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PADDY FIELD MAPPING USING UAV MULTI-SPECTRAL IMAGERY

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ABSTRACT: Paddy is the most famous crop in Indonesia, which dominantly planted primarily in the west and central part of Indonesia. Rice paddy field is the main food source for most of the Indonesian and Indonesian government are very considered about the stability of their food security program. Therefore, monitoring and evaluation of its sustainability and availability become a national priority. One of the solutions to agricultural monitoring and management program is mapping through remote sensing system. In the study, we used high-resolution multi-spectral imagery collected from unmanned aerial vehicles (UAV) to map the paddy field and differentiate them based on their spectral characteristics. An Object-Based Image Analysis (OBIA) method applied to the image for classifying the stage rice paddy field based on their spectral signature. The results of this study are: (i) a high-resolution map of paddy field and its classifications based on the period of planting, (ii) a comparison table showing the different spectral response for a different type of crops such as banana and tea. Hopefully, this study can support the government program on food security with valuable baseline information of the paddy field.
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Keywords: Paddy field mapping, UAV, spatial analysis, OBIA, NDVI

1. INTRODUCTION

Today, the growing need for spatial data is becoming more obvious. It is not just about the accuracy, proper planning, evaluation, and monitoring process are also depending on the temporal coverage of the data [1]. An example of a spatial database is vegetation data, which is highly needed by many parties such as government and agricultural sector [2], especially in Indonesia.

Agriculture is one of the critical sectors in Indonesia. One of the primary sources of food in Indonesia is rice which produced from this sector. The nation's total land area is around 190 million hectares. From the total, 55 million hectares is an agricultural area, and 129 million hectares covered by forest. From the farming area, 24 million hectares are arable land and 20 million hectares are planted with permanent crops [3].

In this sector, agricultural areal mapping has been essential to providing a database for management, improvement, and food security purposes. Regarding the methods in data collection, remote sensing technology has a significant advantage over the conventional terrestrial survey. This technology allows rapid data collection for relatively larger mapping area. UAV system presents as an alternative to the more-conventional airborne or satellite remote sensing system [1]. The objectives of this study are to test the capability of UAV-based multispectral system to map rice paddy field; to generate vegetation index from UAV, and to use the value of vegetation index for classifying different types of crop.

2. METHODS

To answering the objective of the research used high-resolution multi-spectral imagery collected from unmanned aerial vehicles (UAV) to map paddy field and differentiate them based on their spectral characteristics started from the study area, image acquisition, and field data collection. We also used the Geographic Information System to manage image and filed data.

UAV categorized as an airborne-based passive remote sensing system. The platform used in this system is usually smaller than other conventional airborne remote sensing. It had been used for a wide range of application. In 2017, we have been tested the capability of UAV LiDAR to create topography map of urban forest [2]. UAV also have been applied in the field of civil engineering and architecture especially in change detection analysis on historical building [4].

2.1 Study Area

The study area conduct in Parakansalak. It is a village located in Parakansalak sub-district, Sukabumi, West Java Province. The area is about 90 kilometers from the capital city, Jakarta. The area is on the southwest of Mount Salak. The area is about 700 meters above sea level. Our study area comprised of 70 hectares. It covered with various kinds of land-use such as paddy field, tea plantation, mixed garden and settlement area (Figure 1). The study area divided with paddy field and tea plantation. The tea plantation area called The Parakan Salak Tea Plantation.

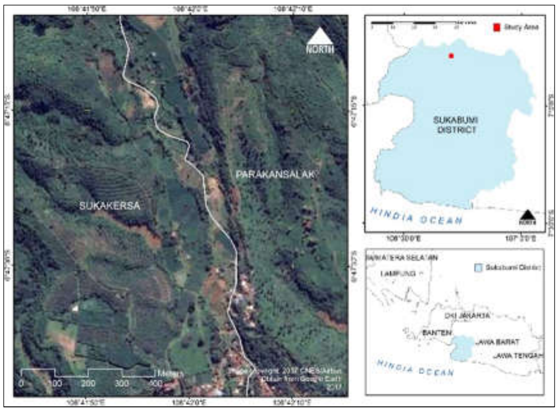


Fig. 1 Study area

2.2 Image Acquisition

2.2.1 Unmanned Aerial Vehicle (UAV)

This study used Parrot Sequoia, a lightweight four bands multi-spectral sensor (72 gram). The sensor has four bands (green, red, red edge and near-infrared), each equipped in 1.2 megapixels global shutter camera. This device coupled with a Sunshine sensor contained similar bands and GPS. The multi-spectral sensor mounted on DJI Phantom 4, a four-rotor UAV controlled by the ground operator.

There are several things that need to be considered in mapping activity using UAV, such as altitude, overlapping, flying time and flight plane. Altitude-related to the image resolution. Overlapping determines the quality of the image, especially when creating a digital elevation model (DEM). Flight time very much related to battery capacity. Flight plan determines the mapping area. The flight plan is designed using Pix4d software (Figure 2). Criteria used in this study served in Table 1. The research used workflow for data acquisition shown in Figure 3.

Vegetation index was generated using different bands from the sensor. This study used NDVI as a tool to differentiate different types of crop. NDVI has widely used in many applications, and one of them is for identifying plant characteristics in the ground [5,6,7]. Some of the NDVI application was specifically used in agricultural issues [8,9]. NDVI calculated with the following formula [10]:

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

where ρred and ρNIR are reflectance value of red and near-infrared bands.

Table 1 Flying criteria in this study

Criteria	This study
Flight time	10-15 minutes
Flight plan	± 300 x 400 meter
Overlap	80 %
Altitude	100 meter above ground

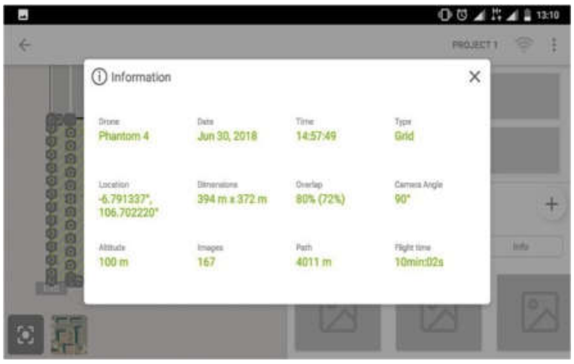


Fig. 2 Flight plan design using Pix4d software

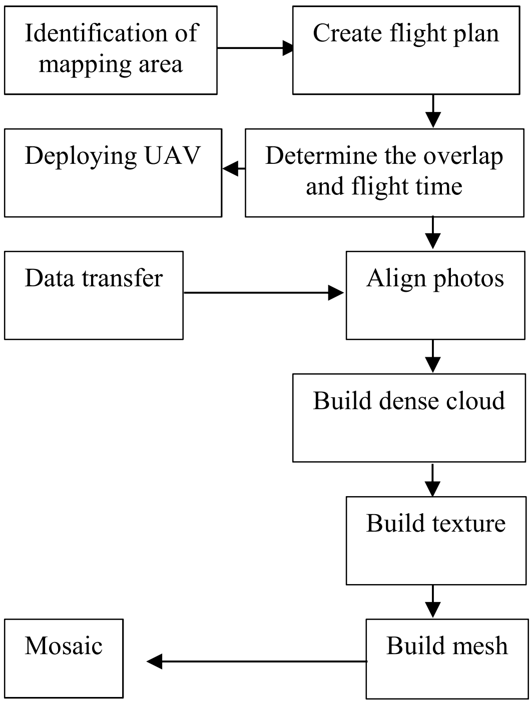


Fig. 3 Workflow of image generation from UAV

Fig. 4 Sample of an image from the UAV with 80% overlap

2.2.2 Field data collection

A field survey conducted in June 2017. Thirty-four sample points collected during the field survey. A field survey conducted for collecting ground data such as types of crops, growth stages of paddy and ground control points for image rectification. A sample distribution is shown in Figure 5. There are three types of crop founded in the area, such as paddy, banana, and tea. The number of samples for every crop is shown in Table 2.

3. RESULTS AND DISCUSSIONS

There are four flight plans used in this study. All of them covered around 70 hectares of agricultural area planted with different types of a crop such as a paddy, banana, cassava, and tea. Each flight plan covers a different area. The area covered by each flight plan and the resulted NDVI are present in Figure 6(a-d).

Table 2 Flying criteria in this study

Crop name	Number of samples
Ketan* / Sticky rice	1
Padi* / Paddy	22
Pisang* / Banana	4
Singkong* / Cassava	1
Teh* / Tea	6

** crop's local name*

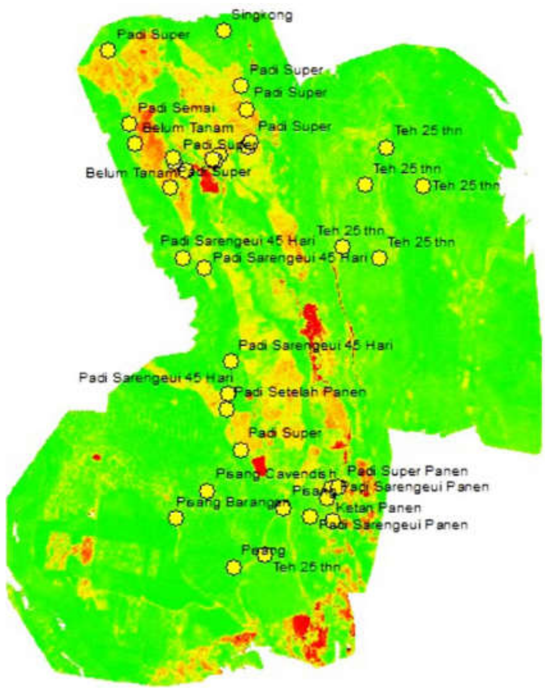
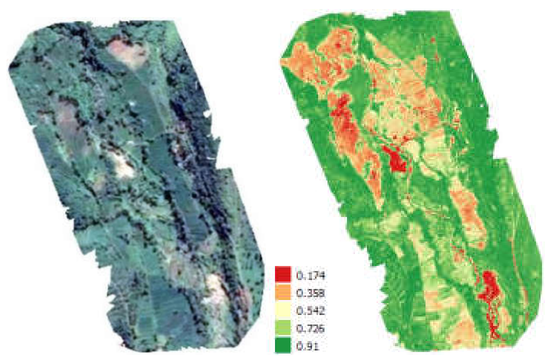
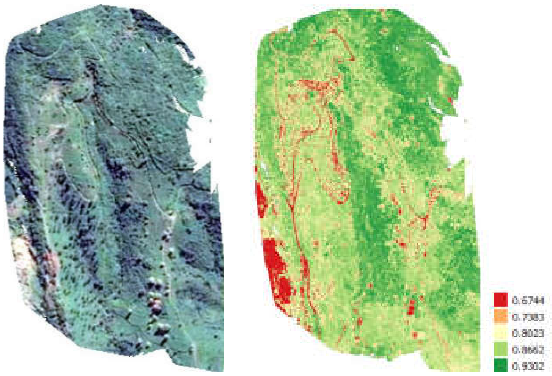


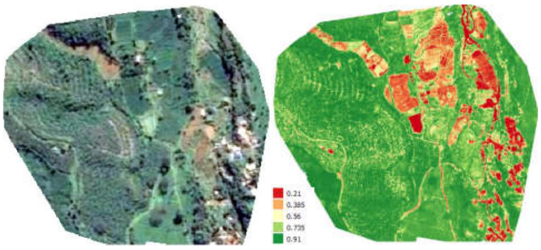
Fig. 5 Ground samples distribution in the study area



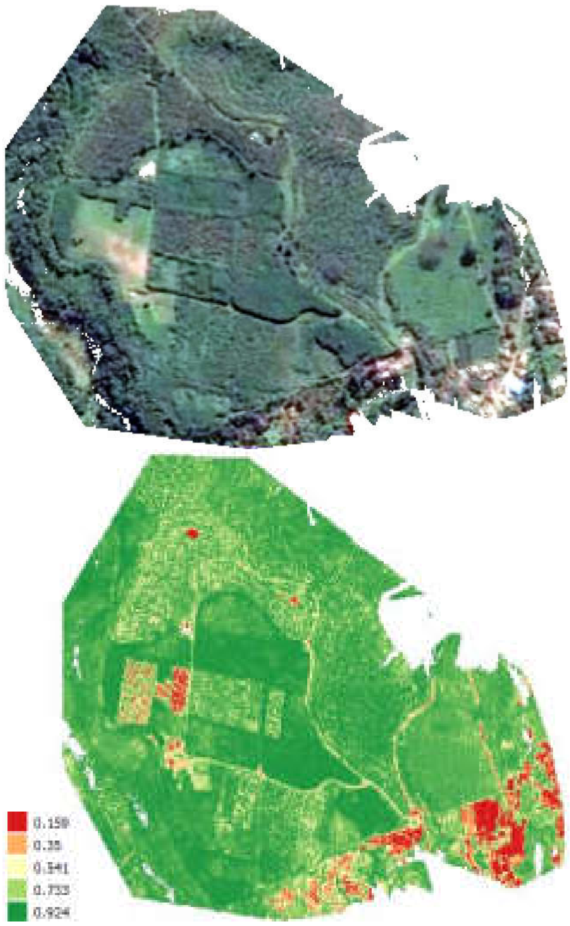
6a – Flight plan 1



6b – Flight plan 2



6c – Flight plan 3



6d – Flight plan 4

Fig. 6 Sample of an image from the UAV with 80% overlap

Fig. 7 Paddy Field from the UAV (May)

Fig. 8 Paddy Field from the UAV

Examples of the different characteristics of crops based on a different period shown in Figure 7 and 8. Figure 7 shows paddy in May. Figure 8 shows paddy in June. Different age phase of paddy might reflect on different NDVI value.

The NDVI value is varied on each flight plan area. The value is ranged from 0.16 to 0.93. Based on the sample points, the NDVI value is varied from 0.21 (paddy) to 0.90 (banana). The range of NDVI values for each crop presented in Table 3.

Table 3 Range of NDVI values for each crop

	Min	Max	Mean	Stdev
Paddy	0.21	0.85	0.61	0.25
Banana	0.56	0.90	0.78	0.14
Tea	0.71	0.86	0.69	0.30

Source: data processing, 2018

Based on the result, the NDVI values for paddy ranges from 0.21 (Sarengeui paddy) to 0.84 (Sarengeui paddy to be harvested). The range of NDVI values for paddy presented in Table 4.

Table 4 Range of NDVI values for paddy

	Min	Max	Mean	Stdev
Sarengui Paddy	0.21	0.80	0.58	0.27
Sarengui Paddy (45 days)	0.79	0.84	0.82	0.02
Sarengui Paddy (to be harvested)	0.38	0.85	0.66	0.25
Super Paddy	0.31	0.83	0.64	0.19

Source: data processing, 2018

The NDVI value can be used to distinguish different types of crop. This study utilized mean and standard deviation values to differentiate crop types. Figure 9 is a boxplot showing a clear separation between paddy and banana. Unfortunately, the separation is somewhat unclear for tea because it could misinterpret.

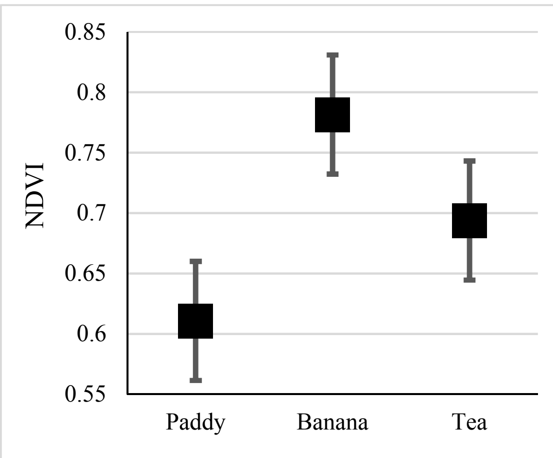


Fig. 9 Separation plot of paddy, banana, and tea based on NDVI value

The NDVI value also can be used to distinguish different types/period of paddy field. Figure 10 shows that NDVI can be utilized to highlight 45 days of Serengeti Paddy. From the value, we can separate 45 days Serengeti Paddy from other types/periods of paddy. Unfortunately, the separation is somewhat unclear for other types/periods of paddy.

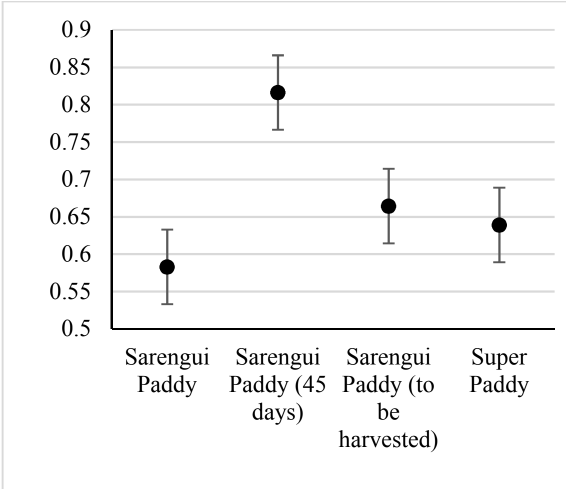


Fig. 10 Separation plot of different types/period of paddy based on NDVI value

4. CONCLUSION

The multispectral sensor mounted on the UAV platform has been successfully used to generate NDVI. The NDVI has been helpful in the image separation process. The NDVI value is useful in discriminating different types of a crop such as a paddy and banana. Moreover, NDVI also can be used to differentiate types and period of paddy field. However, the NDVI values are still varied. Same types of crop might have different NDVI values. Therefore, future works are needed, especially to measure the spectral value of different vegetation using spectroradiometer and use it to verify the result from NDVI.

5. ACKNOWLEDGMENTS

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