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THE USE OF DRONE AND VISIBLE ATMOSPHERICALLY RESISTANT INDEX (VARI) ALGORITHM IMPLEMENTATION IN MANGROVE ECOSYSTEM HEALTH'S MONITORING

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ABSTRACT

Operational limitations are the main problem in monitoring 3.31 million hectares of mangrove forest areas throughout Indonesia. However, with the disruption of technology, there are currently many approaches and methods that can be adapted to answer these problems. One of them is drone technology. This technology can be utilized in high-resolution rapid mapping for limited areas. The output from the data acquired by the drone can be analyzed for various purposes, including assessing the health condition of the vegetation. In this study, the results of the acquisition of unmanned aircraft on mangrove vegetation are used to determine the health level of vegetation in mangrove conservation areas. The research was conducted on 46 hectares of mangrove conservation area. The acquisition process was divided into four flying missions with a flight height of 150 m, 80% patching, and using the Hasselblad L1D-20c camera with a 1-inch sensor. The acquisition results are processed using the online photogrammetry method through the cloud-based photogrammetry service from DroneDeploy. Processing uses standard mode, where this mode is designed to produce good image quality with a relatively fast processing time. The acquisition results of 1614 photos were 100% successfully aligned, with 3.50 cm/px GSD resolution. Based on the application of the VARI algorithm to the resulting orthophoto, it is known that 30.2692% of the AOI is an area and/or dead or non-vegetated vegetation. Then 59.3887% is vegetation in an unhealthy condition, 10.3405% is considered as vegetation in healthy condition, and 0.0015% is vegetation in very healthy condition.

Keywords: Mangrove; Drone; Conservation; Health Index; Monitoring

I. INTRODUCTION

Economically, mangroves have a direct and indirect impact on the surrounding community. Mangrove valuation in Indonesia ranges from US $ 3,624.98 - US $ 26,734.61 / ha/year [1]. [2] found that the total economic valuation of mangrove conservation is higher than aquaculture sector. The production of the coastal fisheries sector is strongly influenced by the existence of mangrove ecosystems [3]. The biota potential of crabs, fish and shellfish is worth US$750 to 11,280 per ha per year [4].

The functions and services provided by the mangrove ecosystem are optimal if the mangrove community is well maintained. However, in the last two decades there has been an increase in land use change and other coastal area development activities that have reduced the area of mangrove forests in Indonesia [5]. Currently, Indonesia has 22.6% of all global mangroves that is the largest in the

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world [6]. Mangrove deforestation is also considered the largest contributor to carbon emissions in the world. [7] states that increasing human populations is a serious threat to mangroves in the future where their activities can have a direct and indirect influence on ecosystem sustainability.

This condition demands massive and consistent monitoring. However, the operational limitations of monitoring mangrove ecosystems are not optimal and trigger many land conversions for various interests, both legal and illegal. This condition has continued for a long time until now. Along with the development of technology, monitoring activities are also disrupted so that it is possible to carry out efficiency. Through the development and utilization of unmanned aircraft technology in the last 5 years, currently the technology has been widely applied in the marine and fisheries sector [8-16]. One of the popular implementation is rapid mapping efforts in limited areas in coastal and marine areas. The advantage of data acquired with unmanned aircraft is that the data obtained can be analyzed for various purposes. One of the things that may be done in the context of monitoring mangrove ecosystems is an assessment of the health condition of vegetation.

2. RESEARCH METHOD

Time and Place

The location was selected (*purposive*) based on data and information regarding the distribution of conservation and rehabilitation areas on the coast of Karawang Regency. The Sedari Village Mangrove Tourism Area was then chosen as a representation of several alternative locations. This area is under the management of the Cikiong Forest Management Unit (BKPH), the Purwakarta Forest Management Unit (KPH), Perum Perhutani Unit III West Java, and the Cibuaya Forest Police Resort (RPH) (Figure 1).

Figure 1. Area of Interest (AOI)

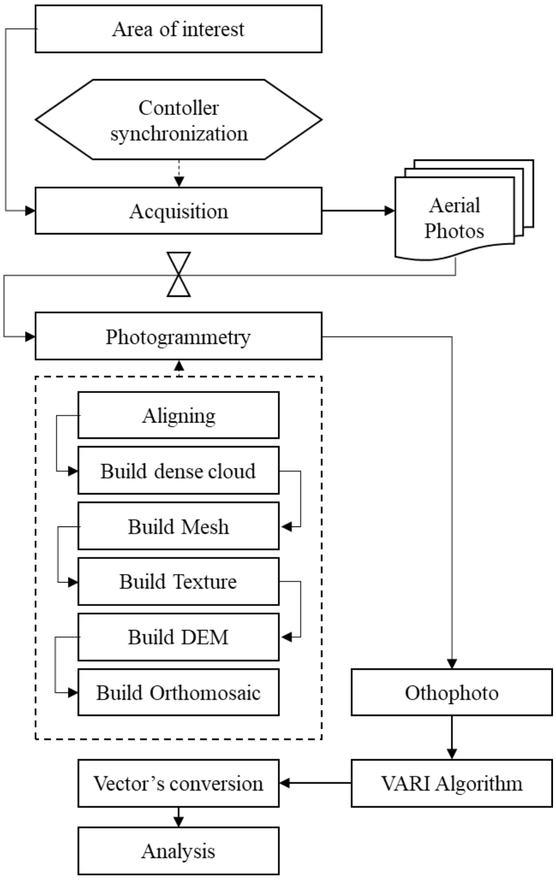

Figure 2. Research flowchart

Research Methods

The main material used in this study was photos of acquisitions using drones. These photos will then be combined into one whole photo image (orthophoto) using photogrammetry techniques. The main tools used in this study are the Mavic 2 Pro type drone with the main specifications of a 1-inch CMOS camera sensor, a lens with a 77 o FOV, and GNSS capable of capturing GPS and GLONASS satellites.

The outline of the activities carried out in this study is as stated in the following diagram (Figure 2).

Research Procedure

The first stage carried out in this study was to create a flight mission. The flight mission is created before taking aerial photo data by determining the area of interest (AOI) of the study area. In order to make it easier to create flying missions, the author first creates polygons on Google earth. Then the polygon is imported into the DJI Pilot application, which has been installed on the drone controller in KML format. Because the observation location is quite wide and in anticipation of signal loss, the observation location is divided into four sub-areas of flying missions (Figure 3).

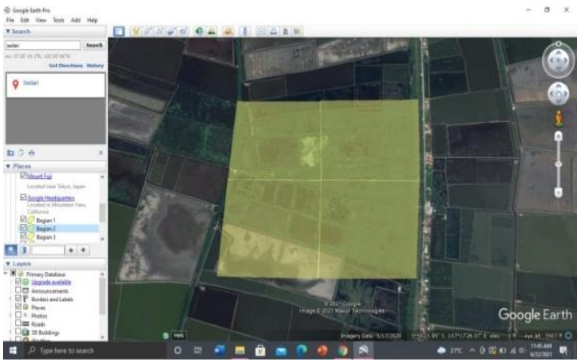

Figure 3. Determination of flight mission sub areas

The second stage is to make some settings on the controller, especially the flight altitude adjuster, the percentage of overlap, and the fixation of the flight mission. The altitude is set at 120 m. Then because the research location is a mangrove conservation area with a high canopy and tight in some parts, so the overlap is set at 85% due to the diverse forest relief. The estimated flight time of each of these missions ranges from 24-30 minutes.

The third stage is the data acquisition process, which is the taking of aerial photos by drones following a pre-arranged flight mission. Furthermore, the fourth stage is data processing, which is carried out using online-based photogrammetry techniques from www.dronedeploy.com. At this stage, in addition to the unification of aerial photos, aerial photo quality measurements will also be carried out which are automatically generated through the platform.

The fifth stage is the application of the VARI algorithm to the orthophoto resulting from the fourth stage. This stage aims to determine the level of health of mangroves, which is based on the level of greenery of the canopy. The greenish level is a reflection of the indirect light of sunlight reflected by the leaves. Like direct light, indirect light reflected from the sun also consists of several spectral canals. The formula used in the VARI algorithm is formulated as follows [17-19]:

$$\text{VARI}=\frac{\text{Green-Red}}{\text{Green +Red-Blue}}$$

The output of the fifth stage is the raster, which is presented as class data. Based on these data, in the sixth stage, with analysis through geographic information data processing system software, it can be known the area of vegetation that is indicated to be very healthy, healthy, and unhealthy and non-vegetation data. Area is known by multiplying the area per class by the area per pixel.

3. RESULT AND DISCUSSION

General Quality and Accuracy of Aerial Imagery (orthophoto)

The area acquired through four flying missions is 89.20 Ha. Processing uses standard mode, which aims to produce good quality imagery and relatively fast processing time. This mode is efficient for mapping open areas such as fields and large crops, especially in producing topographic maps.

Optimization of metric cameras with Hasselblad L1D-20c sensors was measured by 0.03% from manual settings prior to the acquisition process. The acquisition resulted in 1614 photos 100% successfully aligned. The resulting GSD resolution is 3.50 cm/px. GSD or Ground Sampling Distance is the pixel size value of an aerial photograph that has been projected on the ground. Based on the resolution value obtained, the resulting image can be categorized as a high-quality aerial photo image.

Figure 3. Determination of flight mission sub areas

Dataset Quality

The photogrammetry process works by matching key points in multiple photos to align the relative positions of all cameras. Therefore, providing the drone camera with several high-quality images of every point on each surface is the key to producing great maps and 3D models. This quality depends largely on how much of the image overlaps between side-by-side photos.

This quality of exposure can also be referred to as image density. For processing using the DroneDeploy platform, so that the results obtained can be as good as possible, the recommended calculation of the platform provider is an image density of 8-9 images per pixel (equal to 75/70).

In the resulting orthomosaic, the resolution of the image obtained is 5472x3648 pixels (~20MP). The cover of the orthomosaic area was 101.69% of the study area. The number of images per pixel in orthomosaic is 40 images/pixel. The resulting image cover on the resulting orthomosaic can be seen in Figure 5.

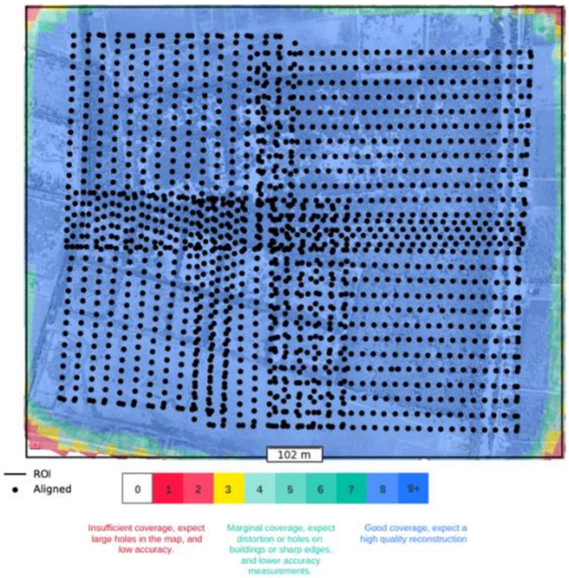

Figure 3. Aerial photo reconstruction quality

Black dots in figure 5 representing each image collected during the on-site acquisition process. You can see a yellow square representing the image aligned with the GPS. If an image is symbolized by a yellow square, it means that the image cannot be aligned with other images using standard algorithms, and the metadata present on the EXIF is used to align the image.

Each image taken on the DroneDeploy platform is optimized to position the camera projection on 3-dimensional space. In addition, the metadata recorded on each image is used to determine geolocation so that it can produce a good image/map. 100% alignment means that all uploaded images are successfully used entirely in map reconstruction. An unalienable image (the red mark in Figure 5) shows a camera location that cannot be found in 3D space so it is not used in image reconstruction.

Root mean square error (RMSE)

Proses acquisitions take place, with an IMU or Inertial measurement unit mechanism. IMU is a component that utilizes measurement systems such as gyroscopes and accelerometers to estimate the relative position, speed, and acceleration of motor motion that estimates movement (X Y Z position) and orientation (*roll, pitch, heading)* [20]. The IMU mechanism will automatically adjust all physical components of the unmanned aircraft to suit field conditions. So that all arrangements made before the acquisition process, it is very possible to undergo changes / adjustments. This adjustment is expressed in the *Root Mean Squared Error* (RMSE), which is a measure of the spread of XYZ camera errors solved versus the location determined by the GPS value recorded in the image. Therefore, for example, the location of the XYZ RMSE camera of 10 feet (3m) means that in general, the location of the acquired XYZ image must be within 10 feet of the GPS location provided. The RMSE on the resulting image (Figure 6) is 3.78 ft (X 4.01 ft Y 3.62 ft Z 3.71 ft).

If GPS conditions are poor, it can lead to large camera location errors, but if the image is acquired correctly, the processed imagery will remain very accurate when measured both distance and volume on a small part of the map. Increased accuracy can be pursued by applying a *Ground Control Point* (GCP). GCP is a point on the ground whose GNSS coordinates are known and is used to calibrate the position/coordinates of acquired imagery

Figure 4. RMSE Orthophoto Imagery at Dimension Z (altitude)

Mangrove Health Index

Mangrove exocytose are a typical ecosystem compared to other vegetation, so they can be identified by remote sensing technology [21]. Efforts to monitor mangrove health in this research as explained in the methods section, using the VARI algorithm. The VARI index scale ranges from -0.1 to 0.2 to represent vegetation that is in an unproductive/dead/non-vegetated state to very healthy. Based on the application of the VARI algorithm to the orthophoto of the Sedari Village mangrove tourism area, a class of vegetation conditions was obtained whose values ranged from -0.06 to 0.24.

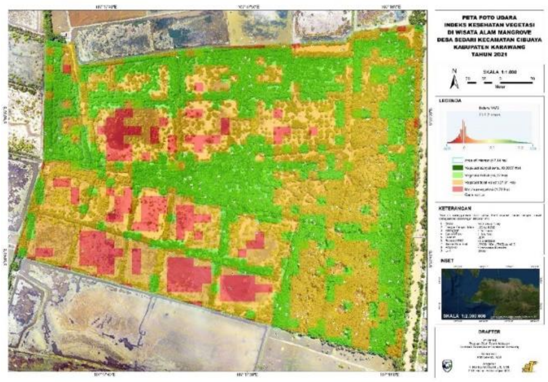

Figure 5. Aerial photo map of mangrove health index with application of VARI algorithm

The index value obtained is then visually transformed so that it becomes a thematic map of mangrove vegetation health mangrove Nature Tourism Sedari Desa Sedari Cibuaya District Karawang Regency as can be seen in Figure 7.

From Figure 7 it can be seen that the majority of the study area is covered by yellow to orange. This informs that mangrove vegetation in the mangrove tourism area of Sedari Village, covering an area of 27.51 ha (59.3887% of the study area / area boundary) is in an unsanitary condition. Based on information from local managers, the westernmost area of AOI is the area that was first planted during the era of President Soeharto. So it is filled with old vegetation that is already less productive

In addition, the remaining 14.02 Ha (30.27%) is classified as healthy, 4.79 Ha is classified as dead/non-vegetation vegetation, and only a few are classified as healthy (0.0007%) asstatedin (Table 1).

Table 1. Class range and area based on vegetation health conditions

No	Category	Color	VARI's scale	Area (Ha)	
1	Very Healthy		> 0,2	0,0007	0,0015 %
2	Healthy		0,1 – 0,2	14,0237	30,2692 %
3	Unhealthy		0 – 0,1	27,5148	59,3887 %
4	Dead/non-vegetation		< 0	4,7907	10,3405 %

Referring to the manager's description, planting and reforestation activities are currently centered on the central area. So that seen in Figure 7, the green color looks more dominant in the central area. Vegetation in young tree stadia is indeed more productive than younger stadia or older trees [22].

4. CONCLUSSION

Referring to the research background, the VARI algorithm can apparently be applied to images/photos obtained with an RGB camera attached to the drone. Thus, there is efficiency obtained both from the operational and technical issues in monitoring the ecosystem. It also emphasizes technological disruption can be optimized to facilitate work in the field of coastal and marine resource conservation.

This research can be a reference for the development of alternative methods of monitoring coastal ecosystems, especially mangroves. For a more optimal result, it is recommended to make an acquisition between 08-00-10.00 WIB (in sunny weather conditions) or at other times during which the sun is not too hot. This aims to minimize *flare* (lens incandescent) which causes a lot of light scattering on photo objects and makes it difficult to identify objects and digitize processes. In addition, please always pay attention to the principles and regulations of unmanned aircraft flight in accordance with applicable regulations

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