The Biophysics Characteristic of palm oil plantation using ground-based and low-altitude Remote Sensing

Bayu Taruna Widjaja Putra
Laboratory of Precision Agriculture and Geo-Informatics, Faculty of Agricultural Technology
University of Jember
Jember, Indonesia
bayu@unej.ac.id

Indarto
Agricultural Engineering, Faculty of Agricultural Technology
University of Jember
Jember, Indonesia

Askin
Agricultural Engineering, Faculty of Agricultural Technology
University of Jember
Jember, Indonesia

Abstract— Palm oil is a promising industrial commodity that has spread widely throughout Indonesia. However, there are still many obstacles to handling on-farm management in crop monitoring, including the penetration of technology that is still slowly adopted by both multi-national companies and smallholders. One of the methods used in developing rapid and non-destructive monitoring of palm oil is to determine the biophysical characteristics using the remote sensing approach. In this study, we investigated the spectral signature of plant tissue characteristics to determine appropriate bands for palm oil monitoring. We believe that determining the right band or spectrum can help make the right decisions related to solving the problems in oil palm monitoring management.

Keywords— Camera, Spectroscopy, Near-infrared, UAV, palm oil plantation

I. INTRODUCTION

Palm oil is one of the country's leading foreign exchange crops, especially in the Southeast Asian region. In Indonesia, oil palms are widespread in various islands, such as Sumatra, Kalimantan, and Sulawesi. Oil palm cultivation is still carried out conventionally so that the effectiveness and efficiency in the use of resources are still relatively low, especially in terms of technology-aided monitoring, which has yet to gain its traction in its application. Several technologies have been developed in the area of monitoring nutritional needs, pests and diseases, as well as plant counting, but these technologies have not been implemented optimally and thoroughly for oil palm farmers. Remote sensing is the most effective technology for monitoring oil palm plantations. The technology can be in the form of aerial remote sensing using satellite, airborne; low-altitude remote sensing by utilizing UAVs by using either a rotor [1] or fixed-wings [2]; ground-based remote sensing can utilize camera/multispectral cameras and spectrometers [3].

One measure that needs to be taken in the use of remote sensing technology is to study the spectral characteristics of each object that exists in oil palm plantations, be it fruit, midrib, bunches, background soil, weeds, male/female flowers, or other plant tissue. Therefore, by studying the characteristics correctly, we can determine the utilization of band/spectrum for oil palm monitoring. Monitoring by utilizing low-cost UAVs has been carried out [4], but the use of consumer-grade cameras and separate UAVs to date has not gained the utmost of its resource. In this study, we attempted to make some recommendations for palm oil researchers regarding bands that can be utilized for oil palm monitoring, as well as the potential for the use of low-cost UAVs.

II. MATERIAL AND METHODS

In this study, we used two remote sensing techniques, namely ground-based and low-altitude remote sensing. Some of the tools we used were RGB cameras, NIR cameras, Spectrometers, and UAVs. These two methods were chosen because they generated more detail results

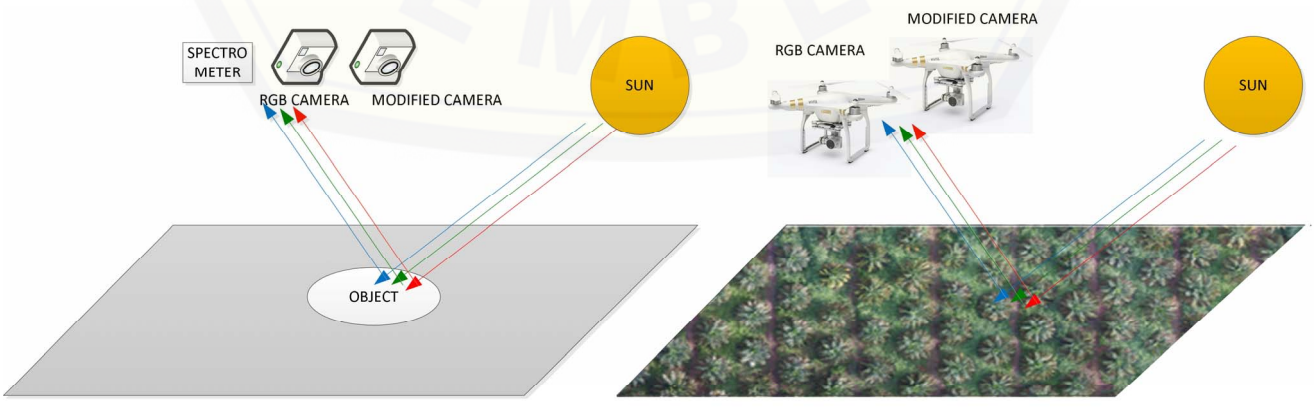

Figure 1. The Methods in data retrieval through ground-based (a) and low-altitude (b) remote sensing

978-1-7281-3436-9/19/$31.00 ©2019 IEEE

without atmospheric disturbances, such as clouds and dust.

A. Ground-based Remote Sensing

A spectrometer with ASEQ Instrument was used in this study. This spectrometer had an operation range of 400-1000 nm and used to measure particular objects by using artificial and natural light sources. Moreover, two sets of built-in UAV cameras were used. These cameras consisted of an RGB camera and a modified camera with an external long pass filter were used for near-surface measurement. This measurement was done to see the characteristics of male and female flowers, midribs, ripe and raw fruits, and leaves. The measurement was done by using the near-surface measurement method because the object was difficult to detect by using low-altitude remote sensing. In addition, we used SPAD-502 Plus meter and compared it with the near-surface measurement by using a modified built-in camera (with long pass filter >665 nm) for the leaves measurement.

B. Low-altitude Remote Sensing

For low-altitude remote sensing, we used 2 professional DJI Phantom 3 UAVs. We modified one of the UAV cameras by detaching the hot mirror from the camera, and we used an external filter (>590 nm) to capture the red and NIR wavelengths [5]. This measurement was done to check the characteristics of palm oil plant from above.

C. Analysis

The spectral data of each plant tissues collected by using spectrometer was analyzed by plotting the spectral data to evaluate the spectral signature of each plant tissue. For the UAVs data, a set of images collected from two UAVs were processed by using Agisoft Metashape ® software and analyzed. The vegetation indices were used to evaluate the Orthophotos obtained from two UAVs. For the RGB images, we utilized the excess greenness (2G-R-B) and Green minus Red (GMR). For the images captured by the modified camera, we utilized the excess Near-infrared (2B-G-R) and green minus red (GMR). Regression analyses were performed to analyze the correlation between vegetation indices.

III. Results and Discussion

A. Spectral characteristics of oil palm plantations

Each object has characteristics that can be distinguished by spectral signatures. The spectral signatures on each palm oil network is different, which makes it possible to distinguishing plant tissues. Figure 2 shows the different spectral signature characteristics of each palm oil plant tissue. The wavelengths of NIR which is located in the wavelength> 700nm has a reflectance value greater than those in the other band ranges, such as R, G, and B. As such, the wavelengths in the NIR area range are highly recommended to be used and incorporated in vegetation indices.

For leaves measurement, we compared the spectral characteristics of leaves generated by artificial light and that produced by natural light sources. Figure 2a shows that using direct leaves measurement with artificial light gives a significantly different spectral response to different leaves of greenness level. This is in line with the research conducted by [6] which confirms that the different greenness of leaves affects their spectral response.

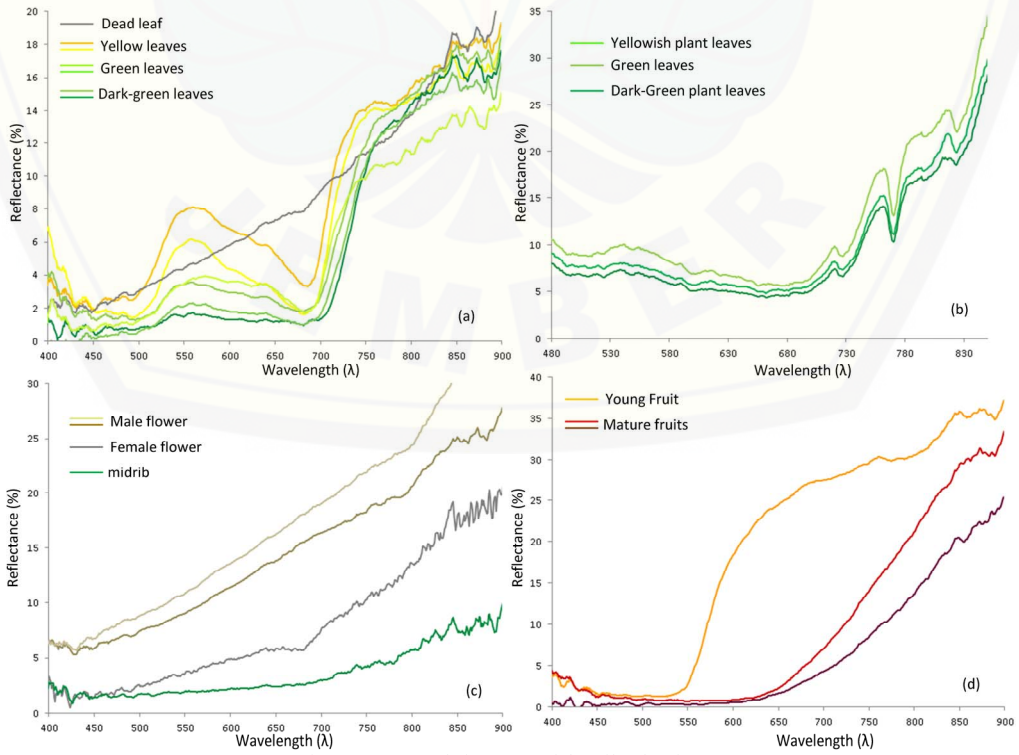

Figure 2. Spectral signature of the oil palm tissues

This article is part of the 2018 IsDB Project of Jember University

Figure 2b shows that the measurement of the spectrometer using natural light demonstrates increase and decrease especially in NIR area response. This is in line with research conducted by [7], which posits that the palm spectral signature using natural light source in areas of red-edge wavelengths (~700nm) and NIR (~ 760nm) identifies volatile trends. However, these trends of the spectral signature cannot be used as the benchmark in determining whether or not oil palms are attacked by disease, but the magnitude of reflectance at certain wavelengths can be used as the benchmark in determining the health of a plant including diseased plant conditions.

B. Leaf greenness characteristics of oil palm

The greenness level of leaves is the most widely used parameter to predict plant health and provide the basic reference for determining fertilization needs. Figure 3 shows the general relationship between SPAD 502 Plus meters and the modified built-in UAV camera in estimating the chlorophyll content of oil palm. A previous study [8] contends that a linear correlation is evident in the relationship between SPAD meter and a modified camera using an external long pass filter >665nm.

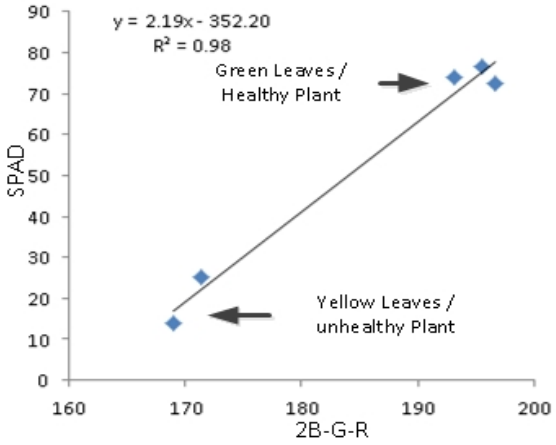

Figure 3. The general relationship between SPAD 502 Plus meter and Excess NIR_B obtained from modified built-in UAV camera with external long pass filter >665nm in assessing leaf greenness of the oil palm.

C. The potential for using low-cost UAV by modifying the built-in camera

The use of UAV by modifying the camera can be used to monitor oil palm plantation. This aims to accelerate technology transfer in the field of precision agriculture by utilizing low-cost equipment, including the use of a modified camera of UAV. By utilizing a modified built-in camera in the UAV and an additional external filter capable

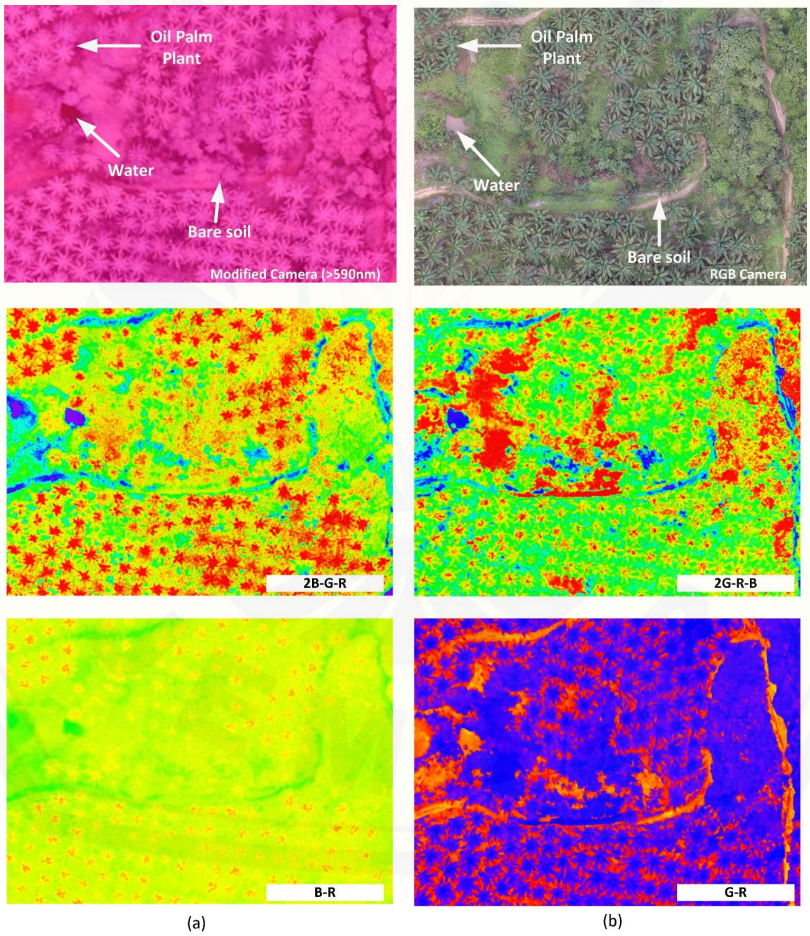

Figure 4. Images captured by a modified camera (a) and RGB (b) camera and their post-processing results based on vegetation indices

of optimizing the use of resources, particularly financial resources. Offering low-cost application, the technology can be utilized by smallholders' farmers.

In accordance with the previous procedures carried out on ground-based remote sensing, the use of NIR bands plays a significant role in accurately classifying objects on oil palm plantations. The analysis results of vegetation indices using the same palette color of the orthomosaics aerial photography showed that the use of NIR bands represented by using B band on modified cameras stimulated a very strong spectral response, especially incorporating the three bands in vegetation index (2B-G-R) compared to incorporating two bands or using RGB camera (Figure 4). For example, water objects, bare soil, and plants can be accurately distinguished by using index 2B-G-R captured by a modified camera.

IV. Conclusion

The use of a modified camera accompanied by a NIR band can help to distinguish an object in plantation accurately, especially in the case of palm canopy. Besides, a modified built-in UAV camera can be used as potential low-cost equipment for counting oil palms through aerial monitoring. The specific findings are summarized below.

- The use of the modified built-in camera in the UAV can increase the accuracy of recognition of an object on an oil palm plantation.
- The use of 3 bands is more recommended rather than the use of 1 or two bands
- The plant canopy becomes more apparent when captured using a modified camera and index 2B-G-R
- The use of an external filter on the camera is more recommended for use as corroborated by survey results.

Acknowledgment

This article is part of the 2018 IsDB Project of Jember University (Batch 2). The authors would like to thank Astra Agro Lestari (Ltd.) – Indonesia, and Laboratory of Precision Agriculture and Geo-informatics of University of Jember– Indonesia.

References

[1] R. Chen, T. Chu, J. A. Landivar, C. Yang, and M. M. Maeda, “Monitoring cotton (Gossypium hirsutum L.) germination using ultrahigh-resolution UAS images,” *Precis. Agric.*, pp. 1–17, Feb. 2017.

[2] X. E. Pantazi, A. A. Tamouridou, T. K. Alexandridis, A. L. Lagopodi, J. Kashefi, and D. Moshou, “Evaluation of hierarchical self-organising maps for weed mapping using UAS multispectral imagery,” *Comput. Electron. Agric.*, vol. 139, pp. 224–230, 2017.

[3] B. T. W. Putra and P. Soni, “Improving nitrogen assessment with an RGB camera across uncertain natural light from above-canopy measurements,” *Precis. Agric.*, pp. 1–13, Apr. 2019.

[4] A. Tugi *et al.*, “OIL PALM TREE GROWTH MONITORING FOR SMALLHOLDERS BY USING UNMANNED AERIAL VEHICLE,” *J. Teknol.*, vol. 77, no. 26, Dec. 2015.

[5] B. T. Widjaja Putra and P. Soni, “Evaluating NIR-Red and NIR-Red edge external filters with digital cameras for assessing vegetation indices under different illumination,” *Infrared Phys. Technol.*, vol. 81, pp. 148–156, 2017.

[6] B. T. Widjaja Putra and P. Soni, “Enhanced broadband greenness in assessing Chlorophyll a and b, Carotenoid, and Nitrogen in Robusta coffee plantations using a digital camera,” *Precis. Agric.*, vol. 19, no. 2, pp. 238–256, Apr. 2018.

[7] A. Camacho, C. V. Correa, and H. Arguello, “An analysis of spectral variability in hyperspectral imagery: a case study of stressed oil palm detection in Colombia,” *Int. J. Remote Sens.*, vol. 40, no. 19, pp. 7603–7623, Oct. 2019.

[8] B. T. Widjaja Putra and P. Soni, “Dataset of Chlorophyll content Estimation of Coffea Canephora using Red and Near-Infrared consumer-grade camera,” *Data Br.*, Oct. 2018.