions that the author can give for the sustainability of the analysis that has been carried out is that there is further research on the distribution of suspended particles, chlorophyll-a in the analyzed area so as to provide an overview of the differences in results obtained for the presence of seasonal variations in the analysis.

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