FOREST HEALTH MAPPING IN GUNUNG BASOR PERMANENT FOREST RESERVE BY USING UNMANNED AERIAL VEHICLE (UAV)

by

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A thesis submitted in fulfillment of the requirements for degree of bachelor of applied science (Natural Resources Science) with Honors

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DECLARATION

I declare that this thesis entitled "Forest Health Mapping in Gunung Basor Permanent Forest Reserve by Using Unmanned Aerial Vehicle (UAV)" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

"I hereby declare that I have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Natural Resources Science) with Honors"

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Forest Health Mapping in Gunung Basor Permanent Forest Reserve by Using Unmanned Aerial Vehicle

ABSTRACT

Unmanned Aerial Vehicle (UAV) is widely use in monitoring the forest and agriculture. The importance of this study was to determine the condition of the forest (healthy or unhealthy) and to mapping the forest health using Unmanned Aerial Vehicle UAV (drone) in Gunung Basor Permanent Forest Reserve. Furthermore, advanced of technology in UAV would hasten the study and yield the result with full coverage of the forest. There was no previous study that has been done to ensure the forest health at Gunung Basor Permanent Forest Reserve. The DJI Phantom 4Pro was used to capture the image of the study area by using Pix4D, and the image will be process in Data Mapper by using VARI algorithm. Besides that, to verify the data obtain from VARI Ground truth was conducted within the area. Based on observation, the forest is alive but not very healthy it verifies by the ground truth that total of necromass is higher than total of individual tree in the area.

Pemetaan Kesihatan Hutan di Hutan Simpan Kekal Gunung Basor dengan Menggunakan Kenderaan Tanpa Pemandu

ABSTRAK

Kenderaan Udara Tanpa Pemandu (UAV) digunakan secara meluas dalam pemantauan hutan dan pertanian. Kepentingan kajian ini adalah untuk menentukan keadaan hutan serta pemetaan terhadap kesihatan hutan menggunakan UAV (Drone) di Hutan Simpan Kekal Gunung Basor. Tambahan pula, teknologi maju UAV akan mempercepatkan proses kajian dan menghasilkan dapatan dengan liputan di kawasan hutan. Tiada kajian terdahulu yang telah dilakukan untuk memastikan kesihatan hutan di Hutan Simpan Kekal Gunung Basor. DJI Phantom 4Pro digunakan untuk menangkap imej kawasan kajian dengan menggunakan Pix4D, dan imej tersebut akan diproses dalam Data Mapper dengan menggunakan algoritma VARI. Disamping itu untuk mengesahkan data yang diperoleh daripada VARI inventori data hutan telah dijalankan di kawasan kajian. Berdasarkan pemerhatian, hutan masih dalam keadaan baik akan tetapi tahap kesihatan adalah kurang daripada inventori data hutan mengesahkan jumlah pokok mati lebih tinggi daripada jumlah pokok individu yang hidup.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

VARI	Visible Atmospheric Resistant Index
UAV	Unmanned Aerial Vehicle
NDVI	Normalized Difference Vegetation Index
NIR	Near Infrared
DBH	Diameter at Breast Height
LAI	Leaf Area Index
GPS	Global Positioning System
GCP	Ground Control Point
km	Kilometer
cm	Centimeter
ha	Hectare
R, G, B	Red, Green, Blue

LIST OF SYMBOLS

°	Degree
×	Multiply
–	Subtraction
+	Addition
=	Equal
%	Percent
<	Less Than
>	Greater Than
/	Division
°C	Degree Celsius
N	North
E	East

CHAPTER 1

INTRODUCTION

1.1 Background Of Study

The forest is a gift from God. This award is invaluable to us. Nature should be maintained before it is too late. Forest is very important to human being like forest can be used as a rain catchment area and the water will be used in various aspects of daily life such as washing, cooking, and others. Other than that forest has become the lifeline for the inhabitants of the earth. The forest can save and protect flora and fauna from extinction because the extinction of flora and fauna closely related to forest, this indirectly will maintain the ecosystem equilibrium.

Forests also play a role as a global warming controller. Globalization occurs because of the pollution and human attitude that does not care about the environment. Because of that the forest is important to reduce level of heat in the world so that there is no heat up. Forest also play roles as a source of livelihood, especially for Orang Asli, with the existence of forest, the product forest such as rattan, herb timber, and medicines product can be sought in addition traditional nursing practices also can be expanded if the forests are well maintained.

Forest is a dynamic ecosystem dominated by trees that continually changing in structure and composition. Forest play an important role in global carbon budget. The fallen leaves and woody material that reach the forest floor decay and continue the cycling of energy and nutrient through an ecosystem (Raymond et al., 2013). The main function of the forest is to produce oxygen and absorb carbon oxide in their cycle of photosynthesis to maintain a balance and healthy atmosphere (Norsuzila et al., 2014). In conclusion, forests should be carefully maintained by every resident areas must be expanded and conserved for future.

In the concept of forest health remote sensing nowadays mean airborne or satellite imaging of forest area. Depending on the number of wavelength channels used images obtained by remote sensing are categorized into aerial photographs, multi- and hyperspectral images (Tuominen, Lipping, Kuosmanen, & Haapanen, 2009).

The study of forest health mapping using unmanned aerial vehicle will be executed at Gunung Basor Forest Reserve to determine the forest condition because there are problems like logging and construction that encountered around Gunung Basor.

1.2 Problem Statement

The importance of this study was to determine the condition of the forest and map the forest health using unmanned aerial vehicles UAV (drone) in Gunung Basor. Furthermore, advanced of technology in UAV would hasten the study and yield the result with full coverage of the whole forest. There was no previous study that has been done to ensure the forest health at Gunung Basor Forest Reserve.

1.3 Objectives

To determine the condition of forest (healthy or unhealthy) and mapping the forest health using unmanned aerial vehicle in Gunung Basor Forest Reserve, Jeli Kelantan.

1.4 Scope of Study

The study area, which is Gunung Basor Forest Reserve, is located in Jeli, Kelantan. The area of study was focused on 0.82 ha area of Gunung Basor. This study was focused on forest health mapping by using unmanned aerial vehicles (drone) remote sensing image.

1.5 Significance of Study

From this study, the result will providing the data and will be shared with Department of Forestry Kelantan so that they can plan for the future management and monitor the forest at Gunung Basor Forest Reserve. This study also helps provide a reference material for future researcher particularly on Forest Health Mapping at Gunung Basor Forest Reserve.

CHAPTER 2

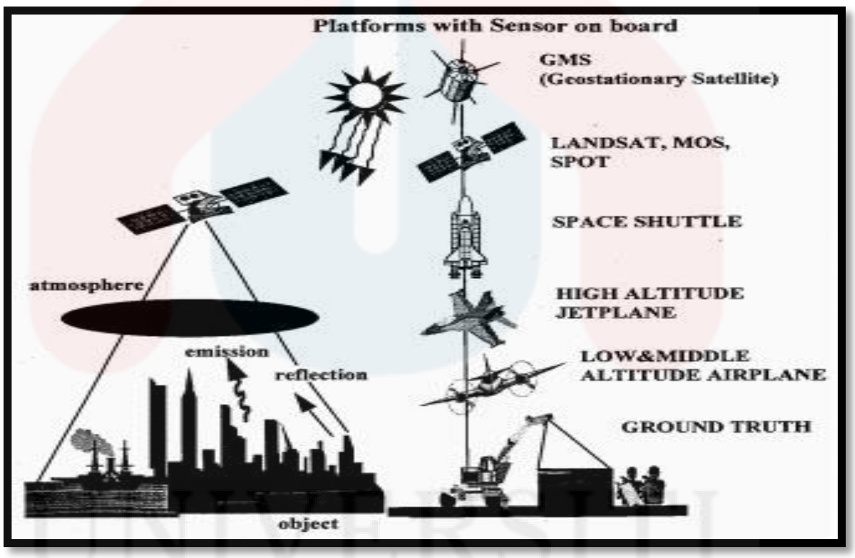
LITERATURE REVIEW

2.1 Use of Remote Sensing in Forest Health

Remote sensing technologies provide the means for wide coverage measurement of forest health with reasonable accuracy (Xiao & McPherson, 2005). In the forest, health management satellite remote sensing has been used as a method for mapping of vegetation, mapping of fire fuel, fire risk estimation, fire detection, mapping of post-fire severity, insect infestation mapping, and relative water stress monitoring (Wang et al., 2010). Remote sensing data have been widely used for vegetation mapping in the rural forest for forest health monitoring (Xiao & McPherson, 2005).

2.2 Remote Sensing Platform

The base on which remote sensors are placed to acquire information about the earth is called platform. There are three platforms of remote sensing firstly Ground-based platforms, it very close to the ground for ground based remote sensing system for earth resources studies are mainly used for collecting the ground truth or for laboratory simulation studies. Second is Air-borne platforms, Aircrafts are generally used to acquire aerial photographs for photo-interpretation and photogrammetric purposes. Scanners are tested against their utility and performance from these platforms before these are flown onboard satellite missions. Lastly Space-borne platforms, in space are not affected by the earth's atmosphere. These platforms are freely moving in their orbits around the earth, and entire earth or any part of the earth can be covered at specified intervals. The coverage mainly depends on the orbit of the satellite. It is through these space borne platforms, we get the enormous amount of remote sensing data and as such the remote sensing has gained international popularity.



(Source: Google image)

Figure 2.1: Platform of remote sensing

2.3 Forest Health Indicator

Forest health indicator is a part of field measurement to evaluate the current forest health condition. There are a few indicators that can use size diversity, different size and ages of the plant had a different layer growth in the forest and each of it has its own special habitat. To determine size diversity the DBH of the trees will measure to see the various habitat layers. Secondly the abundance of lichen, the grow lichen often on trees and shrub to absorb nutrient from the atmosphere. Lichen is very sensitive to air pollution like sulfur dioxide fluoride and ammonia, the acidity of bark also will affect the abundance of lichen. The presence or absence of lichen will be an indicator for forest health. Next, to soil quality, the soil quality in a forest is an important indicator of forest health. The health of the trees and other forest organisms also can depend on how well the soil functions. The soil physical, chemical, and biological makeup at different depths measuring usually involved in the evaluation of soil quality. The process of data collection for producing these indicators through a field survey was rather difficult, expensive, time-consuming and not spatially exhaustive (Meng et al., 2016).

2.4 Causes of Forest Health Decline

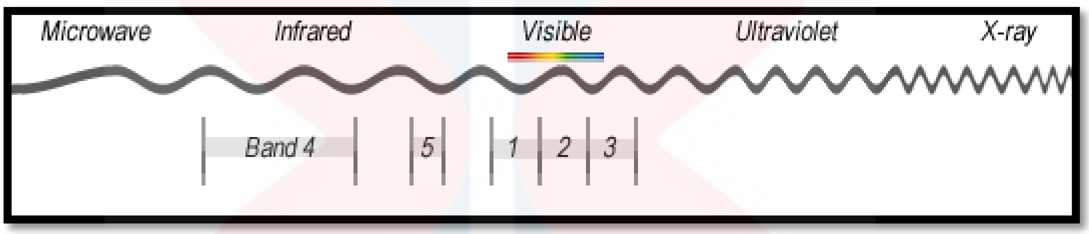
One of the major of forest health decline is air pollution, acid rain, and ground-level ozone. Beside that, disease and insect also influence the health of the forest and other woodland. Globally all ecosystem with tree cover is under increasing threat. Next, the cause of forest health is posed by drought because it can increase the risk of a forest fire to happen. Invasive species also the threat for the forest health decline, they have the potential to cause widespread impacts on the health of the whole ecosystem (Tuominen et al., 2009).

2.5 Unmanned Aerial Vehicle UAV (Drone)

Unmanned Aerial Vehicle (UAV) is an airborne system aircraft operated remotely by human operator or autonomously by onboard computer and it is known as drone. For many forest scenarios, Unmanned Aerial Vehicle (UAV) has emerged as useful of data sources (Dash et al., 2016). UAV also has been used for various applications including forest measurement (Puliti et al., 2017) such as informing silviculture practice, forest health monitoring, wind damage and harvesting. Capabilities of UAV are constantly improve while the cost of the platform and associated sensor are rapidly decrease (Goodbody et al., 2017). UAV are available commercially, usually can cover large areas an also compatible with post processing software such as pix4D (Brovkina et al,. 2018).

2.6 Multispectral and Hyperspectral Imagery

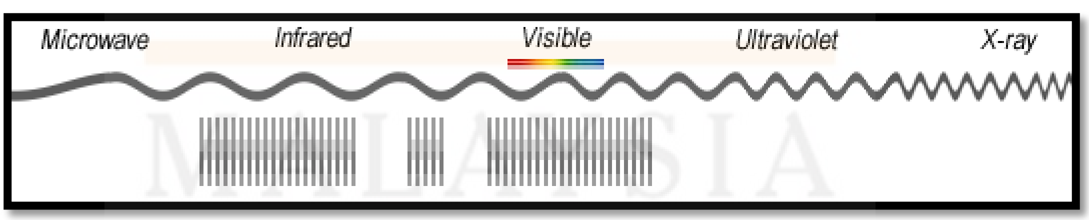
There is a different between multispectral and hyperspectral image, the main difference is the number of bands and how narrow the band is. Multispectral imagery generally refers to 3 to 10 bands. Each band is obtained using remote sensing radiometer (Multispectral vs Hyperspectral Imagery Explained, 2018).



(Source: GISGeography)

Figure 2.2: Multispectral Example

Hyperspectral imagery consists of much narrower bands (10-20nm). A hyperspectral image could have hundreds or thousands of bands. In general, it comes from an imaging spectrometer (Multispectral vs Hyperspectral Imagery Explained, 2018).



(Sources: GISGeography)

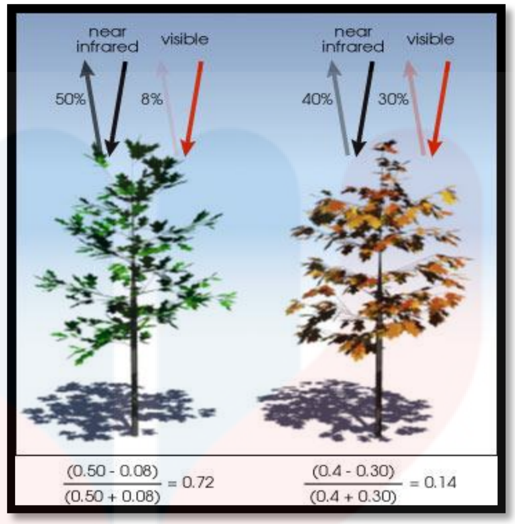
Figure 2.3: Hyperspectral example

In conclusion, Multispectral has 3-10 wider bands and hyperspectral has hundreds of narrow bands.

2.7 Normalized Difference Vegetation Index (NDVI) Extract Forest Cover Classification.

NDVI or normalized difference vegetation index is widely used Vegetation Index (VI) for retrieval of vegetation canopy. NDVI is most well-known and used the index to detect live green plant canopies in multispectral remote sensing data. It is a satellite-derived global vegetation indicator which determines the density of green on a patch of land. The value of this index ranges from -1 to 1 the common range for green vegetation is 0.2 to 0.8 (Asok, 2017). But when NDVI is close to zero, there could even be an urban area because there does not have green leaves.

NDVI uses the NIR and red channels in its formula, NDVI= (NIR–RED)/ (NIR+RED). Compared to other wavelengths healthy vegetation (chlorophyll) reflects more near-infrared (NIR) and green light. But it absorbs more red and blue light. This is why the eyes can see vegetation as the green color. If could see near-infrared, then it would be strong for vegetation too. Satellite sensors like Landsat and Sentinel-2 both have the necessary bands with NIR and red. In forestry, foresters use NDVI to quantify forest supply and leaf area index. Where LAI is defined as the area of single-sided leaves per area of soil (Xue & Su, 2017).



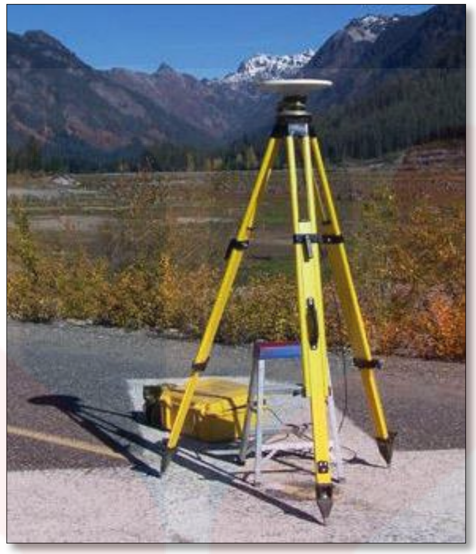
(Sources: Google Image)

Figure 2.4: Example of band reflectance

The value between -1 and +1 will result from the formula. If high reflectance in the NIR channel and low reflectance (or low values) in the red channel, this will yield a high NDVI value. Overall, NDVI is a standardized way to measure healthy vegetation. When NDVI have high values, which mean the forest have healthier vegetation. When NDVI have low, that means the forest have less or no vegetation (Sari & Rosalina, 2016). Generally, to see vegetation change over time, the perform of atmospheric correction will have to do (Song et al., 2001).

2.8 Ground Control Point (GCP)

Ground Control Point (GCP) is objects on the surface of the earth that can be identified and have spatial information in accordance with the mapping reference system. Spatial information in the form of X, Y, Z or Latitude Longitude coordinates and the height of each GCP is measured using sub-meter GPS Geodetic. The main need for GCP is a photo processing geo referencing process so that it has a reference system according to what is needed in the mapping results. GCP is also used during data processing to help process geometry correction on orthophoto mosaic, so the accuracy of the resulting map will be high (Smhh & Atkinson, 2001). In particular, GCP also functions to determinants of geometric accuracy of photographic results (orthophoto, DSM, DTM), the more rigorous the GCP, to create the better geometric accuracy of output (with GCP laying rules fulfilled). Next, the factors that facilitate the relative orientation process between photos so that the presence of GCP can improve the geometric accuracy of a photo map. Factors that make it easier in the process of unifying the results of separate data processing, for example, if the area A and area B data are faster and more effective, than the unification process based on all point cloud (millions) that will take a lot of time. Basically, the use of GCP is optional.



(Source: Google Image)

Figure 2.5 GPS Geodetic use to measure GCP

GCP helps improve the accuracy of the maps produced (up to ± 10 cm), so the consequences of not using GCP are only the accuracy of the resulting map is low (between ± 6-12 m). Installation of GCP can take a long time, with a capacity of 6-10 GCP / day (according to field conditions), which is carried out prior to the acquisition of aerial photo data. For the case of making topographic maps, the role of GCP is quite important. By using GCP, the resulting topographic maps can have high Z accuracy, so that the geographical conditions in the area can be analyzed with a high confidence level.

Every GCP must have a Premark or a sign that can be seen in aerial photography The Premark can be a circle or a cross that has 4 wings and cuts the control point. Premark, which will be self-installed by fabric or paint marker with a minimum premark size in aerial photography, is 10 pixels long and 3 pixels wide for each premark wing. The size of the premark is actually in the field adjusting the value of the ground resolution of aerial photography or about 100 x 40 cm.

(Source: Google Image)

Figure 2.6 Cross Marker use to mark the GCP

2.9 Visible Atmospheric Resistant Index (VARI)

The Visible Atmospherically Resistant Index (VARI) is a vegetation index for estimating vegetation fraction quantitatively with only the visible range of the spectrum (Gitelson et al, 2002). In contrast to NDVI, which is sensitive to changes for small vegetation fractions and insensitive for changes at moderate and high vegetation fractions, VARI shows a linear response to vegetation fraction throughout the entire range. Based on work by Kaufman and Tanré (1992), VARI reduces atmospheric effects by subtracting the blue channel in the denominator. Gitelson et al. (2002) showed that VARI allowed the estimation of green vegetation fraction with an error of less than 10%.

$$VARI = (Green - Red) / (Green + Red - Blue)$$

Where,

Red = pixel values from the red band

Green = pixel values from the green band

Blue = pixel values from the blue band

Using a space-delimited list, the red, green, and blue bands will identify in the following order: Red: 3, Green: 2, Blue: 1. (Gitelson et al., 2002).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

The study area was located in Gunung Basor Forest Reserve, Jeli, Kelantan. The maximum elevation of Gunung Basor is 1000 meters. And its latitude is 5°30'44.019" N and longitude is 101°47'42.382"E. The area of Gunung Basor was approximately 40,613 ha. Gunung Basor was gazetted as permanent Forest Reserve. In Gunung Basor generally, there are three types of forest, namely lowland dipterocarp, hill dipterocarp, and montane forests. (Norashikin et al., 2016)

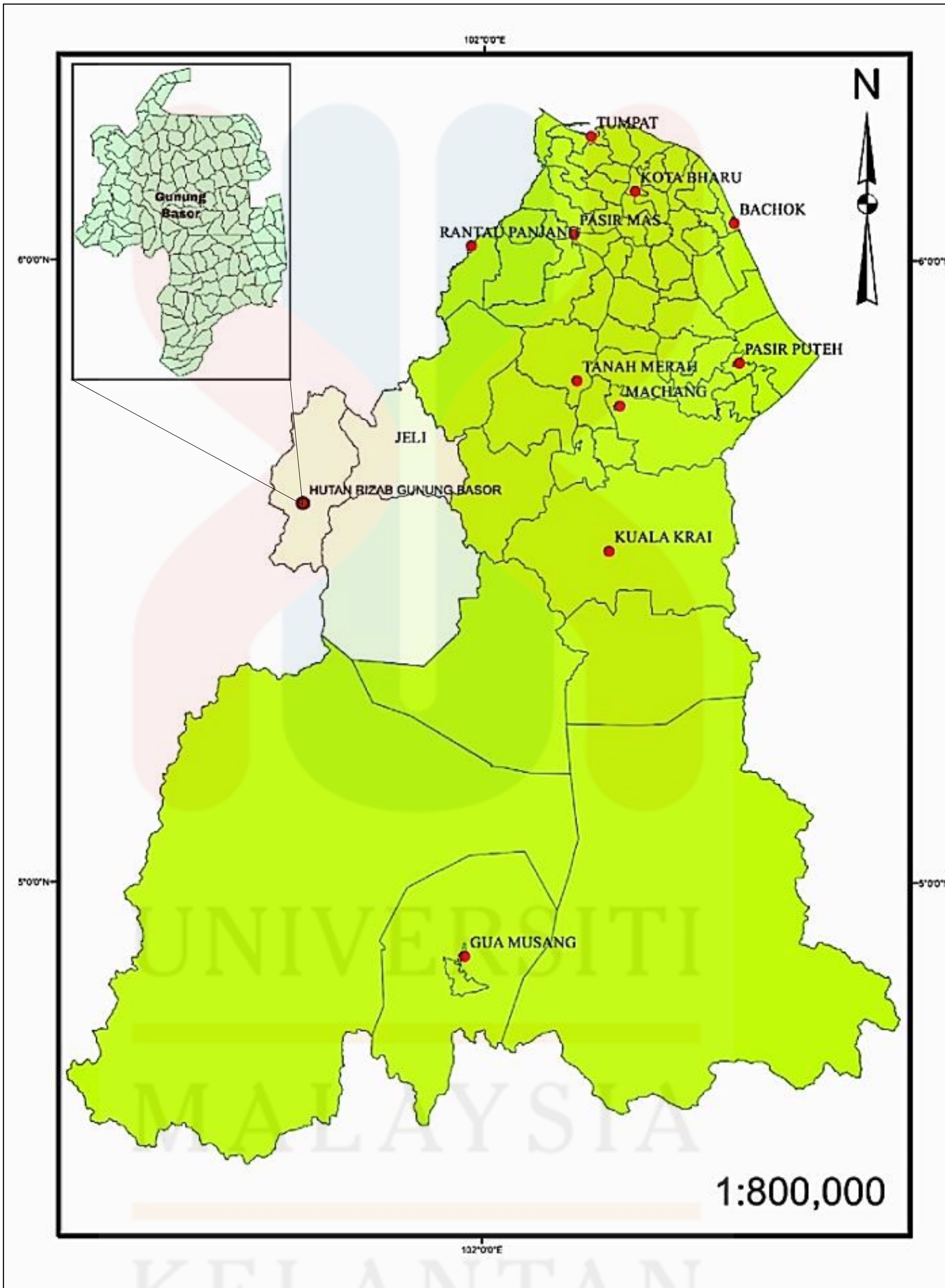


Figure 3.1: Location of Gunung Basor Forest Reserve

3.2 Materials

3.2.1 UAV and Image Sensor Description.

DJI Phantom 4 pro was used in this study, Phantom 4Pro had built with advance technology that can simply set the flight mission using Pix4D capture. Pix4D is the apps and the web base tool, it will move in direction while keep its altitude lock. It also have an advance feature that can detect when no fly zone or flying too high and when battery is running low, the drone will come back to ensure their safe keeping. Phantom 4 pro comes with 5 direction of obstacle avoidance sensing which help to ensure the drone pilot will not mistakenly hit the obstacle. DJI phantom 4Pro deliver 30 minutes flight time before its battery need to recharge, it maximum transmission distance up to 4.3 min (7km).

The camera used in this work is a three band Zenmuse series (FC 6310) camera model with resolution 5472 × 3648, 1-inch 20 megapixel, and color filter array is R (red) G (green) B (blue). The image was saved in JPEG and DNG (RAW) format. This camera is integrated under the drones.

Figure 3.2: Drone remote control

Figure 3.3: DJI Drone Phantom 4 Pro

3.2.2 Designing the Drone Flight Path.

The pilot first connects with the UAV's flight controller via either a ground control radio attached by USB cable to a computer or tablet, or a direct USB link from the UAV to the computer. The pilot opened the software and defined an area to be mapped with a polygon, then specifies the camera model, the desired operational altitude and how the camera will be triggered to take photographs. During the mission, the app was displayed in-flight data on tablet screens, including altitude, GPS status, battery status, and ground signal status.

The drone followed the lane that has been set by area that has been chosen which was 172 × 185 m. The flight height of the drone has been set at 170 m from the ground and the image was captured automatically within the time duration of flight which was 6 min 54 sec.

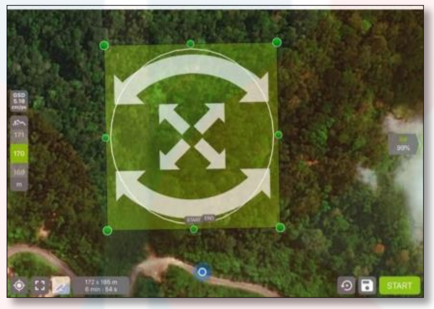


Figure 3.4: Flight mission using pix4D

3.2.3 Establishment of Coordinate

Table 3.1 shows the list of coordinates in study area that has been taken from ground by using GPS handheld Garmin 72 h.

Tables 3.1: List of GPS coordinates taken

Point	Latitude	Longitude
1	5.511528	101.79514
2	5.513083	101.79472
3	5.513083	101.79492
4	5.512417	101.7955
5	5.512222	101.79525
6	5.51225	101.79467
7	5.512556	101.79561
8	5.5125	101.79547
9	5.512361	101.79467

3.3 Methods

3.3.1 Mosaicing

In this study, total thirty five images was captured by the drone, the images has undergo stitching process to generate orthomosaic image by using Data Mapper app. Data mapper is the app and also the web based tools. After the stitching process, the orthomosaic was exported in different format such as GeoTIFF, jpeg (Miranda, Megill, & Ribeiro, 2018).

3.3.2 Image analysis using VARI algorithm

After that, the image was automatically analyzed by using VARI algorithm in Data Mapper.

VARI = (Green - Red) / (Green + Red – Blue)

CHAPTER 4

RESULT AND DISCUSSION

4.1 Orthomosaic Map

Simple approach workflow and low cost UAV was used in this study in order to make it easy for non-expert user. While the drone flies, the drone has already geotag the images, its mean that all of the thirty five image produced by drone has already had its own GPS information, so the alignment and stitching process of the image whole lot more easier to process the product of photogametric such as orthomosaic image. The orthomosaic were generated automatically using Data Mapper apps. In addition, based on Da Cruz Nogueira et al. (2017) orthomosaic can be considered as true orthophoto. The orthomosaic was used as reference image to analyze the VARI and the area of interest chosen at 0.82 ha from the map.

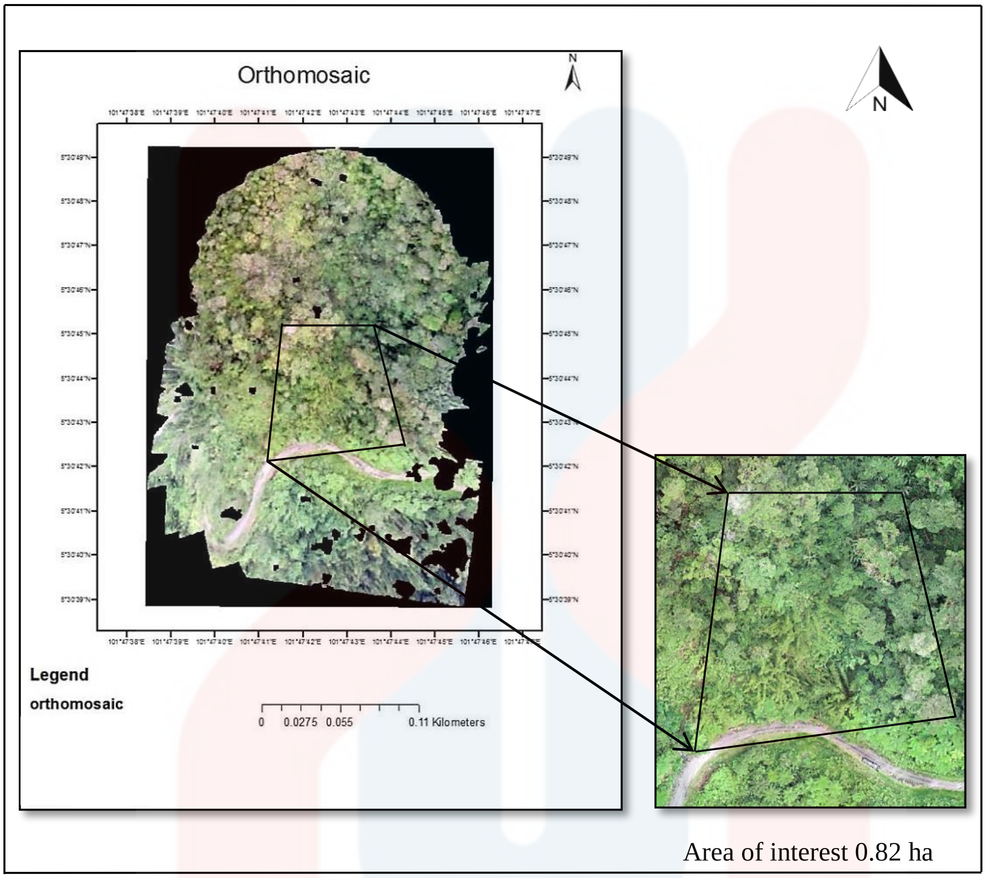


Figure 4.1: Map orthomosaic of study area

4.2 VARI

The area of interest 0.82 ha has been selected from the whole map to use in VARI analysis. Based on the report that have been generated from the data mapper app, show two results from VARI firstly Absolute Greennes index (Figure 4.2). This map give an absolute index of greennes which will provide a better view of changeover time when compared with other surveys of the same area, while the second result of VARI show adjusted greenness index (Figure 4.3), this map compared each areas of the field to one another, so the changes and gradations across the field become more obvious.

4.2.1 Absolute Greenes Index

Based on (Figure 4.2) it show that the map has been covered 99.7 % by orange color which an area was 0.82 ha and the VARI value for this area was 0.00 - 85.00, it indicates that the area in the map has a mixture of soil and vegetation. While another 0.3% covered with red color which shown the VARI value was < 0.00 indicate for non vegetation in that area like soil or road. Based on this map, the area was mostly covered by orange color which indicate the mixture of soil and vegetation.

Table 4.1: Table show the result of Vari

VARI	Description	Area	Cover
> 175.00	Vegetation (high vigor/density)	0.00 ac (0.00 ha)	0.0%
100.00 - 175.00	Vegetation (med vigor/density)	0.00 ac (0.00 ha)	0.0%
85.00 - 100.00	Vegetation (low vigor/density)	0.00 ac (0.00 ha)	0.0%
0.00 - 85.00	Mixture soil and vegetation	2.02 ac (0.82 ha)	99.7%
< 0.00	Non-vegetation (e.g., soil)	0.01 ac (0.00 ha)	0.3%

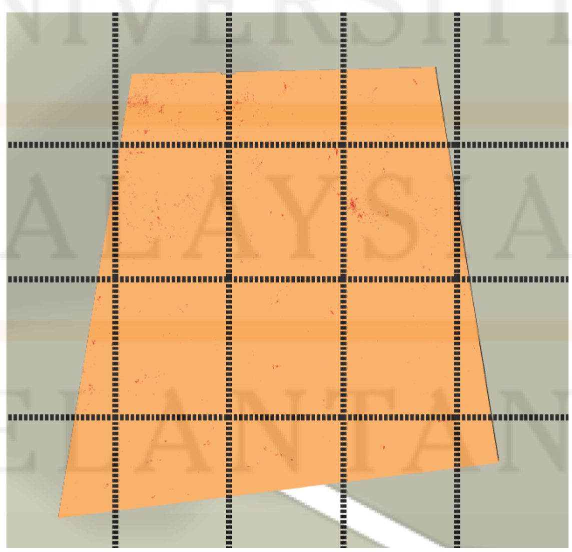


Figure 4.2: Absolute Greenes Index

4.2.2 Adjusted Greenness Index

Based on (Figure 4.3) which the area was 0.82ha, the Table 4.2 show that the less green of the map was indicate the red color, 46.9% of the map which the area was 0.38 ha covered by red color and the value of the VARI was < 0.28, it mean that the area consist of non vegetation area like road, soil, dead tree as shown in image 4.3.1 which was soil, image 4.3.2 which was dead tree, and image 4.3.5 which was road. Other than that, 42.3% of the map in the area of 0.35 ha covers by orange color which the VARI value was 0.28 - 0.46. It shows that this area had mixture of soil and vegetation as shown from image 4.3.3 the land was covered by vegetation. As well as other 10.8% of the map in the area of 0.09 ha was covered by yellowish color which the VARI value was 0.46 - 2.03 and the color of yellowish indicate the low density of vegetation occur in the area as shown in image 4.3.4.

Table 4.2: The tables show Result of VARI

	VARI	Area	Cover
More Green	> 6.33	0.00 ac (0.00 ha)	0.0%
	2.03 - 6.33	0.00 ac (0.00 ha)	0.0%
	0.46 - 2.03	0.22 ac (0.09 ha)	10.8%
	0.28 - 0.46	0.85 ac (0.35 ha)	42.3%
Less Green	< 0.28	0.95 ac (0.38 ha)	46.9%

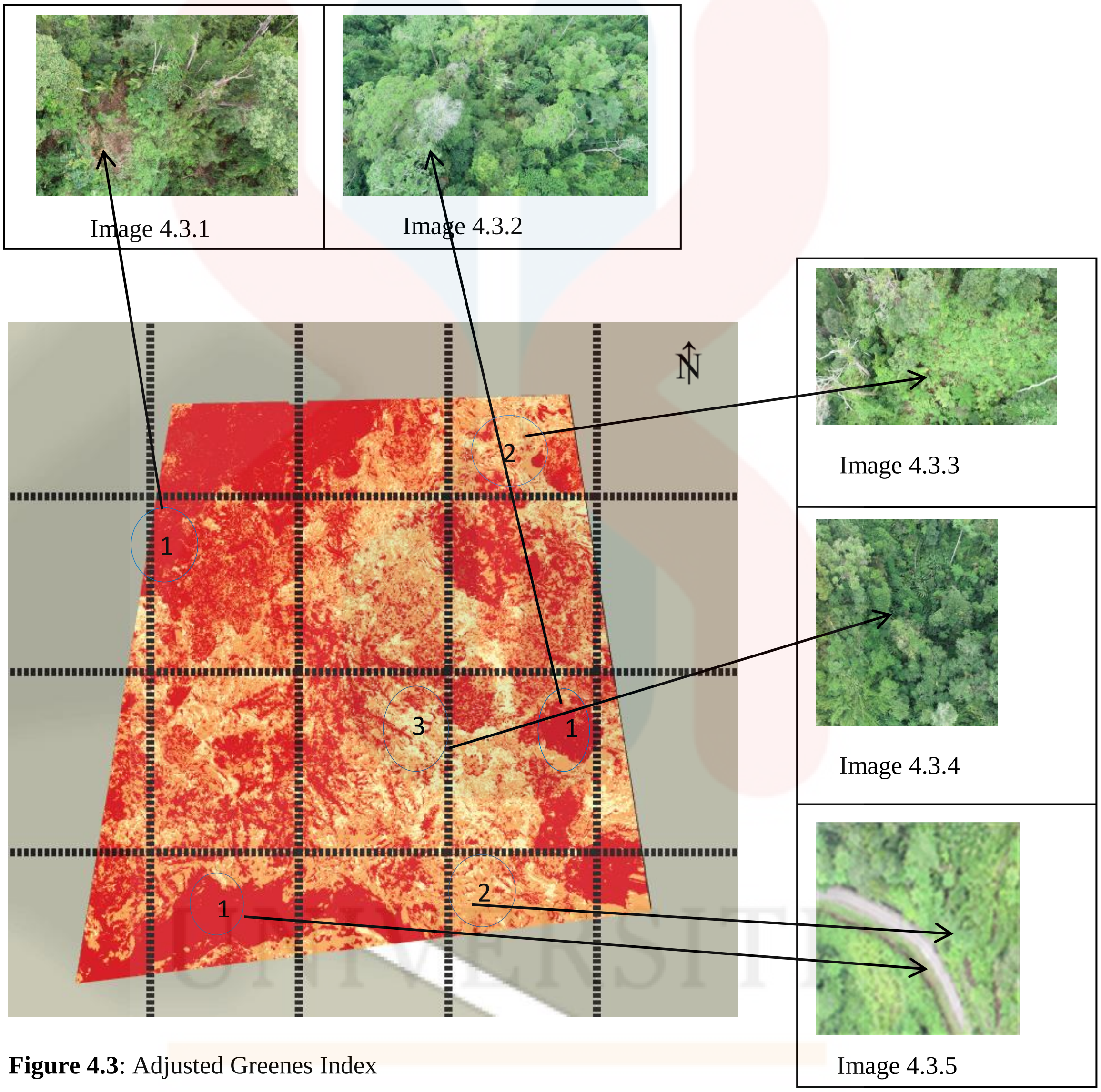


Figure 4.3: Adjusted Greenes Index

4.2.3 Ground Truthing

Based on ground truth, the individual tree and necromass (dead tree) has been counted by measuring it DBH. The individual tree with DBH more than 5cm was measured at 0.82 ha, the total of individual tree accounted in the area was 112. While necromass was also measured by diameter and its height, and the total of necromass found in the area was 16441 in total. It verifies that the total of necromass was higher than individual tree in the 0.82 ha area. There were several factors that may contribute to dead tree such as disease and natural disaster like thunder strike.

Figure 4.4: Dead tree

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the result and discussion, the objective of this study which is to determine the condition of forest (healthy or unhealthy) and mapping the forest health using unmanned aerial vehicle in Gunung Basor forest reserve, Jeli Kelantan was achieved. The using of VARI algorithm that produces by Data Mapper apps at 0.82 ha, area of the forest in Gunung Basor shows that the forest is alive but not in healthy condition. Based on ground truth that being conducted in 0.82 ha area, it verifies that the forest is not in good condition due to the total of necromass found was higher than the total of individual tree found in the area. Ground truthing is very crucial to verify the data obtain from UAV aerial surveillance. VARI algorithm is suitable for the Forest that less dense.

5.2 Recommendations

There were several limitations in this study. Firstly, the black dot and blur in the map shown that there is an error occurs during the flight mission. The factor that can contribute to the error is the turbulence and speed of the drone. By reducing the speed of drone, it can reduce the chances of blurry image produce. Image overlapping also might be the contributor to the error because the recommended of overlap image at least 80% forward and 80% lateral site overlap. So because of that factor, the error can be occurring during the alignment and stitching of image in Data Mapper apps. Other than that, there is no establishment of ground control point GCP in this study. Even though the drone is already geotagging the image while it flies, the GPS accuracy is still low and the result is commonly errors in location of few meters (Rodríguez Larrinaga & Brotons, 2018). From the previous study said that, the used of ground control point GCP around the plot can increase the spatial accuracy (Rodríguez Larrinaga & Brotons, 2018). For future recommendation, establishment of GCP by using GPS Geodetic is needed to enhance the accuracy of image production like orthomosaic. Besides, most of the study in this field used NDVI algorithm to measure the forest health. However, to use NDVI algorithm, the camera need to have a Near Infrared filter, but in this study the VARI algorithm was used because the camera filter has only red, green, blue color. It does not have near infrared filter. Beside that, VARI algorithm is widely used in agriculture, and VARI algorithm is enough to measure health of vegetation (DroneDeploy, 2016).

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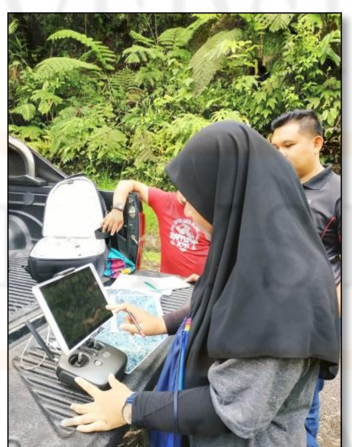
APPENDIX A

The overview of data collection



APPENDIX B

The table below showthe planning of Final Year Project I and Final Year Project II

Final Year Project I	
Research Activities	Date
Proposal Wrinting	February 2018
Submission and Proposal Defence	May 2018
Completion of FYP I	July 2018
Final Year Project II	
Field Sampling	July – September 2018
Data analysis	September – December 2018
Completion of Chapter 4and 5	December 2018
Submission of Final Report	December 2018
Presentation of FYP II	December 2018
Hardbound Submission	January 2019