Non-destructive Measurement Methods of Sugarcane Canopy using Drone Technology

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Abstract. Destructive methods in the field of leaf area measurement are not effective for predicting plant growth. The development of Unmanned Aerial Vehicle (UAV) and digital camera sensors makes it easier to obtain Small Format Aerial Photography (SFAP) data. Non-destructive sugarcane (Saccharum officinarum) cutting using UAV technology is more effective than destructive methods. This study aims to determine the width of the tree canopy using Small-Format Aerial Photography Near-Infrared (NIR). The research stage includes a preliminary survey of sugarcane plantations and determination of Ground Control Point (GCP), data acquisition and SFAP using a modified Syma X8 Pro UAV drone and a Nikon Coolpix a 100 modified NIR camera, infrared aerial photo processing, measurement of cane area on sugarcane objects using Image Processing and Geographic Information Systems (GIS). The results of this research block sugarcane plantation SFAP in Balecatur Village, Sleman Regency, and a map of the area of sugarcane canopy in Balecatur Village, Sleman Regency. The cane canopy area of the study area is 29.3 m².

1. Introduction
Sugarcane (Saccharum officinarum) is a dynamic sugar-producing bio-agent [1,2]. Dynamics can cause difficulties in crop production problems both in quantity and quality [3]. The relationship between the environment and sugarcane is very complicated; environmental control based on plants is input control based on plant ecology [4-6]. These conditions affect the phase of sugarcane growth, especially during the reproductive phase [7].

The reproductive phase indicator of the destructive method is obtained by leaf shaving, and the ratio of leaf length to stem diameter [8]. The shaving leaf area is not useful for predicting plant growth [9]. Because not all leaves in plants photosynthesize optimally. After all, some are not exposed to sunlight. Therefore, growth forecasting is better to use large canopy plants.

UAV technology as a vehicle and infrared digital camera as a sensor are overgrowing, making it easier for SFAP data acquisition [9]. The object of vegetation study has a characteristic in responding to electromagnetic waves [10,11]. The vegetation object has a substantial reflection value in the green band and NIR [8,12]. The spectral reflection pattern of sugar cane with a spectrophotometer has the same value and capability as the reflection pattern of vegetation in general [13,15]. Modifying the
camera sensor into a modified infrared camera adds the sensor's ability to record objects on the NIR, Green, and Blue channels [16-18]. The reason for using UAVs is that they are cheaper, safer, more quality, more accessible, and easier to adapt [19].

In the destructive method, leaves that are not exposed to the sun cannot be identified [20]. The non-destructive method of recording a UAV camera makes the upper part of the plant the object of study (including leaves and petioles) recorded by the camera where the position of the shoot with the camera is relatively perpendicular [21]. Parts of the plant that are not exposed to sunlight mean little to contribute to photosynthesis. If this method is accurate on sugarcane, it will certainly be effectively applied to plantation crops that have a broad canopy such as oil palm. This study aims to determine the extent of sugar cane canopy with a non-destructive shaving method using the SFAP data.

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2. Material and Methods
The research was conducted at one of the sugar cane plantation locations in Gamping District, Sleman, Yogyakarta Special Region, Indonesia.

The stages of this research were: a preliminary survey of sugarcane plantations (vegetative phase) and determination of Ground Control Points (GCP), data acquisition including observations of plant physiology and SFAP, processing near-infrared aerial photos, identification of sugarcane objects using the maximum likelihood classification, and measuring the area of the sugar cane canopy.

The tools and materials used are a benchmark, GPS, modified Syma X8Pro UAV vehicle that carries a modified Nikon Coolpix camera sensor 100 NIR. Nikon Coolpix A100 sensor modification is done by widening the range of the wave spectrum to near-infrared at a wavelength of 0.79 µm to 0.86 µm. Change of the vehicle is made to fly and lift the camera. NIR camera modifications are made so that it can record automatically every time interval. Camera settings are used to adjust the flight plans that have been previously made.

Data processing includes: making orthophoto mosaics using Agisoft Photoscan software; GIS software, namely ArcGis 10.3, is used to identify sugarcane plants using interpretation keys and maximum likelihood classification, and to measure the area of the sugar cane.

3. Result and Discussion
The research location is in Balecatur Village, Sleman Regency. Sugarcane garden is a rice field area that has an irrigation ditch, sugarcane aged 0-4 months, and has a lot of weeds. Weeds that grow have narrow leaves and are a type of weed that usually live in moist open areas. The irrigation water level at the research location has reached the upper lip of the bed, making the potential for weeds to grow.

Photos of the results of data acquisition were produced as many as 110 pieces in good condition; then, the mosaic process was carried out. The results of the aerial photography orthomozaik are presented in Figure 1. The process of making orthomozaik aerial photographs is carried out in the Agisoft software, including making align photos, building dense could, build mesh, blend textures, and build orthomozaik. Orthomozaik manufacture can be done immediately without building a dense could. Based on the orthomozaik results in Figure 1, the area of the sugarcane plantation is 436.8 m². In this area also consists of sugar cane, weeds and grass, irrigation drainage channels, and soil. This initial identification is used for the maximum likelihood classification class parameter.
The modified Nikon Coolpix camera produces photos from 3 wave spectrums, namely NIR, Green, and Blue. Unlike cameras in general, which produce photos from the red, green, and blue wave spectrum. The NIR wave spectrum is good for plant identification.

NIR has a unique pattern that is absorbed by water, so water objects have a dark hue. Based on the SFAP results of the study area, water objects have a dark hue, while vegetation objects have a bright hue. The shape of the leaf also determines the spectral reflection possessed by vegetation. The spectral reflection of NIR is largely influenced by water content. The higher the water content in the vegetation, the lower the spectral reflection, and vice versa.

Sugarcane leaves are bow-shaped and thin like a bow. This does not allow the sugarcane leaves to have a lot of water storage, so the results have a bright hue. When viewed from the SFAP, the characteristics of sugarcane have a distinctive elongated leaf shape. Some will see starfish that have long tentacles. The characteristics of the sugarcane are presented in Figure 3. The sugarcane in the research area has many weeds that have almost the same leaf characteristics. In SFAP, weeds and grasses have a radiant hue that is almost the same as sugar cane. The patterns and hues of the weed and grass objects that resemble sugar cane allow errors during the interpretation process. The 3d...
dense model could also make it easier to identify plant species. In this model, the height of sugarcane is higher than weeds or grass.

![Sugar Cane in Visual vs. SFAP](image)

**Figure 2.** Sugarcane identification on SFAP

The results of these interpretations are used as capital to classify the maximum likelihood. The classification results are presented in Figure 4. The classification results show that the distribution of weeds and grass is wider than the object of sugarcane. This is consistent with the reality in the field as shown in Figure 3. Sugar cane grows surrounded by weeds and grass. The potential for misinterpretation can occur because the pixel values of weeds and grass have similarities to the sugarcane object. Sugarcane that grows well and has a wide canopy area is easier to identify with a small cane.

The results of the classification are reduced to a cane canopy area map, which is presented in Figure 5. The results of the canopy area of the study area are 29.3 m². The characteristics of sugarcane leaves have a narrow area so that it affects the canopy area. The wider the header, the easier it is to recognize the object in SFAP. The ease in identifying sugarcane objects is influenced by the spatial resolution of the object of study. The wider the header, the greater the number of pixels of the cane. The number of pixels affects the canopy area produced in this research method. The cane canopy area has a small area compared to the area of the study, which is influenced by several factors, namely: characteristics of sugarcane leaf shape, errors during interpretation, and level of detail during SFAP data acquisition.
Figure 3. Classification of land cover in the study area

Figure 4. Map of Sugarcane Canopy Area in Balecatur Village, Sleman Regency
4. Conclusion
The results of this research block sugarcane plantation SFAP in Balecatur Village, Sleman Regency, and a map of the area of sugarcane canopy in Balecatur Village, Sleman Regency. The cane canopy area of the study area is 29.3 m$^2$.

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