BIO Web of Conferences **216**, 06005 (2026) https://doi.org/10.1051/bioconf/202621606005
SRCM 2025

UTILIZATION OF LANDSAT 8 LEVEL 2 SATELLITE IMAGERY FOR IDENTIFICATION OF TEA PLANT HEALTH USING THE WEIGHTED OVERLAY METHOD (CASE STUDY: KERTAMANAH UNIT, MALABAR PLANTATION, BANDUNG)

Clara Rosanara Febryna Putri Priyanto[1], *Vivi* Cahyaningrum[1], and *Mokhamad* Nur Cahyadi[1*]

[1]Department of Geomatics Engineering, Faculty of Civil, Planning, and Earth Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

Abstract. Monitoring tea plant health is important to maintain plantation productivity. This study aims to map the health status of tea plants in the Cinyiruan and Kertamanah divisions, Kertamanah Unit, Malabar Plantation owned by PT Perkebunan Nusantara 1 Regional 2 using Landsat 8 Level 2 satellite imagery. The parameters used were NDVI, LST, and slope from DEM. These parameters were integrated using the weighted overlay method with weights of 50% for NDVI, 30% for LST, and 20% for DEM in the Yielding Plant area. NDVI and LST processing were conducted in Google Earth Engine, while weighting and visualization were carried out in ArcMap 10.8.2. The resulting tea plant health map was classified into three classes: very healthy, quite healthy, and unhealthy. Validation using wet tea crop production data per-block for 2020–2024 produced an accuracy of 46.6%, influenced by the 30-meter image resolution and field variations such as crop age, rainfall, pests, and production records. Spatially, very healthy class dominated the central to southern areas, while unhealthy class was generally found in peripheral and steep slopes areas. These results indicate that high NDVI values, low surface temperatures, and gentle topography are closely related to better tea plant conditions.

1 Introduction

Tea has become one of the most widely known and consumed beverages in the world. This beverage generally comes from the Camellia sinensis plant, using its young leaves and buds [1]. In addition to being a beverage, tea is also used in cosmetics and medicine due to its antibacterial and antioxidant content [1]. Tea is one of the plantation commodities that has long been developed in Indonesia and plays a significant role. As one of the non-oil and gas export commodities, tea contributes to the country's foreign exchange earnings in the plantation sub-sector [2]. Furthermore, the tea plantation sector contributes to job creation, with the number of workers reaching around 41.403 people in 2018 [3].

Tea originates from subtropical regions with cool temperatures that tend to remain stable throughout the year. Tea cultivation in Indonesia needs to take environmental conditions into account, especially altitude. Altitude is one of the main ecological factors that affect microclimate conditions, such as air temperature, humidity levels, light intensity, and wind speed. As a subtropical plant, tea grows optimally at temperatures of 18–21°C with humidity above 70%, making it suitable for cultivation in mountainous areas [4]. With rainfall requirements of 1000–2500 mm per year, tea can thrive [5]. Generally, this plant is cultivated in highlands with land slopes ranging from gentle to very steep (>45%) [6].

Remote sensing using satellite or drone imagery is an efficient method for monitoring large-scale plantation conditions without having to visit the location directly. In addition, remote sensing data is also useful for analyzing temporal changes in land surface temperature, as well as identifying major atmospheric dominant gas components

* Corresponding author: cahyadi@geodesy.its.ac.id

such as (SO2) and aerosol concentration particles with Global Navigation Satellite System (GNSS) observations [7]. Positioning systems using satellite navigation have advanced significantly, with the GNSS now increasingly used to support navigation for mobile platforms [8, 9]. GNSS consists of several satellite constellations that orbit the Earth continuously. The system has advanced significantly in recent decades. Using code or pseudo-range measurements, GNSS enables users to determine latitude, longitude, and elevation with accuracy ranging from meters to millimeters [10]. Meanwhile, remote sensing technology employs sensors onboard satellites or drones to capture electromagnetic wave reflections originating from the Earth's surface. One of the most commonly used satellites is Landsat 8, which provides multispectral imagery with a ground resolution of 15–30 meters and a 16 days revisit interval [11]. These images have undergone radiometric and geometric correction, making them suitable for vegetation analysis. In tea plant health studies, one of the indices used is Normalized Difference Vegetation Index (NDVI). NDVI is calculated from the ratio between spectral reflectance in the red band and the near-infrared (NIR) band. Healthy plants tend to absorb more red light and reflect more NIR [12]. NDVI values extend from -1 to +1, where values approaching +1 represent dense and healthy vegetation [12]. NDVI is widely used as an indicator to assess vegetation health, while Land Surface Temperature (LST) reflects thermal stress on the land surface. Integrating NDVI and LST provides an opportunity to produce more comprehensive spatial mapping of areas experiencing vegetation stress [11].

One of the largest tea-producing areas is the Malabar Plantation in Bandung, West Java, which is managed by PT Perkebunan (PTPN) Nusantara 1 Regional 2. The Kertamanah unit, as part of this plantation, plays an important role in supporting national tea productivity. However, crop production levels are greatly influenced by soil quality, nutrient availability, and management. Therefore, an efficient and accurate method is needed to monitor land conditions on a regular basis to support data-driven decision making. Based on this, this study aims to utilize Landsat 8 Level 2 satellite imagery with the weighted overlay method to identify the health of tea plants in the Kertamanah Unit, Malabar Plantation, Bandung. This study aims to generate accurate and valuable information for more effective and sustainable tea plantation management.

2 Data and Methods

2.1 Locations

The study was located in Afdeling Cinyiruan and Kertamanah, Kertamanah Unit, Malabar Plantation, Bandung Regency, West Java (Fig.1). The area is dominated by sloping topography with varying degrees of inclination and a tea plantation (Camellia sinensis) managed by PT Perkebunan Nusantara I Regional 2. This analysis is limited to areas classified as Producing Plant (TM) so that the resulting analysis values can well reflect the condition of actively productive vegetation.

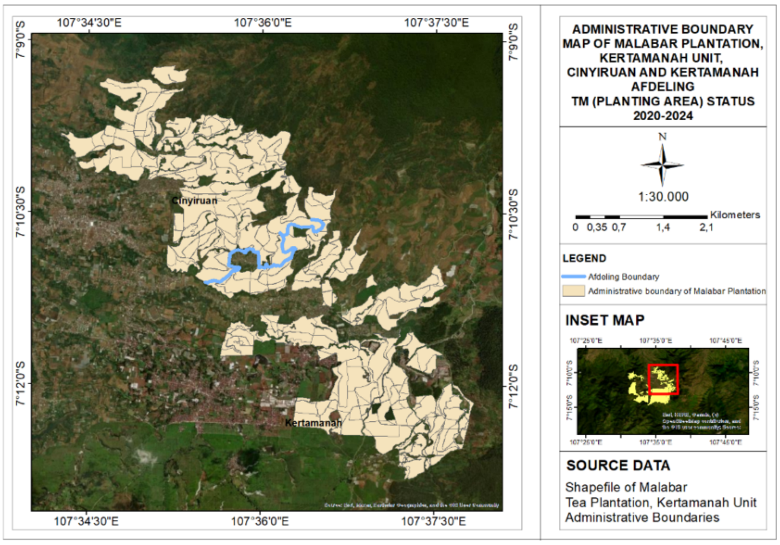

Fig.1. Kertamanah Unit Case Study Area

2.2 Data and Devices

2.2.1 Data

This study uses several types of primary data that serve as the basis for spatial analysis and validation of results. The primary data consists of Landsat 8 Level-2 images with an observation period from 2020 to 2024. These images help gather the standardized vegetation index called NDVI and the land surface temperature, or LST, which are the main factors used to evaluate how healthy the plants are. In addition, shapefile data on the boundaries of TM-status tea plantations in the Cinyiruan and Kertamanah divisions of the Kertamanah Unit, Malabar Plantation, were used to figure out the spatial boundaries of the study area. Wet production and tea plant productivity data for the 2020–2024 period obtained from PT Perkebunan Nusantara I Regional 2 were used as a reference in the validation process to compare the results of spatial analysis with actual conditions in the field.

2.2.2 Tools

Several software programs were used to support the data processing and analysis. Google Earth Engine (GEE) served as a satellite image processing platform to generate NDVI and LST parameters through a cloud-based processing system. ArcMap version 10.8.2 is used to perform advanced spatial analysis, including weighting using the weighted overlay method and compiling thematic maps that describe crop health distribution. Microsoft Excel is used to validate the analysis results by comparing crop health map values with wet production data. Furthermore, Microsoft Word is used to compile research reports in a systematic and structured manner.

2.3 Analysis Parameter Data

2.3.1 NDVI (Normalized Difference Vegetation Index)

NDVI values are calculated using the following equation.

$$NDVI = \frac{(\rho NIR - \rho Red)}{(\rho NIR + \rho Red)} \quad (1)$$

In the Landsat 8 OLI image, NIR refers to the near-infrared channel, which is Band 5, and Red refers to the red channel, which is Band 4. Rephrase The NDVI values go from -1 to +1. When the values are close to +1, it means there is a lot of vegetation. If the values are near -1, it shows places with little or no vegetation, like water or open land [13].

2.3.2 LST (Land Surface Temperature)

LST values are calculated from Brightness Temperature (BT) using the following formula:

$$LST = \frac{BT}{1+(\left(\frac{\lambda BT}{c2}\right)\ln ln\, e\lambda)} \quad (2)$$

The LST parameters show the land surface temperature measured by the TIRS thermal channel, which is Band 10 on Landsat 8 images [14].

2.3.3 Slope

Slope is determined using the Digital Elevation Model (DEM) to understand how the land's shape affects the crops' growth conditions. Steep slopes have the potential to cause erosion and reduce crop productivity [15].

2.4 Workflow

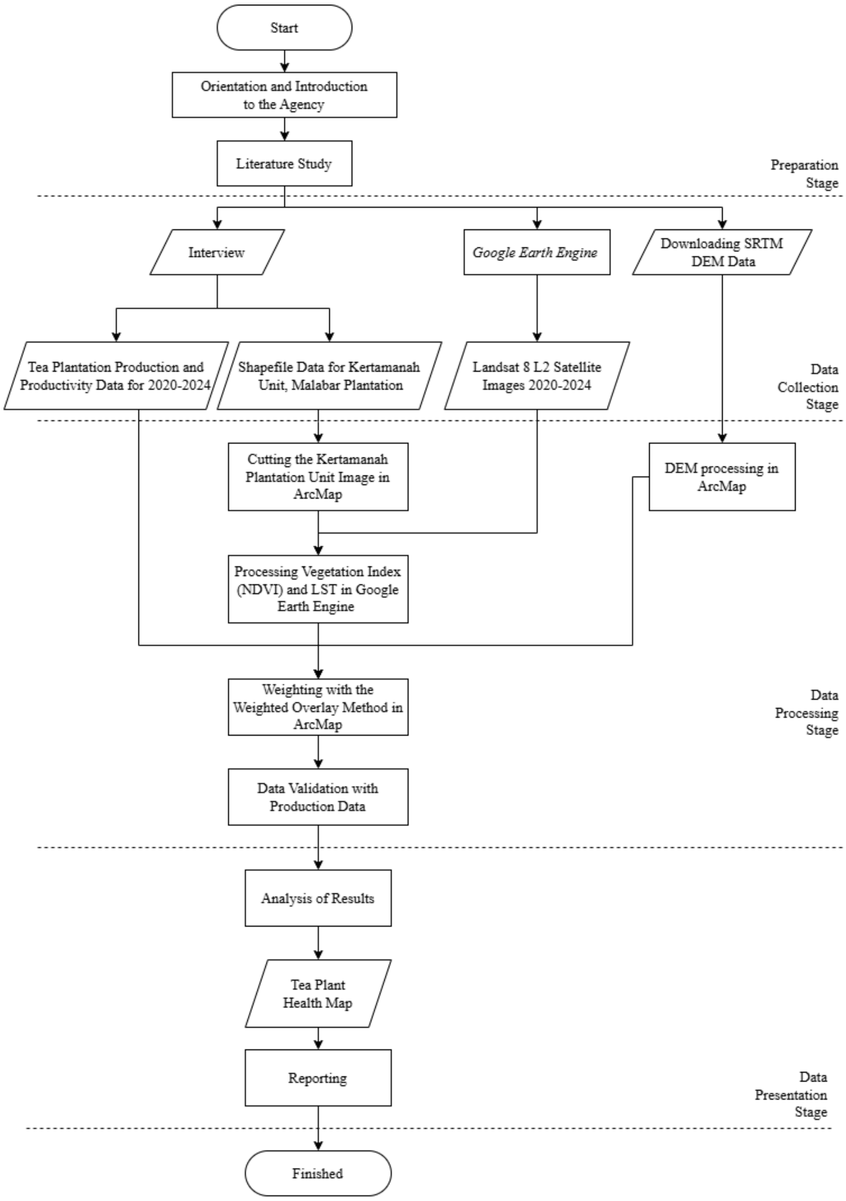

Fig.2. Work Flow Chart

The preparation stage began with an orientation at PTPN I Regional 2 Bandung to understand the plantation management system and tea production process. This activity was followed by a literature review on satellite image processing, NDVI and LST analysis, and the application of the weighted overlay method to strengthen the theoretical basis of the research.

The data collection stage included downloading Landsat 8 Level-2 images through Google Earth Engine (GEE), DEM data from online sources, and production and plantation boundary data from PTPN I Regional 2. All of this data became the main material for spatial analysis and result validation.

In the data processing stage, the images were cropped to focus on the study area using ArcMap 10.8.2. The NDVI and LST parameters were calculated through GEE, while the slope map was generated from DEM processing in ArcMap. The three parameters were combined using the Weighted Overlay method with a weight of 50% for NDVI, 30% for LST, and 20% for slope. The results were then classified into three categories: very healthy, quite healthy, and unhealthy.

The validation stage was carried out by comparing the results of the crop health map classification with wet production data per block using Microsoft Excel. Crops with high health levels generally have greater wet production than less healthy crops.

The determination of plant health categories is carried out using a statistical approach based on quartile values. Plants classified as unhealthy are determined based on wet production values below the first quartile (Q1) or the lowest 25% of data, while plants classified as healthy have production values above the second quartile (Q2), which represents the median value of the data distribution. Quartile values are calculated using equations (3) and (4).

After the class boundaries are set, validation is performed by comparing the map classification results and actual production data. The accuracy of the results is calculated using equation (5).

The final stage, which is the presentation of results, is carried out by visualizing the data in the form of a thematic map showing how healthy the tea plants are in the study area. The map and analysis results are then systematically compiled in a research report to provide a comprehensive overview of the vegetation conditions and productivity of tea plants in the study area.

3 Result

3.1 Average Normalized Difference Vegetation Index (NDVI) of Malabar Tea Plantation, Kertamanah Unit, 2020-2024

An analysis of the average NDVI values in Afdeling Cinyiruan and Kertamanah, Kertamanah Unit, Malabar Tea Plantation, Bandung, during the 2020–2024 period shows clear spatial variations in tea plant vegetation density. The analysis area focused on land with Producing Plant (TM) status to ensure the obtained NDVI values accurately represent productive vegetation conditions. TM land was chosen because it is a plant growth phase that directly contributes to tea shoot productivity and has a relatively uniform maintenance pattern and harvest cycle, thus reflecting the plant's physiological condition consistently from year to year. The average NDVI map shows three main classes that describe the level of vegetation greenness, namely: (1) low vegetation with an NDVI value of 0.190–0.609 (red), (2) moderate vegetation with NDVI values of 0.609–0.692 (yellow), and (3) high vegetation with NDVI values of 0.692–0.819 (green) (Fig.3). The spatial distribution shows that the high vegetation class dominates the central and northern areas of the plantation. These conditions indicate high canopy density and good plant physiological conditions.

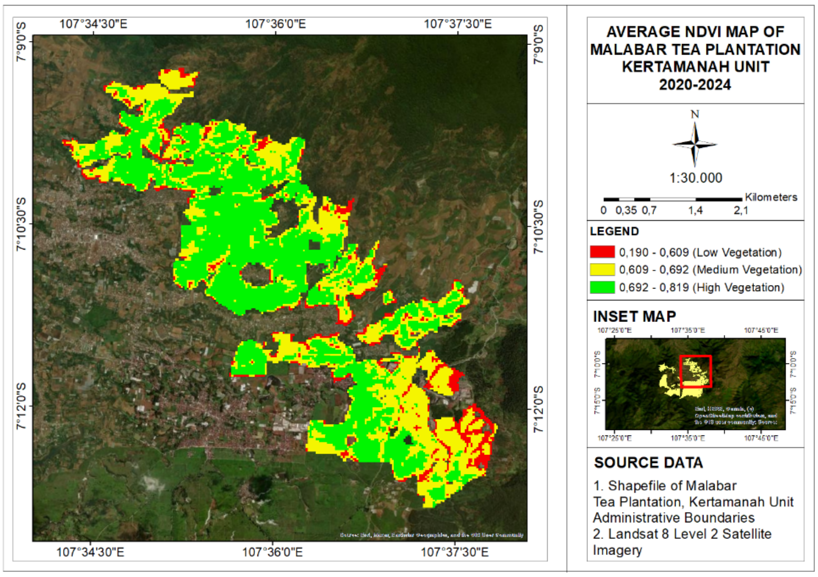

Fig. 3. Average NDVI Map of Kertamanah Unit, Malabar Tea Plantation, 2020-2024.

One representative block is TH0C26 with an NDVI value of 0.759, reflecting healthy and uniform vegetation conditions. Moderate vegetation classes are scattered around the dominant green area, acting as a transition zone between healthy and less healthy vegetation. A representative example is block TH0C38 in the southern part of the plantation with an NDVI value of 0.662. The distribution of this class indicates a phase of recovery or post-harvest vegetation growth, as well as the possibility of more intensive cultivation activities in the area. Meanwhile, low vegetation classes were identified in smaller numbers and were generally located on the northern, southern, and eastern edges of the plantation, close to residential areas and transportation routes. Block TH0C36, with an NDVI value of 0.598, is an example of an area that falls into this category. The spatial distribution of red on the map indicates potential disturbances to vegetation, whether due to human activity, land clearing, or environmental factors such as erosion and differences in land cover types.

Overall, the NDVI distribution pattern shows that vegetation in good condition is concentrated in the center of the plantation, while the edge areas show lower levels of greenness. This pattern indicates a gradient in vegetation condition influenced by topography, land management intensity, and proximity to anthropogenic activities. These findings confirm that multi-year NDVI analysis can be used as an effective indicator for monitoring the spatial and temporal variability of tea plant health across plantation areas.

3.2 Average Land Surface Temperature (LST) of Malabar Tea Plantation, Kertamanah Unit, 2020-2024

Image processing results show the average land surface temperature (LST) distribution in Afdeling Cinyiruan and Kertamanah, Kertamanah Unit, Malabar Tea Plantation, Bandung, during the period 2020–2024 (Fig.4). Spatially, the LST pattern shows clear segmentation between cold, cool, and warm zones. The LST classes are divided into three categories: cold (13.797–17.063°C, colored blue), cool (17.063–18.432°C, colored yellow), and warm (18.432–26.858°C, colored red). The cold zone (13.797–17.063°C) is widely distributed across the eastern and southern parts of the study area, with the highest concentration in areas adjacent to higher elevations. This low temperature distribution correlates with dense vegetation cover and low anthropogenic activity. The cool category (17.063–18.432°C) is indicated by yellow, which is relatively evenly distributed in the central area of the plantation. This zone acts as a transition between the cold and warm areas, often coinciding with flat land that has a mixture of moderate vegetation and active plantation activities. Meanwhile, the warm category (18.432–26.858°C) is dominated by the western and central parts of the plantation. This area is generally associated with open land, sparse vegetation, or the presence of plantation infrastructure that absorbs more heat than vegetative areas.

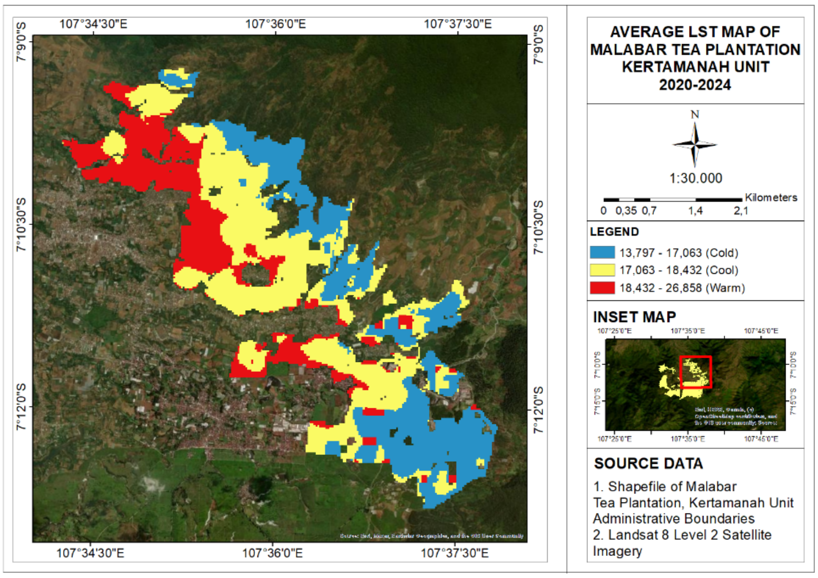

Fig. 4. Average LST Map of Kertamanah Unit, Malabar Tea Plantation, 2020-2024.

Spatial comparisons between LST and topography show a correlation between surface temperature, elevation, and slope. The results of the comparison between the LST map and the Digital Elevation Model (DEM) show that areas labeled "warm" tend to be in zones with low slope (0º–14º), which are depicted in light green on the

DEM map. This condition is common because relatively flat or gentle surfaces receive more even solar radiation and have greater heat storage capacity. Conversely, areas labeled "cool" to "cold" are mostly found on steep slopes with a gradient between 21º–58º, marked in orange to red on the DEM map. Steep slopes generally have denser vegetation, good drainage, and are located at higher elevations, resulting in relatively lower surface temperatures. In addition to the influence of slope, the aspect of the slope also contributes to temperature variation. Slopes with a west to north orientation tend to have higher temperatures in the afternoon due to greater radiation intensity, while east to south slopes are relatively cooler because they receive direct radiation in the morning for a shorter duration. Overall, the analysis results indicate a negative relationship between LST and elevation, the higher the elevation, the lower the surface temperature, and a positive correlation between LST and gentle slope, where flat or gentle areas tend to be warmer. This pattern confirms that surface temperature variations within the study area are controlled by a combination of topographic conditions and land cover characteristics, both of which play an important role in controlling surface energy balance in plantation environments.

3.3 Digital Elevation Model (DEM) of Malabar Tea Plantation, Kertamanah Unit, 2020-2024

After processing the Digital Elevation Model (DEM) data, a slope map was obtained (Fig.5). This map represents the topographic variations in the Kertamanah Unit, Malabar Plantation, particularly in the Yielding Crops (TM) area. Based on the extraction results using ArcMap software, the study area has a slope range of 0° to 58°, which is further classified into five classes, namely flat to gentle slopes (0°–8° in dark green), gentle to moderately steep slopes (8°–14° in light green), moderately steep (14°–21° in yellow), steep (21°–32° in orange), and very steep (32°–58° in red).

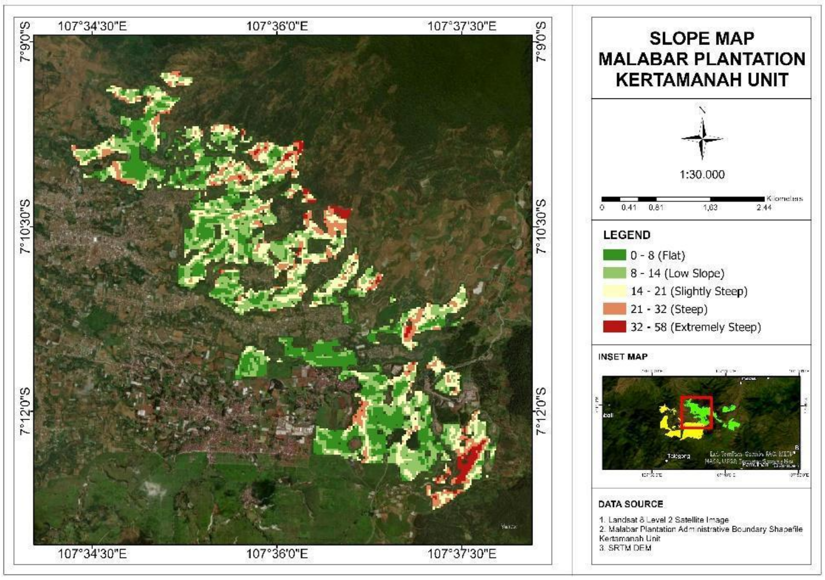

Fig. 5. Slope Map of Kertamanah Unit, Malabar Plantation.

Spatially, the distribution of slope classes shows a clear pattern. Areas with low slopes (0°–14°) are marked with dark green to light green colors and are widely spread across the central and southern parts of the study area, forming relatively flat and homogeneous topographic blocks. Medium slopes (14°–21°), colored yellow, appear as a transition zone between gentle and steep areas. Meanwhile, areas with high slopes (21°–58°) are colored orange to red and dominate the edges of the blocks, especially on the east, west, and southern ends, which are steep slopes or ridges. The presence of red areas on the southern side indicates extreme slopes that require special attention in land management.

The relationship between slope inclination and tea plant health shows that topography plays an important role in determining land suitability. Gentle to moderately steep slopes (0°–14°) are ideal conditions for tea plant growth because they have good drainage and low erosion risk. Medium slopes (14°–21°) are still suitable for tea cultivation but require soil conservation measures such as terracing. Meanwhile, areas with steep to very steep slopes

 https://doi.org/10.1051/bioconf/202621606005

(21°–58°) have the potential for high erosion and difficulty in maintenance, which may impact plantation productivity and plant health. Thus, slope analysis based on DEM data can be used as an important parameter in evaluating land suitability and planning sustainable tea garden management.

3.4 Tea Plants Health Map at Malabar Tea Plantation, Kertamanah Unit, 2020-2024

The results of processing using the weighted overlay method produced a map showing the spatial distribution of tea plant health levels in the Planting Area (TM) in the Kertamanah Unit, Malabar Plantation (Fig.6). This analysis was conducted by considering three main parameters, namely NDVI, LST, and slope, each of which contributes to the physiological condition of plants. The parameter weights were set at 50% for NDVI, 30% for LST, and 20% for slope, with a total weight of 100%. These weights were determined based on the level of influence of each factor on plant health. NDVI plays a dominant role because it reflects the density and greenness of vegetation, which is directly correlated with photosynthetic activity. LST affects plant physiology through the regulation of surface temperature, which influences plant metabolism and stress. Meanwhile, slope plays a role in controlling water distribution, soil stability, and erosion risk, which impact plant growth.

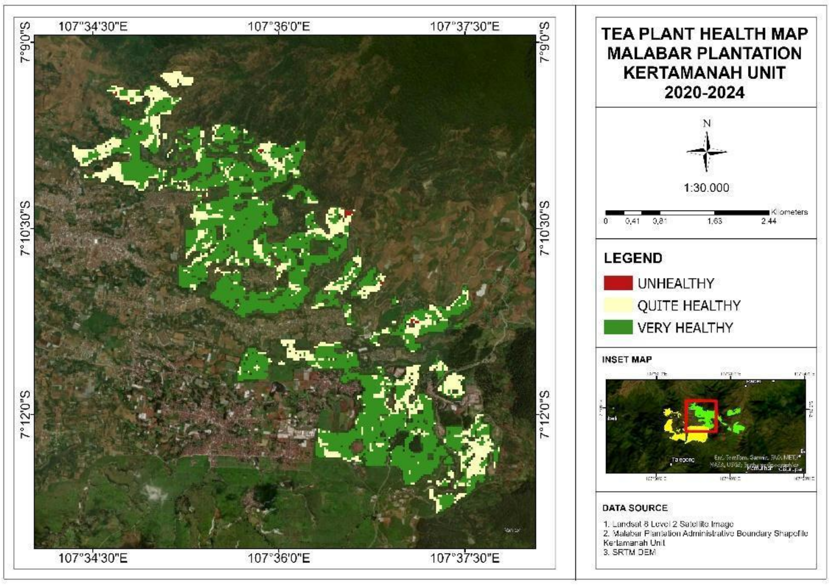

Fig. 6. Tea Plant Health Map of Kertamanah Unit, Malabar Plantation, 2020-2024

The weighted overlay map produces three main classes of tea plant health, namely very healthy (score 3, green color), quite healthy (score 2, yellow color), and unhealthy (score 1, red color). Spatially, the very healthy class dominates most of the plantation area, especially in the central to southern parts, which are characterized by high NDVI values, moderate surface temperatures, and gentle to moderate slope gradients. The quite healthy class (yellow) is scattered as a transition zone around the green area, especially across the northern, eastern, and southern parts of the plantation. For example, in the Singung plantation block with the code TH0D36, this area has moderate NDVI values, relatively high surface temperature variations, and steeper slopes compared to very healthy areas. These conditions have the potential to reduce crop productivity if not balanced with proper management. The unhealthy class (red) is distributed in limited numbers in several small spots, as seen in the Saringan block with code TH0C11. This area is generally located on steep slopes or block edges with low NDVI values, high surface temperatures, and significant erosion risk. These conditions indicate high environmental pressure and an urgent need for rehabilitation measures such as soil and water conservation, soil cover improvement, or crop rejuvenation.

The results of zonal statistics as a table on the tea plant health map show the plant health class values for each plantation block. Based on this table, most plantation blocks are in the very healthy category (score 3), indicating relatively good and productive vegetation conditions. Several blocks with a score of 2 indicate the need for additional management measures, while blocks with a score of 1 are a priority for management intervention.

Overall, the spatial distribution of tea plant health levels provides a comprehensive picture of the variation in plant physiological conditions in the field. This information can be used as a basis for planning plantation management strategies. Areas with a very healthy class need to be maintained through intensive maintenance and control of disruptive factors. Areas that are quite healthy require optimization of management, such as adjusting fertilization and regulating water management. Meanwhile, unhealthy areas are the main focus for the implementation of corrective and conservative measures so that plantation productivity can be improved in a sustainable manner.

3.5 Validation of Tea Plants Health Map

Validation of tea plant health maps is carried out to ensure that the spatial analysis results obtained from satellite imagery represent actual conditions in the field. This validation process is carried out by comparing the plant health index values generated through the weighted overlay method (main parameters NDVI , LST , and slope) with the wet tea production data for each plantation block. Conceptually, a good level of plant health is expected to correlate positively with high wet production, while plants in poor health show lower production yields.

The initial validation step was carried out by calculating the average wet production value of tea plants for the 2020-2024 period for each plantation block. Next, to group plant health levels based on wet production, a statistical approach was used to determine the first quartile (Q1) and second quartile (Q2) values. The first quartile was used as the lower limit for the unhealthy plant category, while the second quartile was used as the upper limit for the moderately healthy plant category. The first quartile value was calculated using the following formula.

$$Kuartil\ 1\ (Q1) = \frac{(n+1)}{4} \quad (3)$$

Meanwhile, the calculation of the second quartile follows the following formula.

$$Kuartil\ 2\ (Q1) = \frac{(n+1)}{2} \quad (4)$$

Where n is the amount of production data. Based on the calculation results, Q1 is 60,889.98 kg and Q2 is 80,595.93 kg. Thus, the classification limits for production volume can be defined as follows: (1) unhealthy plants with a production value ≤ 60,889.98 kg, (2) moderately healthy plants with a production value between 60,889.98 and 80,595.93 kg, and (3) very healthy plants with a production value ≥ 80,595.93 kg.

After the production classification was determined, a comparison was made with the tea plant health index values from the satellite image analysis (value 1 = unhealthy, value 2 = moderately healthy, and value 3 = very healthy). The comparison was carried out for each plantation block. The validation process was carried out by calculating the conformity between the two data sources using the formula.

$$Validasi\ Data = \left(\frac{Sampel\ Benar}{Jumlah\ Sampel}\right) \times 100 \quad (5)$$

Based on the calculation results, out of a total of 103 samples, 48 samples showed consistency between the plant health class from satellite imagery and the category based on wet production data. Thus, the accuracy rate of the tea plant health map reached 46.60%. This accuracy value indicates that the satellite image analysis results do not fully reflect the actual conditions in the field. The 53.40% difference is likely due to various factors, both from the limitations of satellite data and variations in agronomic conditions in the field. Regarding remote sensing data, the limited spatial resolution of the images causes a single pixel to capture mixed surface features, including vegetation, open land, and other non-vegetative elements, thereby affecting the accuracy of the NDVI index. Atmospheric factors such as clouds, fog, or variations in air humidity can also reduce the quality of image reflectance and cause index value deviations. Meanwhile, in terms of field conditions, variations in maintenance practices between blocks, differences in plant age, canopy density, and environmental factors such as rainfall and light intensity also affect tea production. In addition to physiological factors, non-physiological aspects such as pest and disease attacks, the effects of extreme weather, and inaccuracies in production data recording also have the potential to cause differences between observation and spatial analysis results.

In general, these validation results show that tea plant health maps generated from satellite image analysis have moderate capabilities in describing the actual conditions of tea plantations. Although its accuracy is still relatively low, this approach still provides useful spatial information for the initial identification of plant conditions and can be further developed through improvements in image spatial resolution, more detailed field data calibration, and the integration of additional parameters such as rainfall, soil moisture, and plant phenology data.

4 Conclusion

This study demonstrates the potential use of Landsat 8 Level-2 imagery to assess the health level of tea plants in Afdeling Cinyiruan and Kertamanah, Kertamanah Unit, Malabar Tea Plantation, Bandung. The resulting thematic maps can depict spatial variations between tea plant blocks so that areas requiring agronomic attention can be precisely identified. One of the key findings shows that the very healthy class predominantly occupies the central to southern areas of the plantation, while the unhealthy class is generally distributed in peripheral areas and on steeper slopes. This spatial pattern indicates that topography (slope) and geographic location play a dominant role in influencing tea plant health conditions. The main parameters used in the weighted overlay analysis include the Normalized Difference Vegetation Index (NDVI), Land Surface Temperature (LST), and Digital Elevation Model (DEM). NDVI and LST were calculated using the Google Earth Engine platform, while DEM processing, weighting processes, and final map preparation were performed using ArcMap 10.8.2 software. The analysis yielded three classes of plant health: very healthy, moderately healthy, and unhealthy, which were spatially visualized to support plantation management decisions. Validation of the mapping results based on wet production data showed an overall accuracy (total accuracy) of 46.60%, calculated from 48 consistent samples out of a total of 103 samples, where the mapped classes corresponded with the wet production classes. The remaining 53.40% difference is primarily influenced by the mixed pixel effect caused by the 30-meter spatial resolution of Landsat imagery, which mixes vegetation and non-vegetation objects within a single pixel, in addition to atmospheric interference on reflectance values, and variations in field conditions such as differences in maintenance techniques, plant age, rainfall, the presence of pests and diseases, and inaccurate production records. Overall, the study shows that Landsat 8 Level-2 imagery can be used to monitor tea plant health at the plantation scale, particularly for identifying broad spatial patterns related to topography and geographic location, although its accuracy is still limited. Better mapping accuracy can be achieved through the use of higher-resolution satellite imagery, the integration of more detailed field data, and the development of weighting methods that are more adaptive to vegetation characteristics and local environmental conditions.

List of abbreviations:

- NDVI : Normalized Difference Vegetation Index
- LST : Land Surface Temperature
- DEM : Digital Elevation Model
- TM : Planting Area (Tanaman Menghasilkan)

Acknowledgement

The authors gratefully acknowledge financial support from the Institut Teknologi Sepuluh Nopember for this work, under project scheme of the Publication Writing and IPR Incentive Program (PPHKI) 2025.

Availability of data and materials:

All the data used in this research are available at the website Google Earth Engine (GEE) for NDVI and LST processing, website inageoportal to download DEM (https://tanahair.indonesia.go.id/portal-web/unduh), and wet tea production data can be obtained by direct interview with PT Perkebunan Nusantara 1 Regional 2 (this data is confidential).

Author's contributions:

- CRFPP formal analysis, methodology, validation, review & editing
- VC formal analysis, methodology, validation, review & editing
- MNC supervisor

References

[1] P. Wang et al., “Determining the critical threshold of meteorological heat damage to tea plants based on MODIS LST products for tea planting areas in China,” Ecol. Inform., vol. 77, Nov. 2023, doi: 10.1016/j.ecoinf.2023.102235.

[2] S. N. Salimah, A. Junaedi, and Sudradjat, “Pengelolaan Pemetikan Tanaman Teh (Camellia sinensis (L.). O. Kuntze) di Wonosobo, Jawa Tengah,” Buletin Agrohorti, vol. 11, no. 2, pp. 249–259, 2023, doi: 10.29244/agrob.v11i2.47161.

[3] L. P. Caro, Wages and working conditions in the tea sector: the case of India, Indonesia and Viet Nam Background note. 2020. [Online]. Available: www.ilo.org/publns.

[4] C. Wang, J. Han, Y. Pu, and X. Wang, “Tea (Camellia sinensis): A Review of Nutritional Composition, Potential Applications, and Omics Research,” Jun. 01, 2022, MDPI. doi: 10.3390/app12125874.

[5] N. Sahu et al., “Analysis of Tea Plantation Suitability Using Geostatistical and Machine Learning Techniques: A Case of Darjeeling Himalaya, India,” Sustainability (Switzerland), vol. 15, no. 13, Jul. 2023, doi: 10.3390/su151310101.

[6] D. D. P. Afner, A. Aprisal, and Y. Yulnafatmawita, “Indeks Stabilitas Agregat Tanah Pada Perkebunan Teh Berbasis Slope Dan Umur Tanaman Di Kecamatan Gunung Talang Kabupaten Solok,” Jurnal Tanah dan Sumberdaya Lahan, vol. 8, no. 1, pp. 75–81, 2020, doi: 10.21776/ub.jtsl.2021.008.1.10.

[7] M. N. Cahyadi et al., “Analysis of the effect of the 2021 Semeru eruption on water vapor content and atmospheric particles using GNSS and remote sensing,” Geod. Geodyn., vol. 15, no. 1, pp. 33–41, Jan. 2024, doi: 10.1016/j.geog.2023.04.005.

[8] M. N. Cahyadi, T. Asfihani, R. Mardiyanto, and R. Erfianti, “Loosely Coupled GNSS and IMU Integration for Accurate i-Boat Horizontal Navigation,” International Journal of Geoinformatics, vol. 18, no. 3, pp. 111–122, Jun. 2022, doi: 10.52939/ijg.v18i3.2233.

[9] M. N. Cahyadi and I. Rwabudandi, “Integration of GNSS-IMU for increasing the observation accuracy in Condensed Areas (Infrastructure and Forest Canopies),” in E3S Web of Conferences, EDP Sciences, May 2019. doi: 10.1051/e3sconf/20199403015.

[10] M. N. Cahyadi et al., “Comparative Analysis of Low-Cost GNSS OEM Board K706 and BX316 (Case Study: Bulusidokare Village Sidoarjo Regency),” in IOP Conference Series: Earth and Environmental Science, IOP Publishing Ltd, Apr. 2021. doi: 10.1088/1755-1315/731/1/012024.

[11] M. A. Lazaridou and A. C. Karagianni, “Landsat 8 multispectral and pansharpened imagery processing on the study of civil engineering issues,” in International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives, International Society for Photogrammetry and Remote Sensing, 2016, pp. 941–945. doi: 10.5194/isprsarchives-XLI-B8-941-2016.

[12] B. Mamaghani, M. G. Saunders, and C. Salvaggio, “Inherent reflectance variability of vegetation,” Agriculture (Switzerland), vol. 9, no. 11, Nov. 2019, doi: 10.3390/agriculture9110246.

[13] M. B. Moisa, B. T. Gabissa, L. B. Hinkosa, I. N. Dejene, and D. O. Gemeda, “Analysis of land surface temperature using Geospatial technologies in Gida Kiremu, Limu, and Amuru District, Western Ethiopia,” Artificial Intelligence in Agriculture, vol. 6, pp. 90–99, Jan. 2022, doi: 10.1016/j.aiia.2022.06.002.

[14] A. Sekertekin and S. Bonafoni, “Land surface temperature retrieval from Landsat 5, 7, and 8 over rural areas: Assessment of different retrieval algorithms and emissivity models and toolbox implementation,” Remote Sens. (Basel)., vol. 12, no. 2, Jan. 2020, doi: 10.3390/rs12020294.

[15] R. Madugundu et al., “Impact of Field Topography and Soil Characteristics on the Productivity of Alfalfa and Rhodes Grass: RTK-GPS Survey and GIS Approach,” Agronomy, vol. 12, no. 12, Dec. 2022, doi: 10.3390/agronomy12122918.