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The Characteristic of spectral reflectance of LAPAN-IPB (LAPAN-A3) Satellite and Landsat 8 over agricultural area in Probolinggo, East Java

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Abstract. LAPAN-IPB Satellite which was developed by the National Agency of Aeronautics and Space (LAPAN) and Landsat 8 have quite equal specification. However, it is important to investigate the difference of characteristic between the two satellites since the Landsat 8 commonly used by Indonesian researcher in the agriculture field for years. The study was done in Probolinggo Regency which is located in East Java, Indonesia – has a large area of agriculture. Satellite data of LAPAN A3/IPB used in the analysis of its spectral characteristic over agricultural area was acquired on September 18, 2018, while the Landsat 8 image data was taken from acquisition date on September 12, 2018. Field data measurement was done by collecting spectral reflectance of some agricultural crops at study area consist of paddy, maize, sugar cane, and onion. Spectral reflectance from the four crops are quietly the same, except for paddy which has the lowest reflectance on peak of green band compared to other crops. Spectral profile of LAPAN-A3/IPB on Blue, Green and Red band are always lower than Landsat 8, while the NIR band is always higher. NDVI from Landsat 8 OLI ranged from -1 to 0.622844, while NDVI from LAPAN-A3/IPB ranged from -1 to 0.461655. NDVI from Landsat is able to differentiate water more clearly than LAPAN-A3/IPB, indicated by low NDVI value. It is concluded that LAPAN-A3/IPB has quite similar spectral characteristic compared to Landsat-8 OLI. Although there is some difference of spectral characteristic from some crops. It is recommended to consider the age or growth stage of each crop.

1. Introduction

1.1. Background

Since 2012, IPB University and the National Agency of Aeronautics and Space (LAPAN) have approved a partnership to develop satellites which was later named LAPAN-IPB Satellite or LAPAN-A3. This is a micro-experimental satellite which was launched on June 2016 mainly developed to support Indonesia's food security and environmental monitoring program. LAPAN-A3/IPB satellite sensors are four multispectral imager bands (R, G, B, near infrared) with 18 m resolution and 100 km of swath [1]. The LAPAN A3 is also equipped with the Automatic Identification System (AIS) to monitor global marine traffic, similar to the previous satellite generation built by LAPAN (LAPAN A2). The other functions of this satellite are to predict the season, agriculture, and hot spot monitoring.

Landsat is United States' (NASA/USGS) operational satellite mainly developed for earth observation. Landsat-8 is the latest operating satellite in the series of Landsat satellite. It has two main sensors: Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) with 185 km of swath and 15-30 m of spatial resolution. The use of image from Landsat 8 OLI gave satisfied results for nutrient estimation in sea surface to support decision system by stakeholders [2]. Both LAPAN-A3 and Landsat have quite equal specification. However, it is important to investigate the difference of characteristic compared to Landsat 8 as which has been commonly used by Indonesian researcher in the field of agriculture for years.

Spectral is a value that generated from interaction between electromagnetic wave and an object in earth surface [3]. In remote sensing area, an object can be identified using their spectral reflectance signature. This can be done if the sensing system has sufficient spectral resolution to distinguish its spectrum from those of other materials [4]. This is happened because each object reflects and absorb differently at different wavelengths. The object will be recognized by optical remote sensing using visible, near infrared, and shortwave infrared sensors by detecting the solar radiation reflected from targets on the ground (figure 1).

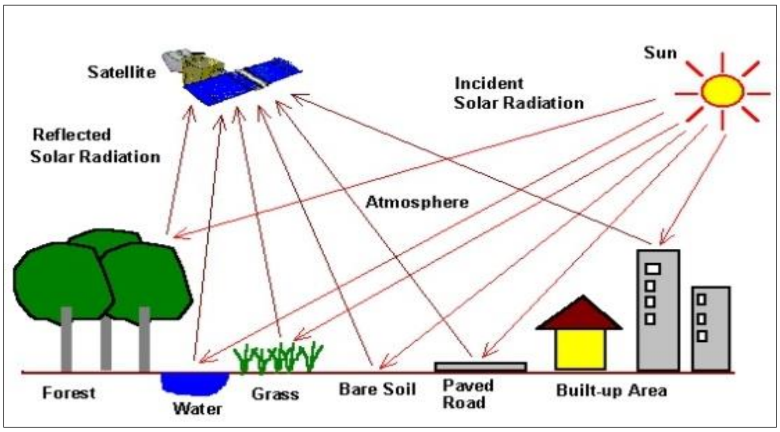

Figure 1. The process of remote sensing in recognizing the objects. [4]

Spectral signature for vegetation is unique because it enables to distinguished one type from other type of land cover in an optical/near-infrared image [5]. The value of reflectance is depended on absorption by chlorophyll for photosynthesis of each spectrum. The low value will be described in blue and red regions of the spectrum, while the high value of reflectance is detected in green region. The typical reflectance spectrum for vegetation is presented in figure 2.

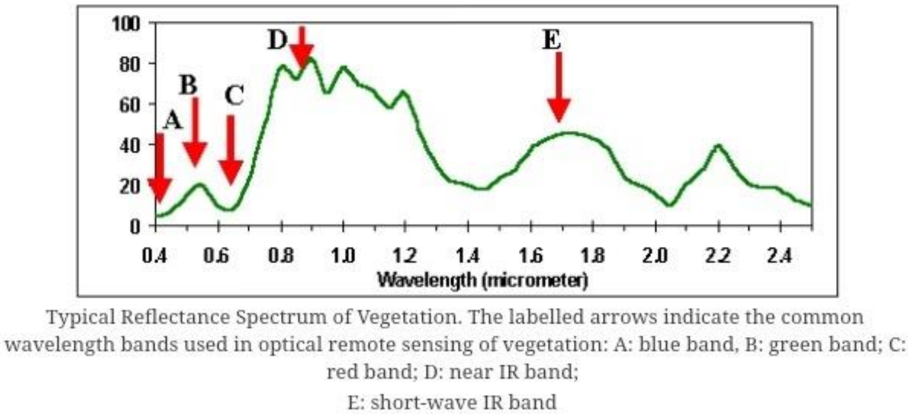

Figure 2. Typical Reflectance Spectrum of Vegetation. [5]

Relative spectral response (RSR) of LANDSAT 8 OLI and LAPAN-A3/IPB Satellite has been summarized by [6]. The study shows that the band wavelengths of Red and NIR on Landsat 8 OLI are in a fairly separate range. This characteristic led to vegetation and non-vegetation can be separated easily by Landsat 8 OLI.

Probolinggo is a regency in East Java, Indonesia – with large area of agriculture. The commodities that can be found in this field consist of maize, cassava, peanuts, mugbeans, and soybeans. In 2016, total production of maize amounted to 259,641.9 tons, higher than other commodities. The largest production is onion that approximately 44,020 tons [7]. The largest area of plantation is used for tobacco plantation. Spatially, this commodity is spread of in plantation and forest plantation area, approximately 8,349 ha. The tobacco productions reach 9,497.3 tons in year 2016 [7]. There are two kind of tobacco crop in Probolinggo Regency, which are Paiton and Jawa. The other commodity with the high production is sugar cane. The production of sugar cane in 2016 amounted to 249,650.59 tons is resulted from total area 4,019.02 ha.Based on the facts, Probolinggo would be a very suitable place to this study.

1.2. Objective
The objective of this project is to investigate the characteristic of spectral reflectance of LAPAN-A3/IPB Satellite by comparing to spectral reflectance of Landsat 8 over agricultural area in Probolinggo regency, East Java, Indonesia. So that the utilization of LAPAN-A3/IPB satellite data can be easily implemented.

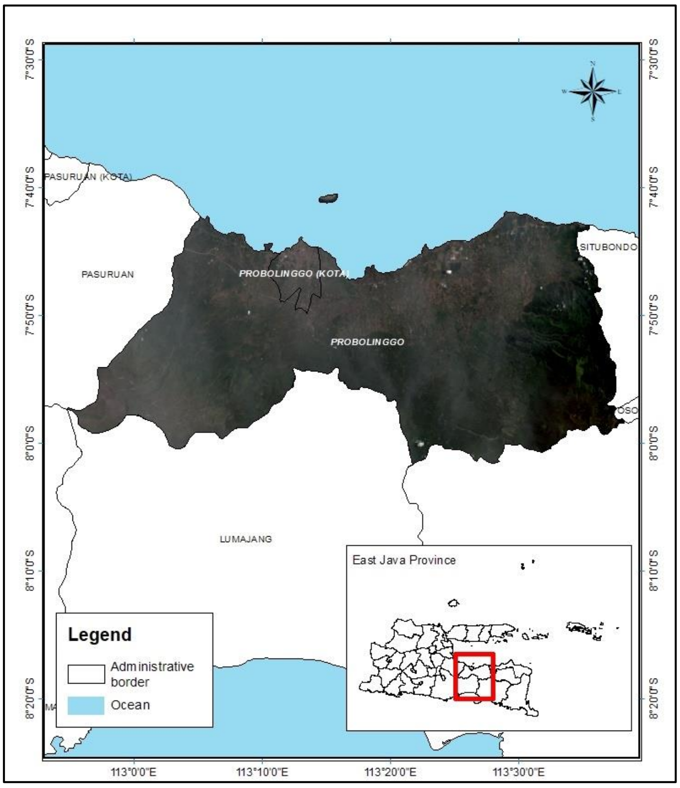

Figure 3. Map of Probolinggo.

2. Methodology
The study area was Probolinggo regency at East Java province (figure 3). Probolinggo is located in the north eastern part of East Java province, or geographically located between 112°51' - 113°30' E and 7°40' - 8°10' S. Total area of Probolinggo is 1,696.17 square km. The boundaries of Probolinggo Regency are:

a. North : Madura Strait,

b. East : Situbondo Regency,
c. South : Lumajang and Jember Regency, and
d. West : Pasuruan Regency.

2.1. Data and Tools
2.1.1. Data
In this study, satellite data of LAPAN A3/IPB used in the analysis of its spectral characteristic over agricultural area in Probolinggo. Image data of LAPAN-A3/IPB measuring 240 x 1006 km with acquisition time on September 18, 2018 is obtained from LISAT Data Order System (LDOS) IPB. The area covered by this dataset is shown in figure 4. While more detail regarding this dataset is shown on table 3.

Figure 4. LAPAN-A3/IPB data used in this study, acquisition date September 18, 2018.

Table 1. Technical metadata of LAPAN-A3/IPB data used in this study.

Metadata	Value
Filename	LA3_L1B_20180918_014400-014503.Tif
Raster dimension	8000 x 33533 pixels
Number of bands	4 bands
Band order	Band 1: N (770-900) Band 2: R (630-700) Band 3: G (510-580 Band 4: B (410-490)
Projection	Geographics (Lat/Long)
Datum	WGS84
Imaging time	Date: 2018-09-18 Time: 01:44:00.131 - 01:45:03.846

Spatial vector data used are land cover map by the Ministry of Environmental and Forestry of Indonesia issued in 2016. This is a land cover map with 23 classes of land cover. Land cover map is used to determine the agricultural area. Specific agricultural area classes based on the land cover data are: dryland agriculture, mixed dryland agriculture, plantation, and paddy field. In addition, satellite image data of Landsat 8 which has the same specification as LAPAN A3/IPB, is also used to assess the spectral characteristics of the sensors used. The Landsat 8 image data used is data (Path 118, row 065) with acquisition date on September 12, 2018 (figure 5), adjacent to the LAPAN-A3/IPB satellite data.

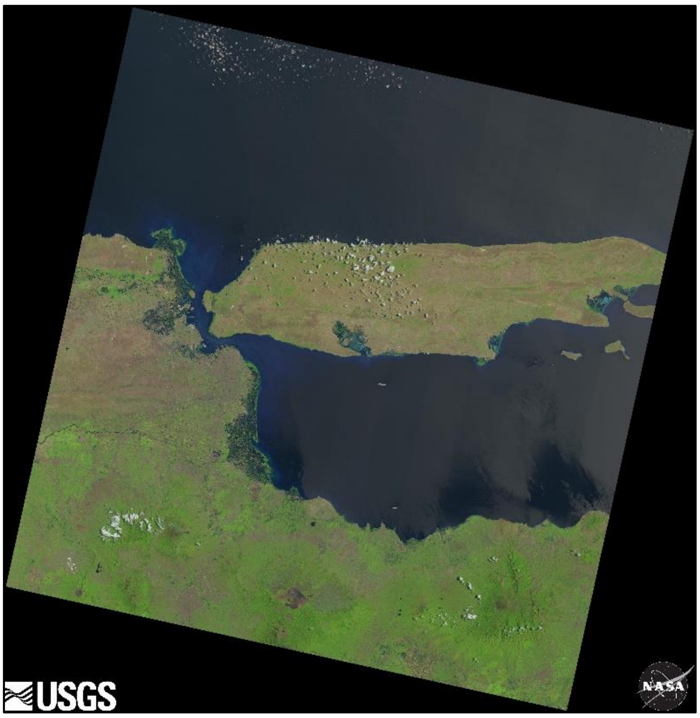

Figure 5. Natural color composite image of Landsat 8 OLI data over East Java (including Probolinggo, in red square) as study area.

Difference in data acquisition between LAPAN-A3/IPB satellite and Landsat is due to limitation of data availability on the same period of time. By this limitation, it was assumed that the crops observed in the field observation have the same condition as both of satellite data.

2.1.2. Tools

Software and utility used are geographic information system (GIS) software and remote sensing software. For field observation and validation, global navigation satellite system (GNSS) were used. A spectrophotometer also utilized to obtain field data of spectral characteristic of agricultural crops on study area (figure 6). High resolution imageries also collected by using drone equipped by RGB and multispectral camera as payload (figure 7 and figure 8). Field data collecting was done on September 2018.

Figure 6. Collecting reference data of spectral reflectance using spectrophotometer.

Figure 7. Utilizing multispectral drone to collect aerial photo over maize field.

Figure 8. Utilizing multispectral drone to collect aerial photo over tobacco.

2.2. Method

2.2.1. Field Data Measurement

Field data measurement was done by collecting spectral reflectance of some agricultural crops located at study area. There were 4 agricultural crops observed in the field observation: (1) paddy, (2) maize, (3) sugar cane, and (4) onion. The field data measurement was done on September 16-18, 2018. Collected spectral data are in the form of reflectance. Due to a problem that LAPAN-A3/IPB still does not have a fix algorithm to convert its data (in Digital Number, DN) to be reflectance data, spectral data from field measurement are converted back into DN format. The multispectral data captured by quadcopter drone with elevation of 60-70 m above ground.

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2.2.2. Satellite Image Pre-Processing

In comparing two satellite data using reference of survey location, geometric correction is mandatory. Geometric correction is done for LAPAN-A3/IPB data by using Landsat 8 OLI as reference data. Landsat 8 OLI is served in the form of unstacked data with separated band. It is required to do layer stacking for this data. The sequence of layer stacking for Landsat 8 OLI is B, G, R, NIR (2, 3, 4, 5). Due to difference in band sequence, it is important to re-order the band sequence of the two satellites data to match to each other. In this study, LAPAN-A3/IPB data which is served in the form of stacked layers, was re-ordered by unstacking the layer and stacking back with the same band sequence as Landsat 8 OLI has: B, G, R, NIR. The next step is overlaying the survey points over the two satellites data to extract its spectral profile. Selected pixels would be 8 pixels adjacent to the survey pixel as shown by figure 9.

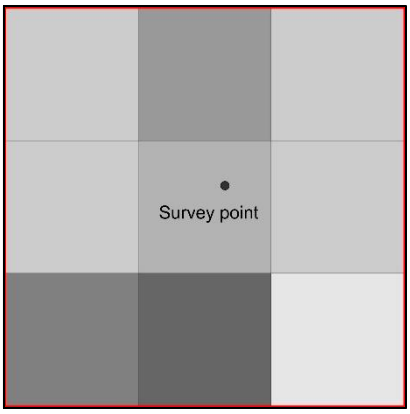
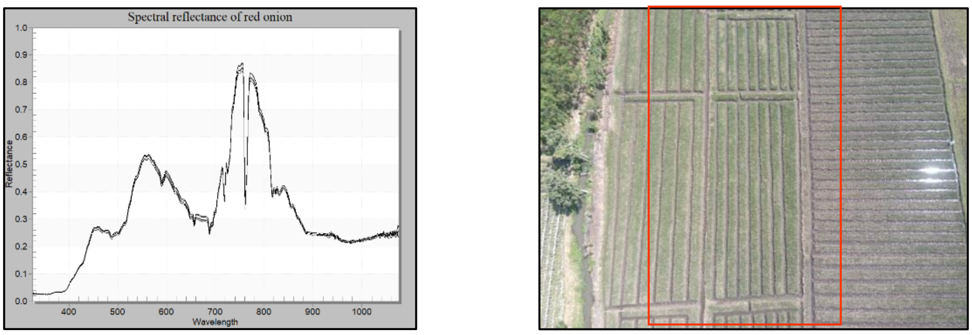


Figure 9. Illustration of pixel selection based on survey point.

3. Result and Discussion

3.1. Spectral Characteristic from on the Field Measurement

Spectral reflectance from four agricultural crops have been collected from on the field measurement using spectrophotometer and drone. Figure 10 shows spectral profile for each crop and its aerial photo captured by drone.



Onion

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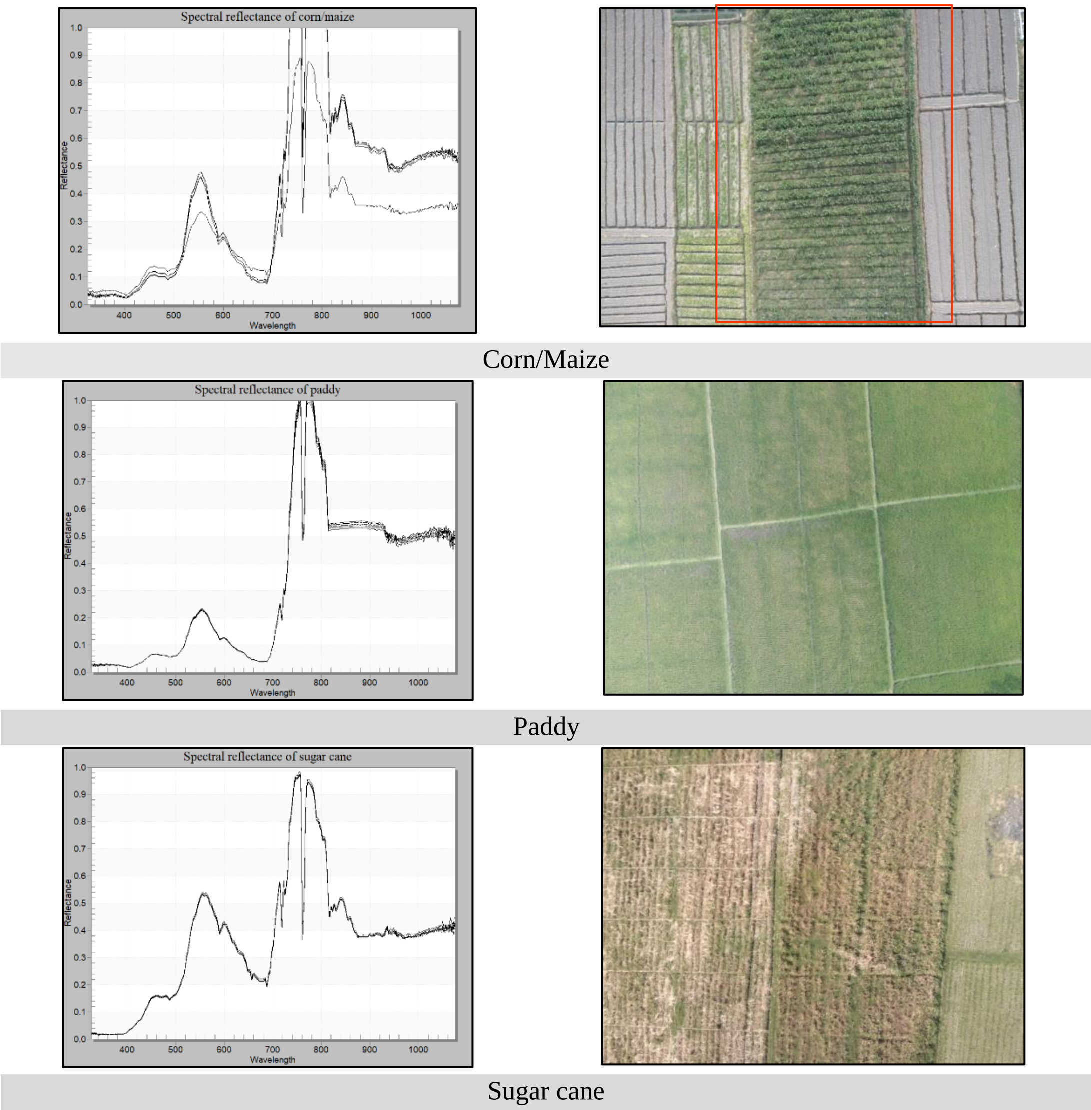
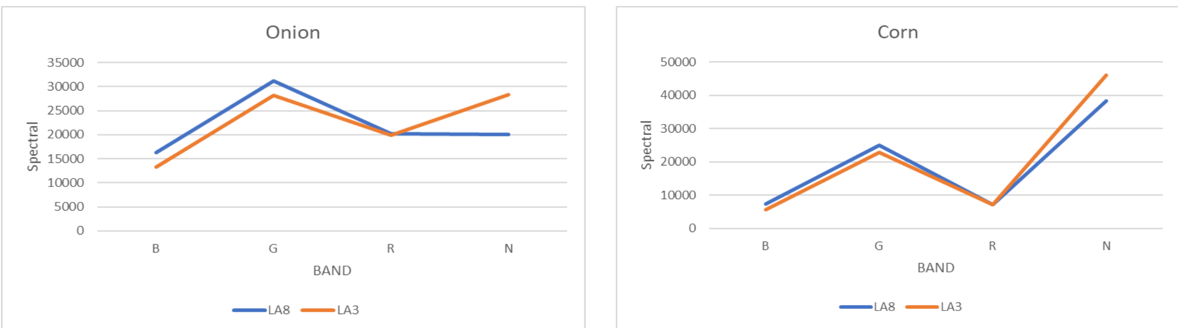
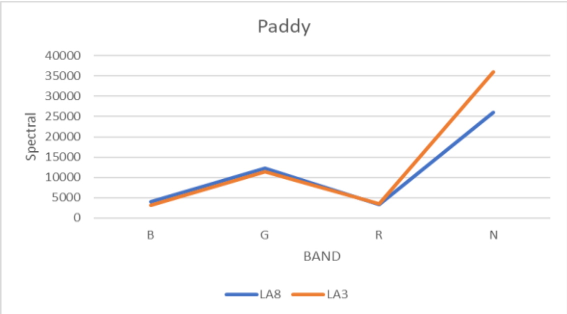


Figure 10. Spectral profile of four observed crops (left) and its aerial photos (right).

As shown by the figure, spectral reflectance from the four crops are quietly the same. Except for paddy which has the lowest reflectance on peak of green band compared to other crops. The data also processed further by generalizing the wavelength into four bands of LAPAN-A3/IPB and Landsat OLI based on each band wavelength. Figure 11 shows the result of the generalization.





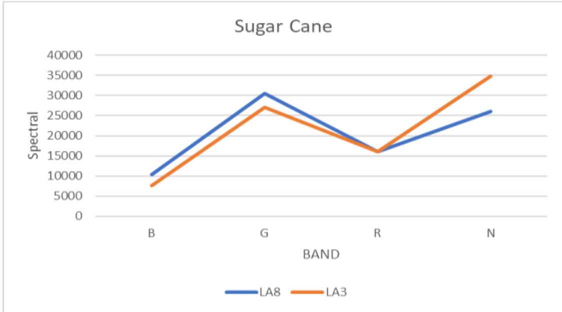
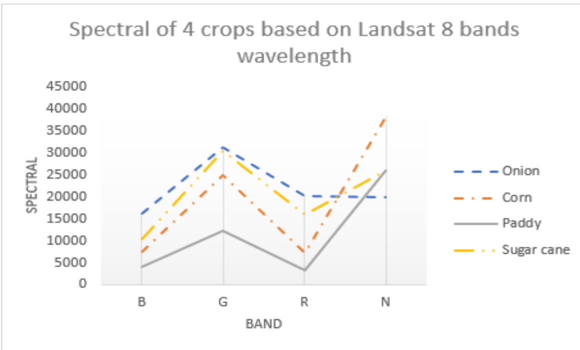


Figure 11. Spectral profile of four observed crops based on wavelength range of LANDSAT 8 OLI and LAPAN-A3/IPB.

The graph shows that on Blue, Green and Red band, spectral profile of LAPAN-A3/IPB are always lower than Landsat 8. On the other hand, on NIR band, LAPAN-A3/IPB is always higher. This is fit to the relative spectral response of Landsat 8 OLI and LAPAN-A3/IPB. Figure 12 below shows a more clearly comparison of spectral profile of each crop based on the two satellites data.



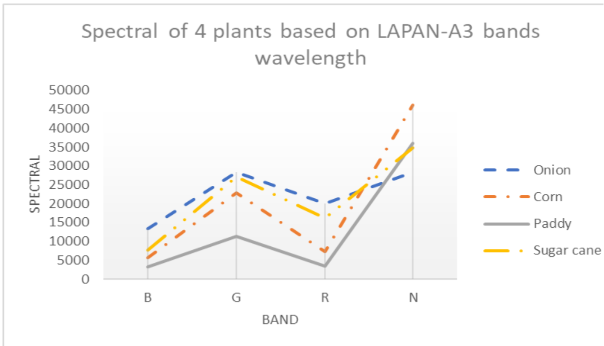
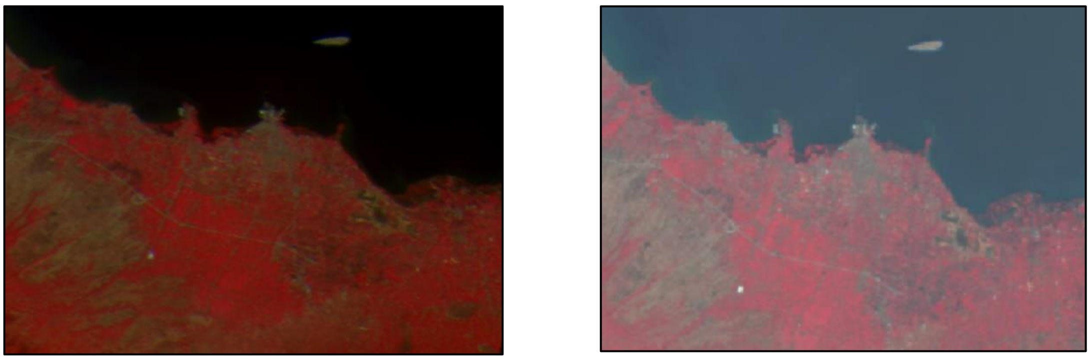


Figure 12. Comparison of spectral profile from 4 crops based on two satellite data band wavelength range.



(a) (b)

Figure 13. LAPAN-A3/IPB Satellite data (a) and Landsat 8 OLI data (b) using false color infrared band combination over Probolinggo.

3.2. Spectral Characteristic from Satellite Data

This comparison of LAPAN A3/IPB and LANDSAT spectral values was carried out on several objects in the 4 available bands, namely: blue, green, red, and near infra-red (NIR) bands (figure 14, 15, 16, 17).

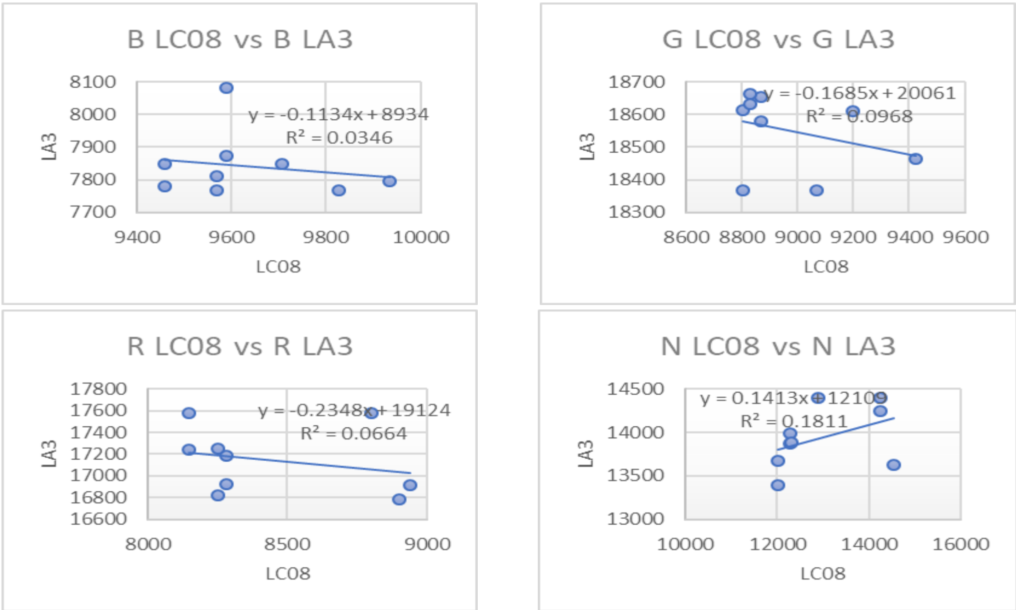


Figure 14. Comparison of spectral value for onion.

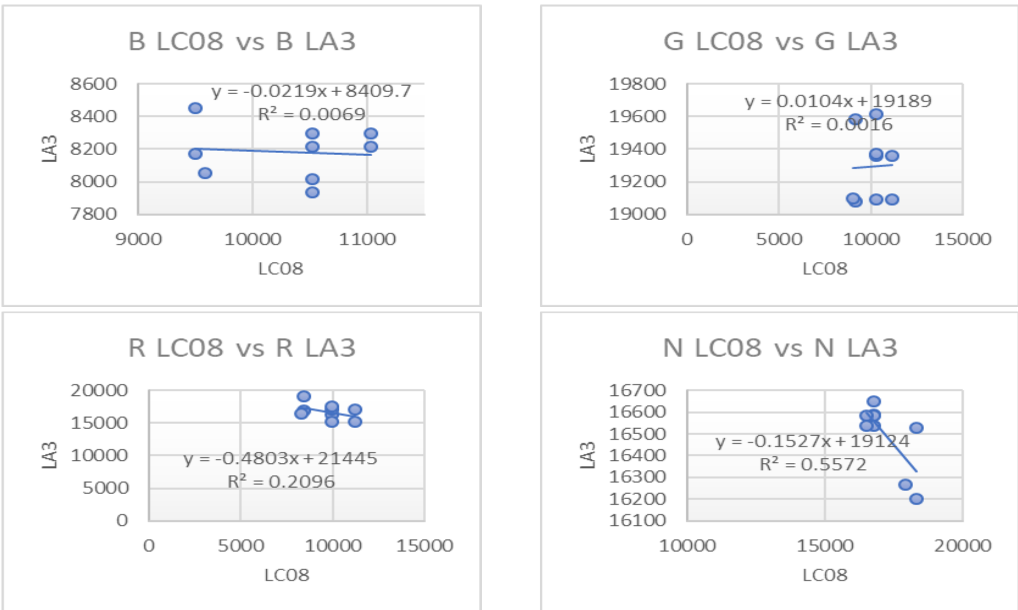


Figure 15. Comparison of spectral value for maize.

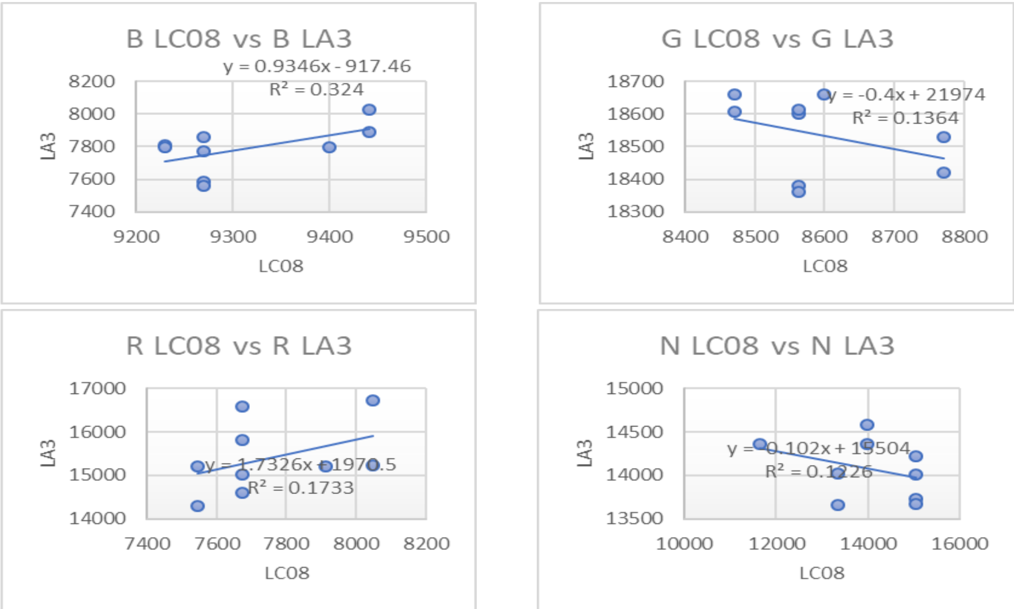


Figure 16. Comparison of spectral value for paddy.

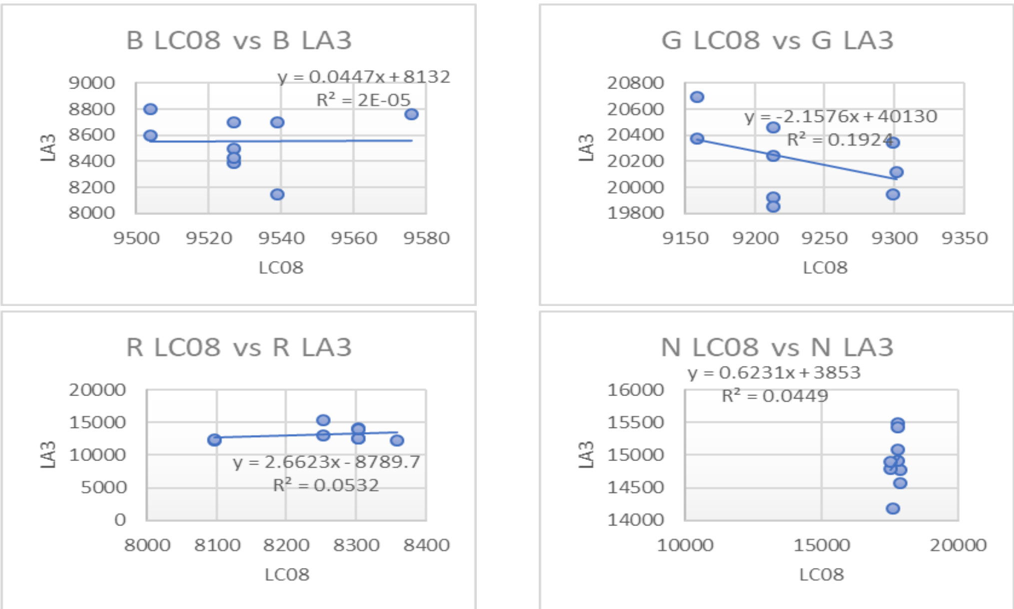
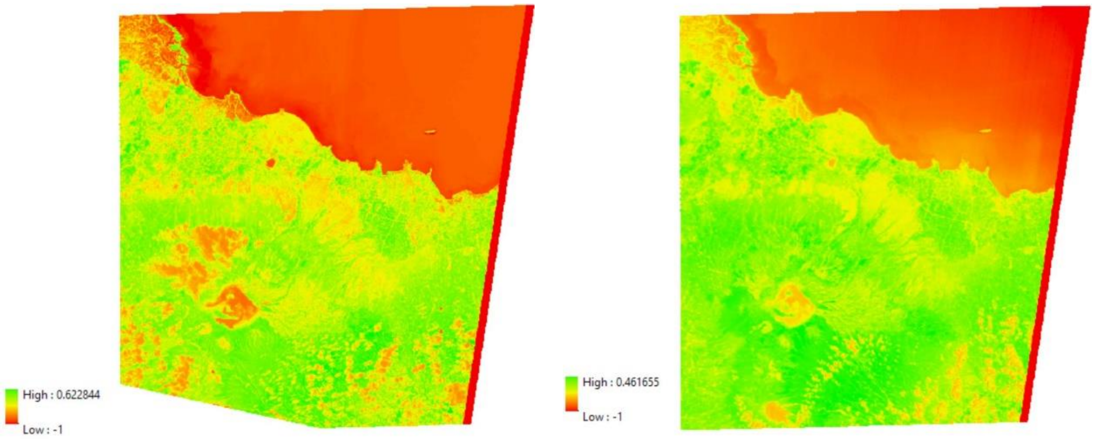


Figure 17. Comparison of spectral value for sugar cane.

From maize and onion, NIR band of Landsat 8 OLI has highest correlation to NIR band of LAPAN-A3/IPB based on its coefficient of determination (R^2). However, on the other hand this band found having low correlation from paddy and sugar cane. The highest correlation found from red band for paddy (0.1733), and green band for sugar cane (0.1924).

3.3. Comparison on NDVI Result

NDVI also generated from the two satellites data to be observed. Figure 18 shows the NDVI generated from both satellites data.



(a) (b)

Figure 18. NDVI generated from Landsat 8 OLI (a) and LAPAN-A3/IPB (b).

The highest NDVI value shows that plant is generative phase and ready to be harvested. While the low index shows non-productive plant or bare land phase. NDVI also used to extract information about plant growing pattern, land cover, plant degradation by disease, and to initial predict on plant yield [8]. A research showed that NDVI value for paddy will reach the highest level at 70 days after planting and decreases with increasing the plant ages [9].

From the figure, NDVI value range from both satellites data are quietly similar. NDVI from Landsat 8 OLI ranged from -1 to 0.622844, while NDVI from LAPAN-A3/IPB ranged from -1 to 0.461655. NDVI from Landsat is able to differentiate water more clearly than LAPAN-A3/IPB, indicated by low NDVI value. Area indicated as water such as sea and lake, obtain lower NDVI value from Landsat. However, it is important to observe more to validate if the low NDVI area in Landsat 8 are truly water or other things having low NDVI value.

4. Conclusion and Recommendation

It is concluded that LAPAN-A3/IPB has quite similar spectral characteristic compared to LANDSAT-8 OLI. Although there is some difference of spectral characteristic from some crops. NDVI from LAPAN-A3/IPB gives higher average but lower variation indicated by narrower range. But still quiet closed compared to NDVI from Landsat 8 OLI which give lower NDVI value especially over area indicated as water.

It is recommended to consider the age or growth stage of each crop. This is to avoid spectral mis-interpretation due to difference in growth stage. More sample also required to be observed. The more samples, the better quality of model will be.

5. Acknowledgement

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