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Analysis of NDVI and NDRE Indices Using Satellite Images for Crop Identification at Kelantan

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Abstract. In Malaysia, the expansion of rubber trees, oil palm, and paddy plantations has become widely increased because of economic demands. Crop identification or monitoring is one of these applications since remote sensing provides precise, up-to-date, and cost-effective data on a range of crop kinds at various temporal and geographic resolutions. This study recommended integrating multispectral images, a tree canopy segmentation algorithm, and vegetable indicators to measure the attributes and spectral properties of crops and plants in a Kelantan region. Normalised difference vegetation index (NDVI) and normalised difference red edge (NDRE) were obtained from five spectral band images (red, green, blue, infrared (NIR), and red edge 2 (REDGE) that were processed by software into a full image map. NDVI is based on a plant's characteristic reflection of a mix of visible red and near-infrared (NIR) light. NDVI function is to calculate the percentages of canopy cover, whereas the NDRE index is to assess leaf chlorophyll concentration or nitrogen content. The Red Edge sensors detected fluctuations in chlorophyll content within the leaf and throughout the plant canopy. Based on Landsat 8 and Sentinel 2A data, this study determined the NDVI and NDRE values for the crops in paddy fields, oil palm plantations and rubber tree plantations from different locations in Kelantan. The data was then analysed, the bar graphs and an emerging analysis of the differences between NDVI and NDRE maps for crop identification were used to present the results, respectively.

1. Introduction

Agricultural producers and tree condition assessors can benefit greatly from new technology to aid in decision-making. The types of trees may be assessed using multispectral pictures obtained by satellite or manned aircraft, and the newest technological options, such as drones, are only practicable or economically feasible. Natural resource management and other earth observation applications rely heavily on remote sensing technologies. Crop monitoring is one of these applications, because remote sensing provides precise, up-to-date, and cost-effective information on a variety of crop types at different temporal and geographic resolutions. To measure the attributes and spectral properties of crops and plants in a Kelantan, this study recommends integrating multispectral images, a tree canopy segmentation algorithm, and vegetable indicators. The possible use of two separate Sentinel 2A vegetation indices on crop type classification, as well as the influence of each index on classification accuracy was examined in this study. Because all of these incorporated the near-infrared (NIR) band from Sentinel 2A images, the normalised difference vegetation index (NDVI) and normalised difference red edge (NDRE) index were obtained from five spectral band images (red, green, blue, infrared (NIR), and red edge (REDGE)) that were processed by software into a full image map. A plant's characteristic reflection of a mix of visible red and near-infrared (NIR) light offers a robust indication of chlorophyll substantially better than what visible light reflectance can indicate NDVI was developed. NDRE able to measure the amount of chlorophyll in plants and provide a more accurate response. The Red Edge

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sensors can detect fluctuations in chlorophyll content within the leaf and throughout the plant canopy, making it more useful in later crop stages when NDVI saturation is present [1].

Crop identification for individual plots as well as the evaluation of soil management choices helps in agro-ecological research, greenhouse gas modelling, and policy development. Because crop production is so essential to many emerging economies' economy, local governments and agricultural agencies must collaborate to guarantee that agricultural areas are maintained in a sustainable manner [2]. On the other hand, remote sensing image processing might be a more precise and economical method of monitoring crop fields across wide areas while also providing reliable temporal data [3]. Remote sensing data and supplementary information can be utilised to identify the geographical distribution of crops at various spatial scales with little financial resources. Crop mapping and identification serve as a foundation for a variety of agricultural uses, including yield estimation, crop rotation data, and soil health. Over this stage, remote sensing technology aids in obtaining precise and dependable information regarding crop kinds across many geographical and temporal domains. The identification of crop yields is essential for food security. Many of these information demands have been attributed to remote sensing as a technology. Changes in canopy density can dominate spectral response, making it difficult to link spectral variations to other crop parameters, especially before the crop reaches full cover. Remote sensing data has increased widely employed in agriculture and agricultural production [4], particularly when based on a predictive empirical model, because such data may be used to estimate crop yield accurately and quantitatively.

Monitoring of vegetation and primary production dynamics may be done using a variety of remote sensing approaches. The quantity and composition of radiation that reaches a surface, as well as the reflectance qualities of the surface itself, affect the amount of light reflected. Green vegetation absorbs energy from the sun in the photosynthetically active spectral area, providing the energy required for photosynthesis [5]. A typical reflectance spectrum of a vegetation canopy can subdivide into three parts, specifically, visible, near infrared (0.73—1.3 pm), and mid-infrared (1.3-2.5 pm). Chlorophyll pigments absorb heavily in the visible spectrum's red and blue areas, but not in green [5][6]. The Normalised Difference Vegetation Index (NDVI) function is to calculate percentage of canopy cover, whereas the Normalised Difference Red Edge (NDRE) index is to assess leaf chlorophyll concentration or nitrogen content [7]. Therefore, this study aims to identify and analyze the differences of NDVI and NDRE value for the paddy fields, oil palm plantations and rubber tree plantation crop in Kelantan based on Landsat 8 and Sentinel 2A images.

2. Materials and Method

2.1. Study Area

This study was conducted in Kelantan, which is located in the northeast of Peninsular Malaysia between coordinates (4.546180 – 6.243976)° North and (101.333321 – 102.666456)° East. Kelantan is bounded by Narathiwat Province of Thailand on the north, Terengganu state on its southeast, Perak on the west, and Pahang state on the south. Kelantan comprises 1.51 million hectares of Peninsular Malaysia's total area of 13.18 million ha. Kelantan's total forested area is 812,916 ha as of 2016, with a total Permanent Reserve Forest (PRF) of 635,437 ha. Bachok, Gua Musang, Jeli, Kota Bharu, Kuala Krai, Machang, Pasir Mas, Pasir Puteh, Tanah Merah, and Tumpat are the ten districts that make up Kelantan. Figure 1 shows the study sites which is 10 sites for each 3 crop types of oil palm, paddy and rubber. The GPS location for each site was collected by visiting to the site for ground truth data validation.

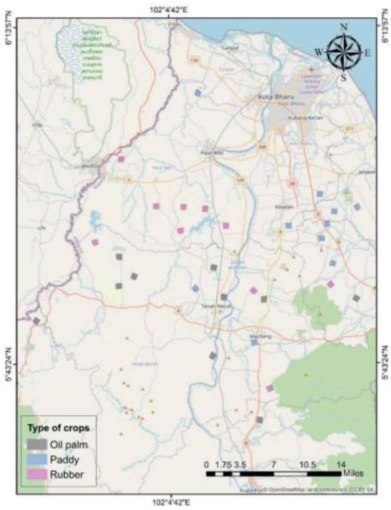


Figure 1. The study area of Kelantan

2.2. Data Collection

USGS Earth Explorer was used to obtain and download Landsat 8 and Sentinel 2A satellite images from March 2022. The acquired data was then utilised to examine vegetation indicators such as NDVI and NDRE. The location of paddy fields, oil palm plantations, and rubber plantations were collected and exported from Google Earth Pro to get shapefiles that KML files for use in Google Earth Pro by utilising the Layer to KML tool to save the shapefiles as a KML file and utilized in ArcGIS.

The additional bands of the sensor are REDGE and NIR. The NIR band is in the spectral region behind the red band and is useful in detecting of plant’s chlorophyll. Another constituent spectral region is the REDGE. This band is located between the red band and the NIR band. Plants increase the reflection coefficient between the red and NIR region, which leads to a sharp increase in the reflection coefficient through the REDGE band. Different combinations of the bands of NDVI and NDRE allowed to observe different analytical layers.

$$NDVI = (NIR - R)/(NIR + R) \quad (1)$$
$$NDRE = (NIR - RE)/(NIR + RE) \quad (2)$$

Crop vegetations activity and chlorophyll content been evaluated by using NDVI and NDRE indices and analyzed using ArcGIS and Excel software.

3. Results and Discussion

This study addressed the data obtained from satellite photos taken in Kelantan using two different sensors, Landsat 8, and Sentinel 2A. Data were generated with the classification accuracy index utilising two vegetation indices, NDVI and NDRE, that classifier variety indices value of for paddy fields, oil palm plantations, and rubber tree plantations. The categorization is designed to establish a distinction between two indices. The goals were to compare the differences between NDVI and NDRE for crop identification and to identify the types of crops.

3.1. Image Pre-Processing

The pre-processing was done to increase the image's quality so that the analysis more effectively. The unwanted distortions been reduced and boost some qualities that are required for the application that are working on by pre-processing. This study used radiometric correction and atmospheric adjustment for pre-processing. The satellite images captured by Sentinel-2A, and Landsat 8 undergo pre-processing Radiometric process in ArcGIS 10.3 Software to improve the fidelity of the brightness value magnitudes.

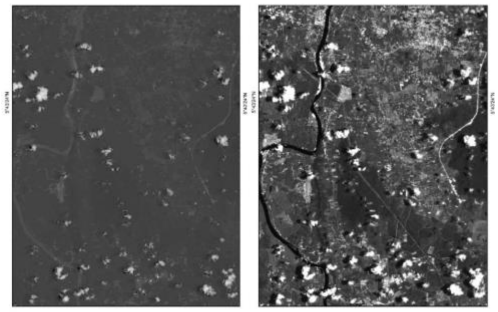


Figure 2. Differences of before and after Radiometric Correction.

The objective of atmospheric correction is to determine true surface reflectance values by removing atmospheric effects from satellite images.

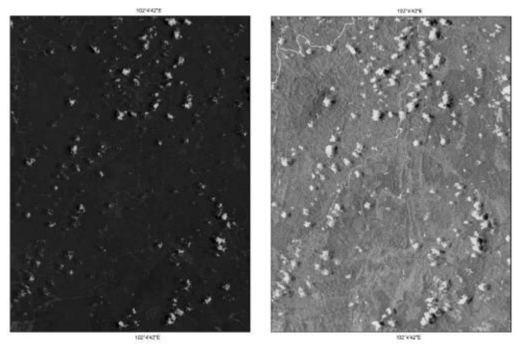
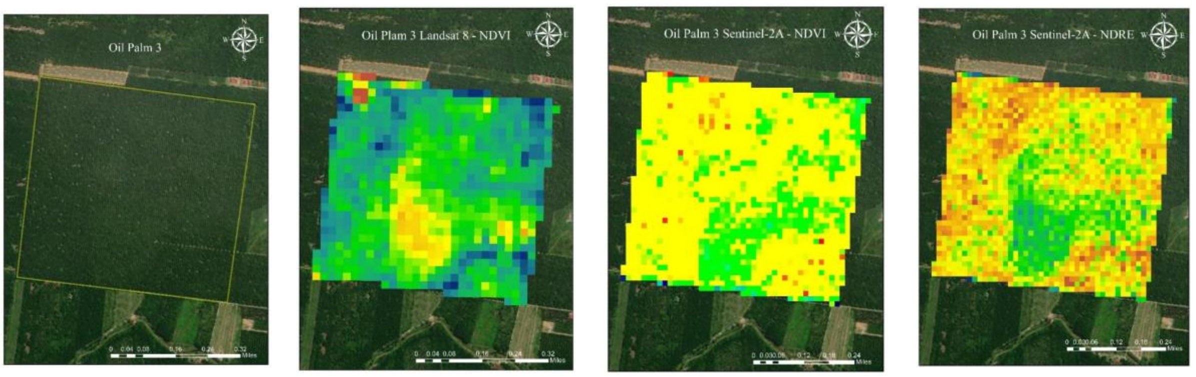


Figure 3. Differences between before and after Atmospheric Correction.

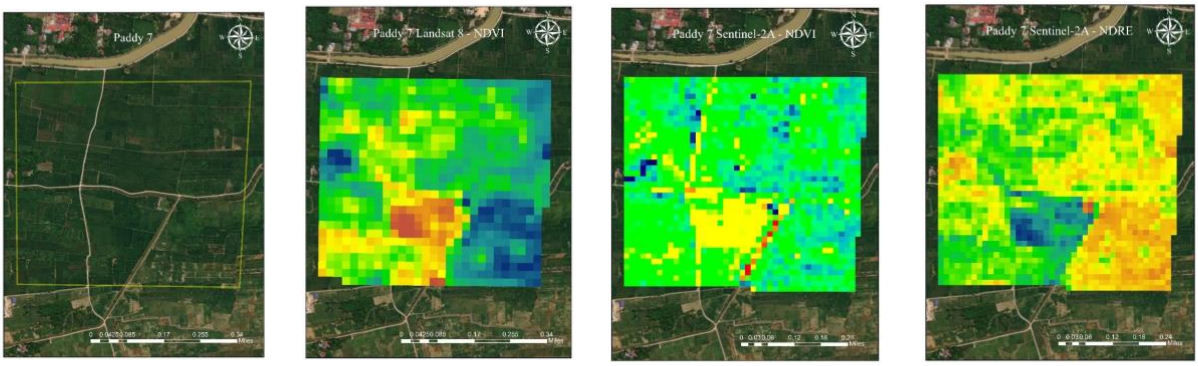
3.2. Results of NDVI and NDRE

Figure 4 to Figure 6 shows the NDVI and NDRE between 2 satellite images from Landsat 8 and Sentinel 2A based on the selected location of oil palm (site 3), paddy (site 7) and rubber tree (site 2), respectively.



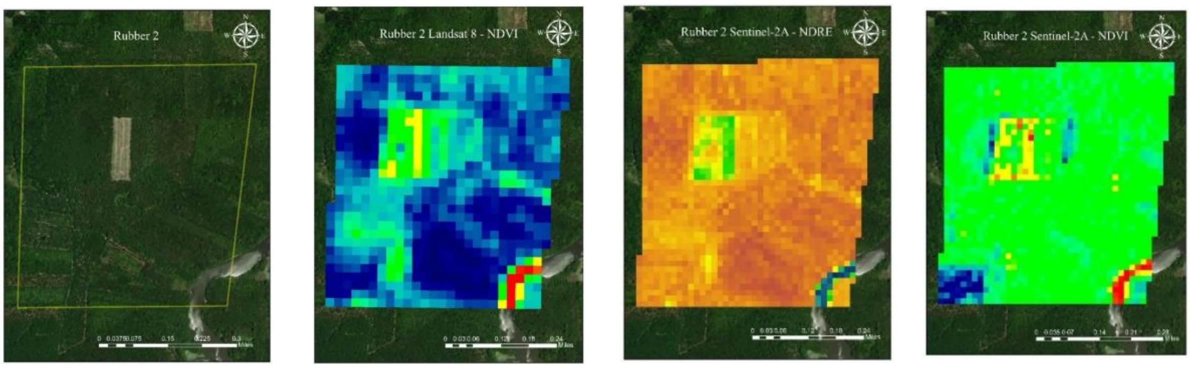
a) b) c) d)

Figure 4. Images of oil palm plantation area of a) study site oil palm 3, b) NDVI of Landsat 8, c) NDVI of Sentinel 2A and d) NDRE of Sentinel 2A



a) b) c) d)

Figure 5. Images of paddy field area of a) study site paddy 7, b) NDVI of Landsat 8, c) NDVI of Sentinel 2A and d) NDRE of Sentinel 2A



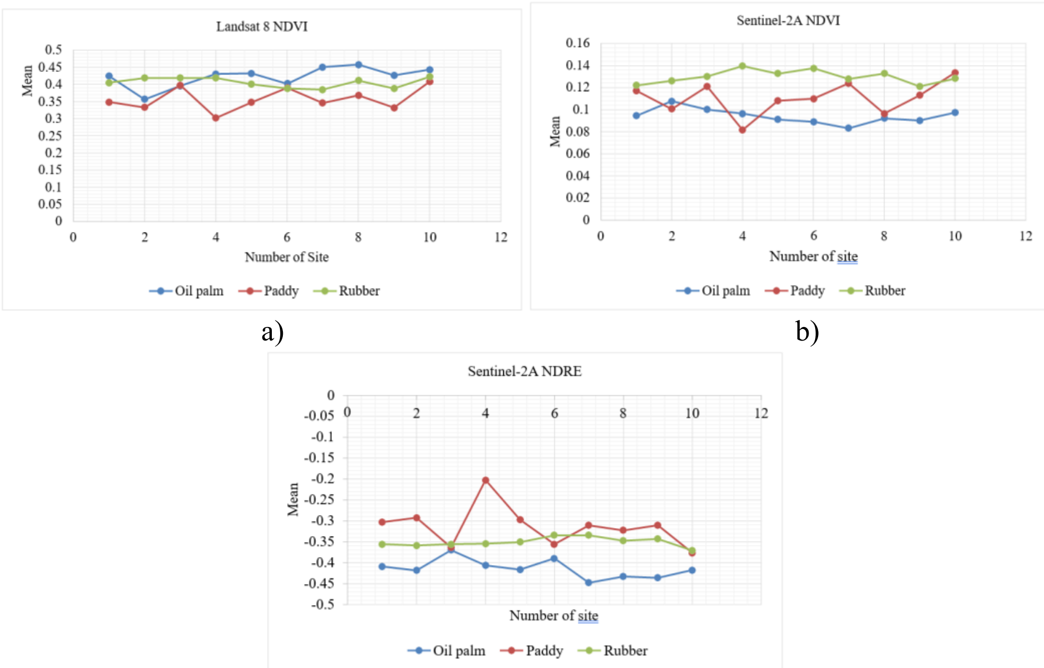
a) b) c) d)

Figure 6. Images of rubber tree area of a) study site rubber 2, b) NDVI of Landsat 8, c) NDVI of Sentinel 2A and d) NDRE of Sentinel 2A

3.3. *Analysis of NDVI and NDRE*

The result of average value of NDVI and NDRE based on Landsat-8 and Sentinel-2A for every site of oil palm plantation, paddy fields and rubber tree are shown in Figure 7. In Figure 7a), the oil palm plantation area indicates higher NDVI value with the greatest NDVI mean values ranging from site 8 to site 10. Rubber tree area has a generally homogeneous and uniform height value, whereas paddy has an irregular but extremely low fluctuation value ranging from 0.302 to 0.408. The NDVI value on Sentinel 2A indicates little difference in palm oil value. When compared to Landsat 8, the average value of oil palm at Sentinel 2A was between 0.089 and 0.108. Next, with the exception of site 10, the value of rubber was dominating throughout from site 1 to 9. The result ranged from 0.134 to 0.121. Paddy, on the other hand, has an extremely volatile value that fluctuates between low and high.

Furthermore, the NDRE value on Sentinel 2A remains rather high, with the maximum reaching -0.203 and the lowest -0.377. Rubber's steady and stable range is -0.335 to -0.359. The oil palm fixed decline value for Sentinel 2A is between -0.37 and -0.448. The distinction between NDVI Landsat 8 and NDVI Sentinel-2A, values Rubber still displays the greatest value for both types of sensors as a total, but in terms of value, Landsat 8 shows the highest value compared to Sentinel 2A, which is 0.422 to 0.385 for Landsat 8 and 0.121 to 0.140 for sentinel 2A. The results for both sensors for Paddy reveal non-uniform values on both satellite pictures. Oil palm had a comparatively high value between 0.458 and 0.356 at Landsat 8, but a relatively low value between 0.108 and 0.083 at Sentinel 2A.



a) b)

c)

Figure 7. Average value of a) Landsat-8 NDVI, b) Sentinel-2A NDVI and c) Sentinel 2A NDRE

4. Conclusion

Landsat-8 and Sentinel-2A datasets are compared for the categorization of three types of crops: oil palm, paddy, and rubber. In this investigation NDVI and VDRE are two vegetation indices will be used for crop categorization and evaluating agricultural vegetation activity and chlorophyll content. In both indices, the Sentinel-2A dataset outperforms the Landsat-8 dataset in crop categorization accuracy. This improvement is mostly due to the presence of red-edge spectral bands in the Sentinel-2A dataset, and the value obtained via band computation. The classification performance of each crop is evaluated using different analytical layers, and it is discovered that most crops are classified accurately with the exception of paddy due to the lack of pixels with uniform spectral responses and an adequate number of pixels, respectively, and possibly due to crop seasonality.

On the most basic stage, NDVI corresponds with chlorophyll, which associates with plant condition. Now that drone platforms are accessible, NDVI amounts can take advantage of high-resolution photography to ascertain measurements at initial growing phases that were previously practicable or economically feasible with satellite or manned aircraft. NDVI is a great common marker of plant status. The visual-band red content employed in NDVI is heavily absorbed by the upper of the crop cover. This indicates that lower layers of the crop cover have less influence on an NDVI assessment. This impact is amplified in plants with several leaf layers. Furthermore, chlorophyll content reaches a threshold in a few cereal crops, grasess and perennial crops, or throughout next development phases of specific row crops, where NDVI "saturates" at the maximum NDVI value of 1.0 [8]. When the red band of NDVI is replaced with the red edge band of NDRE, the measurement is less intensely absorbed by the uppermost levels of leaves. NDRE can offer more insight into permanent or later stage crops since it can measure deeper into the canopy. In pasture biomass estimating measures, NDRE is encountered. As a result, NDRE can occasionally offer a more accurate assessment of variability in areas where NDVI would just detect a consistent +1.0.

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