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HEALTHINESS OF OIL PALM PLANTATION TOWARDS SUSTAINABILITY OF ENVIRONMENT

Faradina Marzukhi[1], Nur Nadhirah Rusyda Rosnan[1]
Universiti Technology MARA, Perlis Branch

E-mail: faradina454@uitm.edu.my

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ABSTRACT

The aim of this study is to analyse the relationship between vegetation indices of Normalized Difference Vegetation Index (NDVI) and soil nutrient of oil palm plantation at Felcra Nasaruddin Bota in Perak for future sustainable environment. The satellite image was used and processed in the research. By Using NDVI, the vegetation index was obtained which varies from -1 to +1. Then, the soil sample and soil moisture analysis were carried in order to identify the nutrient values of Nitrogen (N), Phosphorus (P) and Potassium (K). A total of seven soil samples were acquired within the oil palm plantation area. A regression model was then made between physical condition of the oil palms and soil nutrients for determining the strength of the relationship. It is hoped that the risk map of oil palm healthiness can be produced for various applications which are related to agricultural plantation.

Keywords: *Oil palm, Remote Sensing, Vegetation Indices, Environment*

INTRODUCTION

In this new millennium, the concept of sustainability is trending in the oil palm industry. This is because currently, worldwide focuses on holistic concept of food producing process that includes three main perspectives of sustainable development such as social, environmental and economic sustainability (Yew, et al., 2016).

This research aims to determine the environmental causes of the destruction of oil palm trees using Remote Sensing technique and produce a risk map of Felcra Nasaruddin Bota, Perak. Besides that, this study focuses more on the sustainability of oil palm plantations, as it can assist in detecting and finding which areas of an oil palm plantation are infected by pests. The information gained may help relevant agencies such as the Department of Agriculture in preventing the oil palms from being destroyed unnecessarily.

In order to achieve the objectives, the latest Remote Sensing imagery obtained from the Malaysian Space Agency (MYSA) is processed using ERDAS Imagine software, in which the vegetation index, Normalized Difference Vegetation Index (NDVI) was used. The range of vegetation index varies from -1 to +1. An analysis of soil sample and soil moisture was done at a physics lab to obtain the nutrient values of Nitrogen (N), Phosphorus (P) and Potassium (K). These tests determine their influence on oil palm trees. A total of seven soil samples were obtained from the oil palm plantation area.

The results from the tests indicate nutrient value in soil. A regression model will then be made between the palm oil's condition and soil nutrient. The risk map that is produced from this can be used in evaluating the health of other oil palm plantations. Thus, the usage and implementation of remote sensing data can be a method of sourcing information on large oil palm plantations. By using this method, the management of oil palm plantations would be able to obtain specific details about the oil palm physically and soil fertility.

LITERATURE REVIEW

Analysing the physical characteristics and soil nutrient of an oil palm tree are crucial steps in identifying its health. This is to make sure that the palm tree is free of pest infestation so that the oil palm yield can experience rapid growth. In return, this will affect the socio-economic demography of Malaysia as the oil palm plantation sector has been generating employment for approximately 570,000 people so far since 2011 as mentioned by Prof. Datuk Dr. Mohd. Azmi Mohd Lila (2016), who was a former Vice Chancellor of Research and Innovation from UPM. The process involves determining the correlation between soil nutrient and physical characteristics of oil palm trees. Table 1 shows the review of other researches that are related in analysing the physical characteristic and soil nutrient of palm trees.

The previous studies conducted looked at the processing of digital images to classify plant disease (Barbedo, 2013; Shafri and Hamdan, 2009; Lelong et al., 2010; Azahar et al., 2008; Tawfik et al., 2013). All the research objectives were basically similar, while the difference lies in the type of data and methods implemented. A study on detecting the potential of Red Palm Weevil in destroying oil palm was conducted by Idris et al. (2014), which was done in the states of Kelantan and Terengganu respectively, while Pohl and Loong (2015) collected the physical characteristic of oil palm such as height. Another study, conducted by Chemura (2015) involved collecting information about the age of oil palm to do mapping on the oil palm area.

Earlier research on this, however, lacked some data. Based on the reading from earlier research, there are different types of data processing and data collection that can be referred to in the methodology. Nevertheless, some research methodologies mentioned in the research did not explain the processes used explicitly. This has created some difficulties for readers to understand the method used by the researchers. In addition some of the earlier researchers also did not describe the results and analysis clearly. The results and analysis are the most important parts of the research; this has created a disadvantage for the readers.

Therefore, based on the earlier research in Table 1, the research gap identified is on the analysis of the physical characteristics and soil nutrient of oil palm trees at Felcra Nasaruddin, Perak. The data used a satellite image

of mosaic SPOT 6 and SPOT 7, while the method implemented for analysis is Normalized Difference Vegetation Index (NDVI).

Table 1: Previous Research

Author	Title	Objectives	Methods	Research Gap
(Tawfik, Shafri, & Mohammed, 2013)	Disease Detection from Field Spectrometer Data	To determine Ganoderma diseases	Vegetation Indices was used using Math Lab.	Detection by doing correlation between soil nutrient and palm oil age
(Pohl, Loong, & Van Genderen, 2015)	Multisensor Approach to Oil Palm Plantation Monitoring Using Data Fusion and GIS	To map oil palm age profiles of the plantations in the country	Ground data collection and processing	Physical characteristics such as height, fronds, trunks, and age.
(Idris et al., 2014)	The Potential of Red Palm Weevil Infesting and Destroying Oil Palm Industry in Malaysia	To monitor the red palm weevil infestation.	To monitor the red palm weevil infestation using pheromone trap.	Physical components that attract the insect infesting oil palm have not been studied.

Therefore, this section discusses on oil palm tree, soil nutrient, vegetation indices and remote sensing technique to determine the relationship of oil palm nutrient deficiencies with vegetation indices.

Oil Palm Nutrients

Nutrient is one of the most important things needed by crops or trees in order to growth healthy. Nutrient can be defined as the substances that provide food and is important to maintain life. There are two types of nutrients for plants, macronutrients which can be derived from air and water as well as micronutrients, which can be obtained from trace minerals. There are three main nutrients in oil palm - nitrogen (N), phosphorus (P) and potassium (K). All these nutrients are important for the growth of the oil palm (Azahar, Boursier, & Idris, 2008). These nutrients that oil palm requires to grow well are acquired from fertilizers. The ratio of fertilizer needed for oil palm is 3N: 0.4P: 1.7K (Broschat, 2008).

Vegetation Indices

Vegetation indices are a mathematical combination that describes the greenness of vegetation by using visible and near-infrared bands of electromagnetic spectrum. It describes the health condition and relative density of vegetation whereby the information can be seen through pixels in a satellite image and cause spectral properties of green plants to materialize more distinctively from other image features. There are various types of vegetation indices such as Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI). However, NDVI is the most widely used.

Additionally, it is a combination of exterior reflectance at two or more wavelengths in order to focus on a certain trait of the plants. The vegetation indices will indicate the amount of vegetation such as leaf area index (LAI) and able to distinguish between soil and vegetation (Hamdan, 2009).

Remote Sensing and GIS Technique in Determining the Nutrients Deficiencies of Oil Palm

Oil palm plantations are an important resource in Malaysia because the fabrication of palm oil is one of the major economic sources in Malaysia. By using Remote Sensing and GIS technique, it can help farmers and the management of oil palm plantation to sustain the oil palm plantation especially in detecting disease, nutrient and production of the kernel even in large areas.

Nowadays, remote sensing imagery is widely used to monitor the oil palm plantation, whereas the GIS acts as the geographic database which gives spatial information such as tree coordinate, type of disease, age and nutrient content. Besides that, utilizing vegetation index using near infrared and visible region from electromagnetic spectrum can determine the greenness of the vegetation. There are a lot of vegetation indices that can be used such as Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI) (Marzukhi et al., 2016).

METHODOLOGY

The methodology for this research was constructed based on three objectives. The first stage was data acquisition. This stage involved two processes, satellite image processing and ground verification respectively. The data required for satellite image processing were remote sensing images from mosaic of SPOT 6 and SPOT 7. There are four steps of processing satellite images which are define projection, data import, subset, and image enhancement. For data import, satellite images were acquired using ERDAS imagine software, while for subset box technique was used instead. Next, for the image enhancement process, the technique used was haze reduction and rescale. Following that, the ground verification process was required. For this process, site preparation and identification were carried out. It was divided into two tasks namely soil sampling and detecting physical characteristics. The purpose of soil sampling is to identify the content of Nitrogen (N), Phosphorus (P) and Potassium (K), while the physical characteristics that were analysed include the trunk, age, and fronds. Finally, GIS software was used to develop a database to produce a risk map. The purpose of producing a risk map is to use to predict the health of other oil palm plantations.

Satellite Image Processing

Image processing is the most important step in processing remote sensing imagery. The processing of SPOT 6 and SPOT 7 images were done using ERDAS Imagine 2014 software. The steps included data import, subset and image enhancement. Besides the tools in ERDAS Imagine 2014, the process also included the NDVI method to identify the range of greenness in the vegetation, whereas define projection was done using Arc GIS 10.4. In addition, Arc GIS 10.4 software was also used to extract the NDVI value of each oil palm that had undergone soil testing and to produce the NDVI map.

Vegetation Index Processing

Next, the satellite image underwent the Normalize Differential Vegetation Indices (NDVI) process. This was to determine the range of greenness of the oil palm tree. It is the simplest but most effective way to determine vegetation index. The value of NDVI varies from -1 to +1. In addition, the highest NDVI value will determine the healthiest oil palm tree.

The bands that are needed in the NDVI process are red and near infrared band. This is shown by using the formula below:

$$NDVI = (NIR - RED) / (NIR + RED)$$

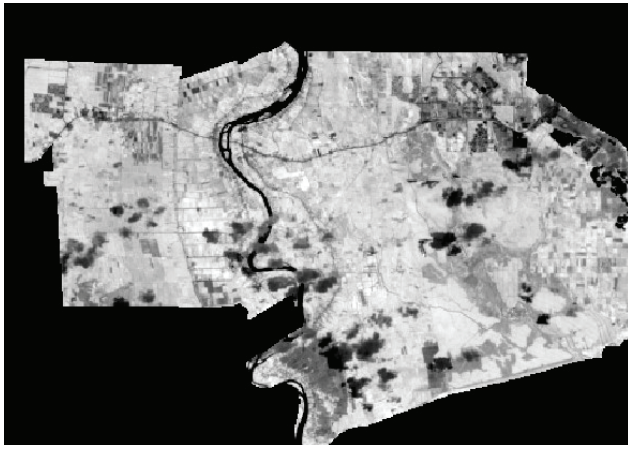


Figure 1: Image After NDVI Process
Source: Author

After running the NDVI process, the image was exported to Arc GIS 10.4 software to extract the NDVI value. Then, classification of the NDVI image was done based on the classification that was needed. The NDVI map was also produced using Arc GIS 10.4.

Soil Sampling

Soil sampling was divided into seven sections as there were seven soil samples taken to analyse the nutrient of nitrogen (N), phosphorus (P) and potassium (K). The acquisition of soil samples must adhere to guidelines as to ensure the accuracy of nutrient value. In addition to this, the apparatus required for soil sampling include a clean bucket for mixing the soil, plastic bag for keeping the soil, marker pen to mark the sampling beg and shovel in order to take out the soil from the ground.

After the soil test was conducted, a regression model between palm oil age and soil nutrient was produced through statistical process.

Determination of Oil Palm Physical Characteristics

The physical characteristics of oil palm trees in the areas of soil analysis were also identified. There are many parts of oil palm trees which can be diagnosed for nutrient deficiencies such as the trunk, fronds and leaves, age, the fruit and bunch production.

Nitrogen is one of the most important nutrients in a plant including oil palm trees. Trees that are lacking nitrogen will have yellowing fronds. Other than that, it will cause the production of oil palm fruit to decrease. As we can see, the nitrogen content at Bendang Bekul and Plot 6 is very low at only 0.10% and 0.09%. It is proven because when oil palm trees from these plots were diagnosed it showed frond and leaves that were yellowish in colour (Figure 2).

Figure 2: Oil Palm Trees that are Nitrogen Deficient
Source: Author

Phosphorus is important to plants because it helps to convert other nutrients into usable building blocks to grow. If the oil palm tree has a phosphorus deficiency, it will cause the trunks of oil palm tree become narrow and tapered. Previous studies reveal that it will cause the fruits and bunch size to reduce. Based on this study, it can be concluded that Plot 9 and 4 have a phosphorus deficiency because the phosphorus content in this plot is low compared to other plots. In Figure 3 below, fruits fall from its bunch due to lack of phosphorus.

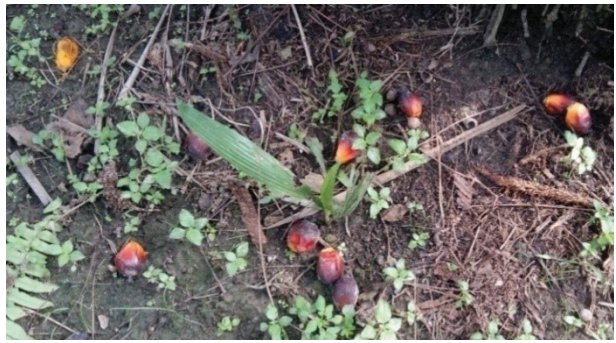


Figure 3: Oil Palm Fruits with Phosphorus Deficiencies
Source: Author

Meanwhile, potassium deficiencies are more prevalent in older oil palm trees (Figure 4). As seen in the results of potassium content for the plot Bendang Bekul, the age of the oil palm tree is 26 years old and the potassium content in the tree is lowest compared to other plots, with only 0.34 cmol+/kg potassium content. Other than that, the lack of potassium can cause Ganoderma basal stem-rot and vascular of the oil palm tree wilt. Based on this study, it can be concluded that lacking potassium can also cause Ganoderma disease. Plot 4 has the second lowest potassium value among other plots at 0.45 cmol+/kg and the oil palm tree had been infected by the disease.

Figure 4: Oil Palm Tree with Potassium Deficiency
Source: Author

Statistical Analysis Process

Statistical analysis process is a mathematical model used to interpret data for making analysis. The statistical model for this research was done using Microsoft Excel. The result of the statistical process is based on the data collection and data processing through satellite image processing and soil sampling.

Data analysis can be described as the process of systematically applying statistical or logical techniques to explain and demonstrate, compress, summarize, and to assess data. In this research, the tools used were regression analysis and correlation analysis.

Regression analysis is a statistical process to estimate the relationship among variables. It has numerous techniques for modeling and analyzing variables. There are two types of regression analysis - linear and non-linear. This analysis can help users to understand the changes experienced by dependent variables when some independent variables are varied, while some are fixed. Regression analysis is popular in weather forecasting and prediction. The performance of the method, however, depends on the type of the data generating process.

Correlation analysis is the statistical application used to study the closeness of the relationship between two or more fundamentals. It is the analysis that measures the hardiness of association between two variables and the direction of the relationship. In terms of the toughness of relationship, the value of the correlation coefficient varies between +1 and -1. When the value of the correlation coefficient lies around ± 1, then it is said to be a perfect degree of association between the two variables. As the correlation coefficient value goes towards 0, the relationship between the two variables will be weaker. There are five types of correlation analysis for instance Pearson, regression, Spearman, partial and multivariate.

RESULTS AND DISCUSSIONS

There are seven soil samples that were collected from seven different plots. Observation on the physical condition of oil palm was done before the

soil samples were collected. Table 2 shows the information and condition of the oil palm tree, whereas Table 3 shows the results of nutrient value in soil sample and its content. Lastly, Table 4 shows the NDVI value of each soil sample. Based on the physical condition of the oil palm tree, the health stage of the oil palm tree can be predicted, whether it is healthy or unhealthy. In addition, Mosaic of SPOT 6 and SPOT 7 were used as it has a higher resolution of 1.5m, while LANDSAT 8 image has a resolution of 30m. Besides that, SPOT satellite imagery has two spectral bands that is important in NDVI analysis which are visible light (red) and near infrared. Based on Figure 5 (i), (ii), (iii) and (iv), the strong correlation is between phosphorus and NDVI that is R^2 that is equal to 0.420. This result shows that the element that interacts strongly with NDVI is phosphorus.

Table 2: Information and Condition of Oil Palm Tree

Plot	Coordinate		Year	Age	Physical Condition
	Northing	Easting			
7	477773.424	328935.478	2014	3	unhealthy
4	476922.317	328301.489	2006	11	unhealthy
Pulau Juar	474839.321	327764.681	2016	1	healthy
6	476336.103	331805.617	2009	8	unhealthy
Bendang Bekul	476500.31	331857.674	1991	26	unhealthy
9	475221.15	333590.663	2010	7	healthy
10	476153.35	333246.647	2010	7	healthy

Source: Author

Based on Table 2, there are seven soil samples collected from seven different plots. As we can see, the status of nutrient content in Plot 7 and 10 were the same, indicating a high level in nitrogen and phosphorus at 0.75%, 0.64%, 873.3 ppm and 830.5 ppm, while low potassium content was at 0.61 cmol+/kg and 0.47 cmol+/kg. Other than that, the nutrient content in Plot 4 and 9 were the same that was very low nitrogen content at 0.06% and 0.04%, medium phosphorus content at 293.1 ppm and 268.7 ppm, and low potassium content at 0.45 cmol+/kg and 0.69 cmol+/kg.

Next, the nitrogen content for Plot 6 and Bendang Bekul were the same, which was very low despite a slight difference in value at 0.01%, while the phosphorus content was high. Besides that, the potassium content for these plots is different that was very high for Plot 6 at 2.28 cmol+/kg and very low for Plot Bendang Bekul at 0.34 cmol+/kg. Lastly, the nitrogen content in Plot Pulau Juar was medium at 0.21%, phophorus and potassium content was high at 781.9ppm and 1.46 cmol+/kg respectively. Based on this result, we can see that the content of phosphorus is high in majority of the soil sample. From the previous research, if the content of phosphorus is high in soil, it will cause excessive growth of vegetation and damage to the aquatic ecosystem; this is evidence especially if there movement from the soil into water surface (Horneck, 2011).

Table 3: Result of Soil Nutrient Value and its Content

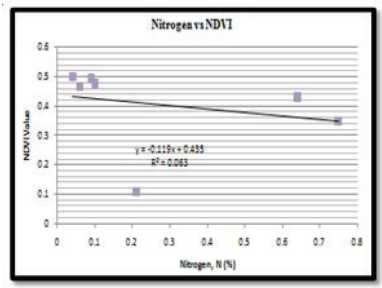
Plot	Element					
	Total Nitrogen (N)-%	Content	Total Phosphorus (P)-ppm	Content	Exchangeable Potassium (K)-c mol +/kg	Content
7	0.75	High	873.3	High	0.61	Low
4	0.06	Very Low	293.1	Medium	0.45	Low
Pulau Juar	0.21	Medium	781.9	High	1.46	High
6	0.09	Very Low	423.9	High	2.28	Very High
Bendang Bekul	0.10	Very Low	410.1	High	0.34	Very Low
9	0.04	Very Low	268.7	Medium	0.69	Low
10	0.64	High	830.5	High	0.47	Low

Source: Author

Table 4: Result of Normalized Difference Vegetation Index (NDVI)

Plot	NDVI Value
7	0.348478
4	0.467281
Pulau Juar	0.108099
6	0.495016
Bendang Bekul	0.476967
9	0.499632

Source: Author



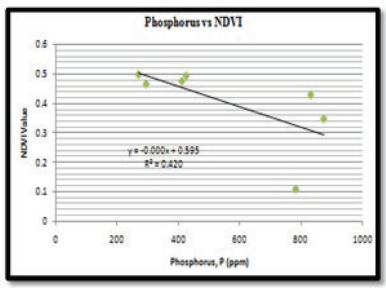
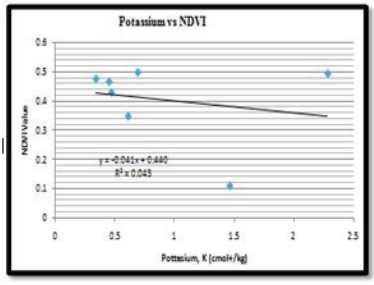


Figure 5(i): Nitrogen vs NDVI **Figure 5(ii): Phosphorus vs NDVI**
Source: Author



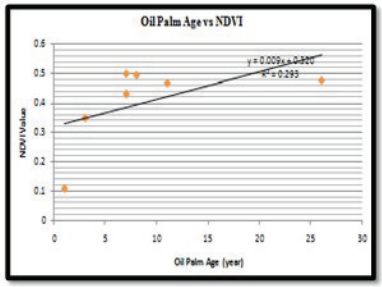


Figure 5(iii): Potassium vs NDVI **Figure 5(iv): Oil Palm Age vs NDVI**
Source: Author

Furthermore, Figure 6 below shows the NDVI map that depicts the greenness value of oil palm tree and Figure 7 shows the risk map that indicates the health condition of the oil palm tree based on five feature classes.

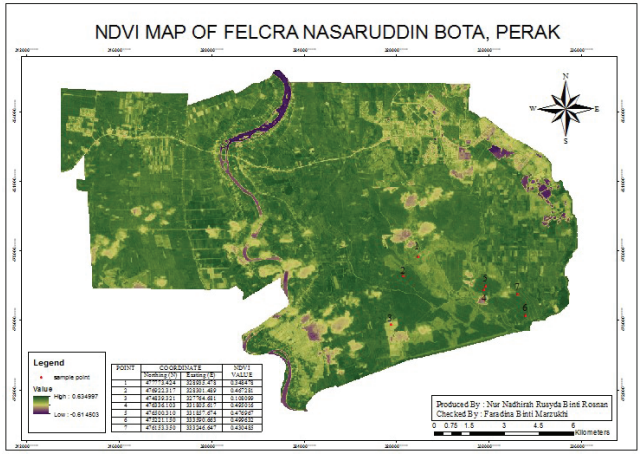


Figure 6: NDVI Map
Source: Author

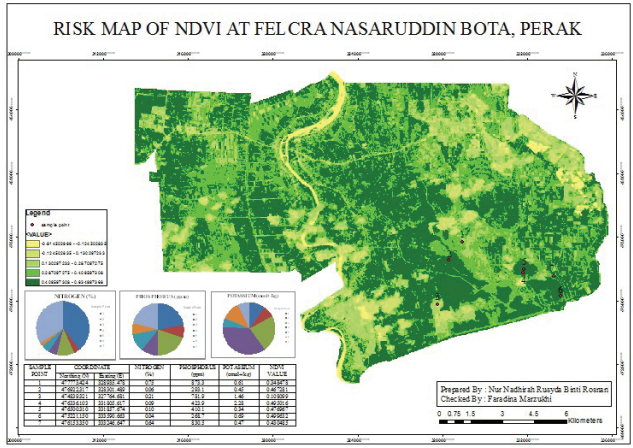


Figure 7: Risk Map
Source: Author

CONCLUSION

Based on the analysis that has been done, both techniques were used in this study to determine the relationship between soil nutrient and NDVI

value. The techniques used showed a good indication in determining the healthiness of oil palm tree. This is because the value of soil nutrient can be compared with the NDVI value to determine the relationship. Besides that, by using NDVI technique, the greenness of the vegetation area can be identified. Furthermore, the regression analysis (R^2) result can also show which nutrients play an important role in determining the health's condition of the vegetation.

Therefore, by doing this research, it is hoped that it can assist the government agencies that are related to agriculture especially oil palm in determining other factors that might influence the deteriorating of oil palm tree production and of course to maintain the sustainability of physical environment for future development.

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