Using visible spectral-index as alternative methods for identifying levels of *Ganoderma Boninense* infection

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Abstract: Ganoderma boninense is a major devastating disease for oil palm. The severity level identification of Ganoderma boninense on oil palm plantation is important to support the decision making on managerial activities. There have been researches conducted about the usage of unmanned aerial photograph (UAV) on oil palm plantation, nonetheless, the utilization of digital data on the visible aerial photograph has not optimally used. This study aims to obtain alternative methods to identify the severity level of Ganoderma boninense infection with visible spectral index from a visible aerial photograph (RGB). Visible aerial photograph (RGB-aerial photograph) is adopted on this research and carried out at Dusun Ulu plantation with various visible spectral-index methods. The visible spectral-index methods are the excess green index (ExG), the excess red index (ExR), the excess green minus excess red index, and the colour of vegetation extraction (CIVE). The results of four visible spectral-index methods are able to differentiate the severity level of Ganoderma boninense infection on each individual of oil palm.

1. Introduction

*Ganoderma boninense* Pat. is one of the causes of basal stem rot disease which is the most detrimental in Indonesia oil palm plantation. This disease inflicts a heavy loss up to 50% in some of oil palm plantation, peculiarly happened on more than two generations of planting and reduces oil palm production up to 80% [1, 2]. Formerly, *G. boninense* was considered to only attack old mature plants, but now it is known for its ability to attack immature oil palm which not producing fruits yet, even potentially for accelerated the replanting phase [3]. Since it is difficult to control, then this disease seems to always occur and found on oil palm plantation [4]. Consequently, the plantation which infected by this disease with abundant of *Ganoderma* inoculum also known as *Ganoderma* endemic areas. This pathogen has sufficient self-defence tools such as *psedosklerosia* [5], fruit body, and basidiospores [6, 7]. Forthwith, the symptoms are not only inflicting basal stem rot but also upper stem rot [8, 9].

Early detection for this disease symptoms is needed as the first step to take control of *Ganoderma* [10]. Generally, at the beginning of the infection, the deployment of *Ganoderma* into the stem tissue is not extensive. So, the development of pathogens is more easily inhibited [11]. Unfortunately, in that condition, the external symptoms like the appearance of spear leaves and fruit body have not perceived yet [12]. Hence, the methods for detecting *Ganoderma* infection on various level of severity with high accuracy, expeditious, affordable, and wide-ranging is necessary. There have been adequate researches
discussed about the early detection for *Ganoderma* symptoms (Ariffin and Idris, 1992; Yanti and Susanto, 2004) up to the utilization of satellite imagery and aerial photography [13]. Along with the development of remote sensing using aerial photography and satellite imagery, the early detection of *Ganoderma* symptoms is feasible to enforce.

The current condition of Indonesian Oil Palm Plantations has possessed an aerial photographic data which taken through unmanned aerial vehicles (UAVs) in the form of visible photo data. The data are not utilized optimally to solving problems in the plantations. [14] introduces some vegetation index with a visible band which used for the agricultural image. According to that, the visible image is potentially used to distinguish the symptoms of *Ganoderma* infection on Oil Palm. This study aims to obtain alternative methods to identify the severity level of *Ganoderma boninense* infection with visible spectral index from a visible aerial photograph (RGB).

2. Methods

2.1. Study Area

This study area is in Block 23, Division 3, Dusun Ulu Estate, PT. Perkebunan Nusantara III. Dusun Ulu estate is located in Batubara Regency, North Sumatra at 99° 27' 43.74'' - 99° 28' 3.9'' E and 3° 9' 50.96'' - 3° 10' 12.14'' – N (figure 1). Oil palm in this site were planted in 2004, and already 12 years old when the study was conducted.

![Figure 1. Map of Area Study on Blok 23, Division 3, Dusun Ulu Estate](image)

2.2. Imagery taking

The equipment for this study was using multirotor DJI S900. As for the utilized censor was Sony Nex-7 Camera with 3 bands i.e. red, green and blue. Then, the photo results were converted into mosaics through Agisoft Photoscan software.

2.3. Data processing
The utilized photo is taken on 3 February 2016 with altitude 150 metres above sea level with Sony Nex-7 camera. Pre-processing photo has done with geometric correction and radiometric correction. The geometric correction has done with ArcGIS software with control point taken with GPS EPOCH 35 RTK. The radiometric correction has done with ENVI software. Data processing after being corrected with radiometric were using 4 vegetation index which involves visible bands (red, green, and blue). The 4 visible vegetation index were Excess Green (ExG), Excess Red (ExR), Excess Blue (ExB), and Color index of vegetation extraction (CIVE). Each of vegetation index equation is presented in Table 1.

### Table 1. Vegetation index formula with visible band used on this study

| Vegetation Index          | Equation     | Reference                      |
|---------------------------|--------------|--------------------------------|
| Excess Green (ExG)        | ExG = 2g - r - b | Woebbecke et.al, 1995          |
| Excess red (ExR)          | ExR = 1.4 r - g | Meyer et.al., 1998             |
| Excess blue (ExB)         | ExB = 1.4b - g | Meyer and Camargo-Neto, 2008   |
| Color index of vegetation | CIVE = 0.441r - 0.81 lg + 0.385b + 18.7874 | Kataoka et al., 2003           |

#### 2.4. Visualization of Severity level of *Ganoderma* infection

The severity level of *Ganoderma* was conducted through individual plant census (palm by palm) by examining the disease symptoms on leaves and trunk according to the Indonesian Oil Palm Research Institute standard. The severity level of *Ganoderma* was divided into 5 (five) levels, such as L0 (healthy palm/not infected), L1 (light infection), L2 (medium infection), L3 (severe infection), and L4 (collapsed palm).

### Table 2. Criteria level of severity level of *Ganoderma* on oil palm

| Level (code) | Criteria                                      |
|--------------|-----------------------------------------------|
| Level 0      | L0 Healthy palm, normal growth, and leaves still looks good |
| Level 1      | L1 2 (two) spear fronds, yellow leaves start to occur, but basal stem rot symptoms still not visible and oil palm still producing fruits |
| Level 2      | L2 more than 2 (two) spear fronds occur, yellow leaves with smaller size of new leaves, some old fronds dried and frond base fracture occurred, basal stem rot starts to appear, and oil palm still producing fruits |
| Level 3      | L3 more than 3 (three) spear fronds appear, most of the old fronds fracture, yellowing and dried (chlorosis), basal stem rot and *Ganoderma* fruit body appear, and no fruits produced |
| Level 4      | L4 all fronds dried or all oil palm collapsed |

The criteria were adopted from [15] for classified the severity level (Table 2). The census results were mapped with GPS EPOCH-35 RTK. Then, the individual mapping results used to measure the accuracy of identification results for classified the severity level of *Ganoderma* with vegetation index transformation on the visible band.

### 3. Results And Discussion

#### 3.1. Visible Spectral-Index (VSI)
There were four visible spectral-index (VSI) used in this study such as Excess Green (ExG), Excess Red (ExR), Excess Blue (ExB), and Color index of vegetation extraction (CIVE). These four VSI have certain characteristics in describing the condition of Ganoderma incidence on oil palm. The description of severity condition obtained from the level of material greenness which came from each level of attack. Every VSI has a different response to any material greenness with soil as the background. Based on this, the response of each visible spectral-index towards the incidence of Ganoderma are explained below.

3.2. Excess Green (ExG)

Results of the Excess Green (ExG) calculation were obtained from oil palm which attacked by Ganoderma values between (-28) to 142 with a mean value of 51.74. ExG tends to decrease maximal value, and minimum value in line with the increase in Ganoderma attack levels. The ExG value according to the attack level is presented in Figure 2 and the distribution of ExG values is presented in Figure 3. [16] informed that ExG has an advantage compared to other color indices, especially in distinguishing the greenness of plants with other soils / residues.

![Figure 2](image2.png)

**Figure 2.** ExG value match the level of Ganoderma incidence which suitable with Ganoderma severity levels

![Figure 3](image3.png)

**Figure 3.** Distribution of ExG values in the study area

ExG has a similarity with the range of visible wavelength (RGB) which affect the number from a recording sensor. Therefore it is quite difficult to distinguish the comparison of absolute value. [17], [18] also stated that the information of the level of greenness is strongly emphasized in the green band that conjures up images with greater intensity caused by high contrast values from oil crops to weeds which were influenced by shadow and plant growth
condition. [19] research's also mentioned that ExG and CIVE can process images taken under different environmental conditions with a high degree of accuracy.

3.3. Excess Blue (ExB)
Results of ExB calculation obtained values between (-53.6) to 89.8 with an average value of 15.5. ExB tends to increase the maximum and minimum values along with the increasing level of Ganoderma infection. The higher of Ganoderma infection level, the greater ExB value. ExB value is the extraction number of bluish value owned by the object, in this case, is oil palm with an infection level from L0 to L4 (figure 4). The higher level of incidence affected the reduction of the canopy and greenish leaves so that some parts of the soil are exposed, this caused the blue extraction from ExB equation to become higher.

![Figure 4](image_url) ExG value according to the level of Ganoderma infection

![Figure 5](image_url) Distribution of ExB value on this study area

This is following [14] opinion stated that the blue extraction will be increased at the time of object opening from the ground which caused by soil texture has a high bluish level beside the dominance of red extraction. The value of ExB according to a level of incidence is presented in Table 2 and the distribution of ExB value is presented in Figure 5.
3.4. Excess Red (ExR)
Results of ExR calculation obtained values between (-39,8) to 150,4 with an average value of 40,33. ExR tends to decrease the maximum value and to increase the minimum value which in line with the increasing number in infection level. The higher number of infection, decreasing the range of ExR values. The reddish index came from ExR value which emphasizes the colour of wilting leaves. This value probably shows the differences between normal greenish leaves and wilting leaves [14].

![Figure 6. ExR value according to the level of Ganoderma infection](image)

The disparate leaves colour in this object which is oil palm with Ganoderma infection with a severity level from L0 to L4. The higher level of infection affects the less canopy and green wilting colour. This condition also affects a higher red extraction from ExR. On his research [20] gave a result that ExR has a lower standard deviation compared with ExG and ExB. The ExR value according to the level of attack is presented in Figure 6 and the distribution of ExR values is presented in Figure 7.

3.5. Color Index of Vegetation Extraction (CIVE)
Results of Color Index of Vegetation Extraction (CIVE) calculation obtained values between (-41,00) to 40,89 with average on 3,37. CIVE tends to increase both maximum and minimum values along with increasing the level of Ganoderma infection. The higher number of severity level is in line with the
increasing CIVE value. [19] which stated that ExG and CIVE can do image processing which taken on the different environmental condition. In addition to that, the number of ExR which according to the level of *Ganoderma* is presented in Figure 8 and the distribution of EXR values is presented in figure 9.

![Figure 8. CIVE value according to the level of Ganoderma infection](image_url)

![Figure 9. Distribution of CIVE value on this study area](image_url)

### 3.6 Identification of Oil Palm which infected with *Ganoderma* through Visible spectral-index (VSI)

The Visible spectral-index (VSI) analysis results used for oil palm identification through infection criteria start from level 0 (L0) which means healthy palm to level 4 (L4) collapsed palm. Level 0 on healthy oil palm that identified using ExG showed that the shape of the canopy with a bright colour, while on ExB is formed in grey colour, followed by ExR and CIVE which made from darker colours. This value gradually decreases according to the level of the infection. Table 3 shows the characteristics of the attack level with all four used visible spectral-index (VSI). It is also in line with [13] which mention that a higher level of infection will reduce the number of the canopy.

The calculation of accuracy value came from the precision sampling of *Ganoderma* infection level through VSI and field sensus with ExG, ExR, and CIVE have a higher accuracy value of 83.4-83.6% compared with ExB which reached 81%. These results are in line with [16] which informed that ExG has an advance value compared with others colour index, more importantly on differentiate greenness.
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of oil palm with soil or other residues as the background. [19] also states that CIVE and ExG tend to process images clearly under different environmental conditions. Meanwhile, [20] supports the results by giving the lowest standard deviation value on ExR. The misinterpretation in determining the level of *Ganoderma* infection through stipulation of VSI has caused some of the oil palm not showing the external symptoms even though the basal stem rot occurred (Breton, et al. 2010). Nevertheless, the use of visible imagery (RGB) can be used as an alternative for identifying diseases caused by *Ganoderma* infection.

Table 3. Character of the images formed from VSI (ExG, ExB, ExR, and CIVE) on five levels of *Ganoderma* infection.

| Visible-Vegetation Index | Level 0 (L0) Healthy Palm | Level 1 (L1) Light | Level 2 (L2) Medium | Level 3 (L3) Severe | Level 4 (L4) Collapsed |
|--------------------------|--------------------------|-------------------|-------------------|-------------------|-------------------|
| ExG                      | ![Image of ExG Level 0](image) | ![Image of ExG Level 1](image) | ![Image of ExG Level 2](image) | ![Image of ExG Level 3](image) | ![Image of ExG Level 4](image) |
| ExB                      | ![Image of ExB Level 0](image) | ![Image of ExB Level 1](image) | ![Image of ExB Level 2](image) | ![Image of ExB Level 3](image) | ![Image of ExB Level 4](image) |
| ExR                      | ![Image of ExR Level 0](image) | ![Image of ExR Level 1](image) | ![Image of ExR Level 2](image) | ![Image of ExR Level 3](image) | ![Image of ExR Level 4](image) |
| CIVE                     | ![Image of CIVE Level 0](image) | ![Image of CIVE Level 1](image) | ![Image of CIVE Level 2](image) | ![Image of CIVE Level 3](image) | ![Image of CIVE Level 4](image) |

4. References

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