TEA LEAF AREA INDEX ESTIMATION BY LEVERAGING UAV MULTISPECTRAL IMAGERY UNDER DIFFERENT FARMING METHOD - A CASE STUDY IN NANTOU COUNTY IN TAIWAN

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Tea (Camellia sinensis) is one of the most widely consumed beverages globally. According to the report published by FAO in 2022, global tea production has been consistently increasing, indicating a growing trend in the global tea consumption market. The tender shoots of the tea are considered the most crucial part of the tea leaves. The growth environment and geographical conditions influence the flavor and play a vital role in determining the yield, quality, and sales. Traditional methods for measuring Leaf Area Index (LAI) are time-consuming and labor-intensive. However, with advancements in Remote Sensing technology, it has gained recognition for its non-destructive and large-scale measurement applications. Particularly, unmanned aerial vehicles (UAV) suitable for low-altitude flights have high spatial resolution and can achieve precise monitoring in agriculture. Furthermore, vegetation indices (VIs), derived from multispectral sensors, can detect wavelengths beyond visible light and reflect the growth information of crops in the field. Remote sensing images are tools for extracting extensive information, and machine learning is an essential method for analyzing remote sensing data.

This study aims to integrate UAV multispectral images of tea plantations with in situ LAI measurements and compare the accuracy of various machine learning algorithms in predicting LAI for both conventional and sustainable farming. The research sites were in the low-altitude Mingjian Township, Nantou County, Central Taiwan. We collected data for a year and calculated 36 VIs derived from multispectral images. Subsequently, correlation analysis was performed to select the top 10 VIs as independent variables for the machine learning algorithms. Finally, the optimal predictive model was used to estimate LAI across the tea plantation sites.

The result presents the LAI for conventional and sustainable farming, demonstrating seasonal variations with values around 4.37 in summer and autumn and approximately 2.70 in winter and spring, indicating a denser tea tree canopy during the growth season. Based on the Pearson correlation analysis, most VIs showed significant positive correlations with correlation coefficients ranging from 0.3 to 0.8. Regression analysis using original multispectral data revealed that the Support Vector Machine (SVM) regression model achieved an accuracy 0.713 for conventional farming data. In contrast, the Partial Least Squares (PLS) regression model achieved an accuracy of 0.521 for sustainable farming data. However, with the inclusion of the most correlated VIs, the SVM regression model using the top 8 correlated VIs resulted in the best regression accuracy of 0.726 for conventional, whereas the PLS regression using the top 10 correlated VIs showed the highest model accuracy of 0.581 for sustainable, indicating that the incorporation of VIs can enhance LAI prediction and serve as a tool for predicting LAI over large areas. Nevertheless, due to their less human-intervened management approach in the sustainable farming site, the LAI needed consistent growth levels, resulting in slightly less satisfactory LAI regression prediction accuracy. Future research should consider incorporating texture features, canopy height, and other information for different farming to improve the accuracy of the regression models.

Keywords: Tea tree, Unmanned aerial vehicle (UAV), Crop physiological index, Spectral vegetation index