GROWTH PROFILE ANALYSIS OF OIL PALM BY USING SPOT 6 THE CASE OF NORTH SUMATRA

Ita Carolita[1*)], J. Sitorus[2], Johannes Manalu[1], and Dhimas Wiratmoko[4]
[1]Remote Sensing Applications Center
Indonesian National Institute of Aeronautics and Space (LAPAN)
[2]Indonesian Oil Palm Research Institute, Medan, Indonesia
*)e-mail: ita.carolita@yahoo.com
Received: 3 February 2015; Revised: 11 March 2015; Approved: 10 April 2015

Abstract. Oil Palm (*Elaeis guineensis* Jack.) is one of the world's most important tropical tree crops. Its expansion has been reported to cause widespread environment impacts. SPOT 6 data is one of high resolution satellite data that can give information more detail about vegetation and the age of oil palm plantation. The objective of this study was to analyze the growth profile of oil palm and to estimate the productivity age of oil palm. The study area is PTP N 3 in Tebing Tinggi North Sumatera Indonesia. The method that used is NDVI analysis and regression analysis for getting the model of oil palm growth profile. Data from the field were collected as the secondary data to build that model. The data that collected were age of oil palm and diameters of canopy for every age. Results indicate that oil palm growth can be explained by variation of NDVI with formula $y = -0.0004x^2 + 0.0107x + 0.3912$, where x is oil palm age and Y is NDVI of SPOT, with $R^2 = 0.657$. This equation can be used to predict the age of oil palm for range 4 to 11 years with R^2 around 0.89.

Keywords: *growth profile, SPOT 6, oil palm plantation age*

1 INTRODUCTION

Palm oil (*Elaeis guineensis* Jack.) is one of the world's most important tropical tree crops. It is grown commercially in Southeast Asia, Africa and Central and South America for its palm oil, the world's second most widely consumed edible oil (Salunkhe *et. al.*, 1992). World production of palm oil has increased spectacularly in the last 20 years, especially in Indonesia and Malaysia. Indonesia is the largest producer of palm oil (data of oil world).

As the largest producer, good management in oil palm plantation is very important, such as detecting unhealthy plants, fertilization plan, irrigation management. Therefore the information of oil palm age or condition of their growth is needed. Those are important for increasing quality and yield of palm oil.

Remote Sensing has significant potential to provide data for oil palm monitoring and detection efforts. It also provides a cost-effective method to these purposes and at the same time provides site-specific assessments of management practices and growth performance of the palms. Some aspects of oil palm monitoring have been studied. Within the domain of land cover classification, previous studies show that oil palm can be mapped. Koh *et al.* (2011) for instance, have reported that oil palm plantation in some South East Asian countries can be observed by coarse-scale MODIS. Remotely Sensed Satellites data including Landsat Thematic Mapper and SPOT have been successfully used to identify oil palm growing areas and to map stand age at early stages of their growth. (Morrow, 2001; Wahid *et al.*, 2005, Lukman *et al.*, 1996).

The expansion of plantation also must be well panned, because its existence must not affect the surrounding environment. Identification, mapping and monitoring are therefore required to impose such ideal working environment. RS has significant potential to aid oil palm plantation monitoring and detection efforts. It also provides a cost-effective method to map oil palm and at the same time provides site-specific assessments of management practices and growth performance of the palms.

The age of oil palm is the main indicator that may be used to estimate the productivity of oil palm. The research performed by PPKS (Sutarta, E.S., and Rahutomo, S. 2013) indicates that there is a strong correlation between age and production of oil palm. The productivity increase sharply from age 3 years to 11 years then getting the maximum at 12 years old. Furthermore, the productivity decrease gradually from 13 years up to 25 years old (Figure 1-1 and Table 1-1).

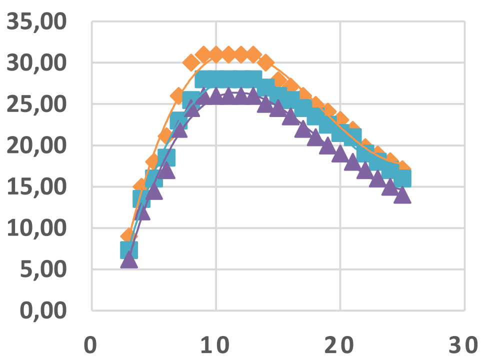

Figure 1-1:The productivity of oil palm according to it's age, whre x = age (year), y = ton/ha

Research by LAPAN (Sitorus *et al.*, 2004) on oil palm plantation using Landsat in Lampung Sumatera Indonesia showed that the coefficient between Landsat band 5 and oil palm age is 69%; while research by (Fadli 1995) also showed there is good correlation between oil palm age and spectral values of SPOT. Considering the above, this study examined the use of SPOT data for estimating the crop age in significantly different geographic zone. The objective of this study is to estimate the productivity age of oil palm. This model can be used by users (in this case the oil palm company) to monitor the growth of its palm oil in each block.

Table 1-1:Data of Oil Palm Productivity

Age of Plant (Year)	Yield Potential Based on Land Class Fresh Fruit Bunches (FFB)		
	S1	S2	S3
3	9,00	7,30	6,20
4	15,00	13,50	12,00
5	18,00	16,00	14,50
6	21,10	18,50	17,00
7	26,00	23,00	22,00
8	30,00	25,50	24,50
9	31,00	28,00	26,00
10	31,00	28,00	26,00
11	31,00	28,00	26,00
12	31,00	28,00	26,00
13	31,00	28,00	26,00
14	30,00	27,00	25,00
15	27,90	26,00	24,50
16	27,10	25,50	23,50
17	26,00	24,50	22,00
18	24,90	23,50	21,00
19	24,10	22,50	20,00
20	23,10	21,50	19,00
21	21,90	21,00	18,00
22	19,80	19,00	17,00
23	18,90	18,00	16,00
24	18,10	17,00	15,00
25	17,10	16,00	14,00

2 MATERIALS AND METHODOLOGY

2.1 Study Area

The study area was performed in Oil Palm Plantation area of PTPN 3 Tebing Tinggi, North Sumatera Indonesia. Tebing Tinggi is located between 02°01'37" and

02°35'58" South, and from 114°50'24" to 115°50'24" East.

Tebing Tinggi has climate of low land tropic. The altitude of area is 24 to 26 above sea level and the topography is flat and undulating. Temperature is around 25° – 27 °C. Average rainfall is 1.776 mm/year and air humidity is around 80 % – 90%. (kotatebingtinggi.wordpress.com). Figure 2-1 shows the area of this study.

Figure 2-1: Study area and SPOT image of Medan and Tebing Tinggi, North Sumatera

2.2 Data Collection

Satellite data that used in this study are SPOT 6 with date February, 11, 2014 and February, 12, 2015 (Figure 2-2 and Figure 2-3).

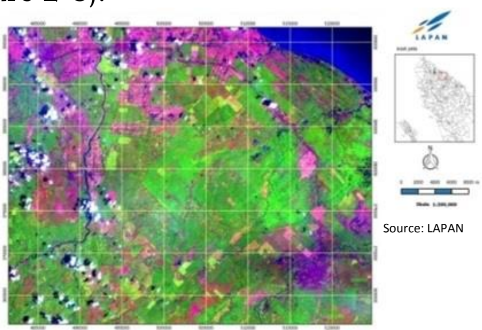

Figure 2-2: SPOT 6 data of Tebing-Tinggi

Figure 2-3: SPOT 6 data of Tebing-Tinggi

Observation and measurement in field is needed for analyze of oil palm growth profile. The ground data collection was carried out in collaboration between LAPAN team and PTPN 3.

Field measurements were performed by checking the age of oil palm trees and their appearance in SPOT 6 hard copy. The position of observation points were measured by using GPS Trimble Juno series. Figure 2-4 below shows several condition of oil palm at age 1, 3, 5, 10, 14 and 22 years and the the performance of pan-sharpening of MS and PS of SPOT 6.

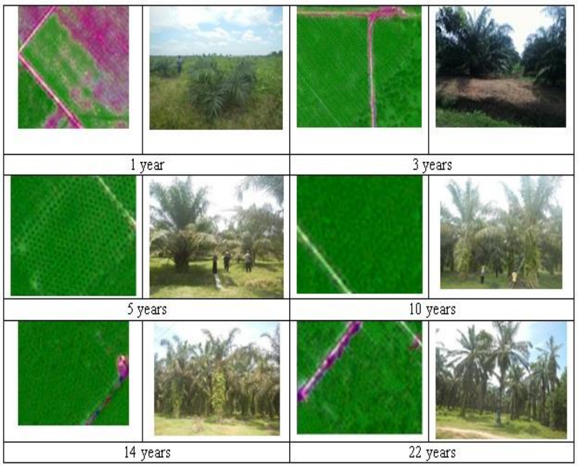

Figure 2-4: Condition of oil palm trees at the age of 1, 3, 5, 10, 14 and 22 years

2.3 Data Processing

The flow of data pre-processing and processing is outlined in figure 2-5 covering the following: (1) image and auxiliary data collection, (2) Image correction, (3) visual interpretation for selecting area representing each age of oil palm, (4) Modelling for finding oil palm growth model and model of oil palm's age estimation. Beside using spectral values of each band, model building also used vegetation indelx (NDVI). The formula for NDVI is (Silleos, 2006):

$$NDVI = (NIR - VIS) / (NIR + VIS) \qquad (2\text{-}1)$$

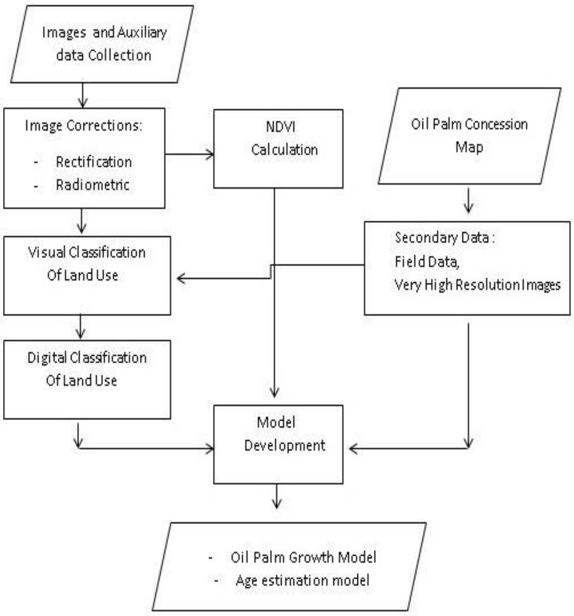

Figure 2-5: Flow Chart of Data Processing

3 RESULTS AND DISCUSSION

The measurement of canopy diameters of representative oil palm trees in each block shows that the diameter of canopy become increase sharply according to the age until age reach 15 years old, then decrease slowly from 16 to 22 years old. Figure 3-1 shows the result of measurement of canopies in PTP N 3.

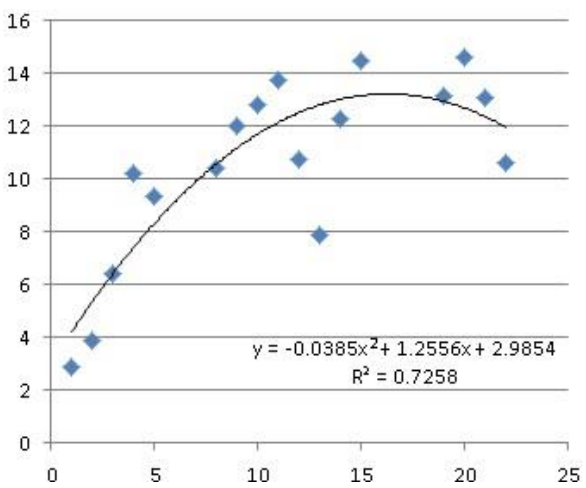

Figure 3-1: The canopy diameter according to it's age, where x = age (year), y = diameter of canopy (meter)

Visual interpretation of SPOT 6 image shows that the distance between plant canopies is far away. At the age of 3 years and 4 years the diameter of canopy of oil palm become higher reach about 6 meters, and the number of leaves increase. Therefore the distance between the plant canopies become much more closely than at age 1 or 2 years. Then at the age of 7 and 8 years old, the diameter of canopy of oil palm reach 10 or 11 meters, and the number of leaves more increase because the leaves cover the ground under trees; the distance between canopy is getting much more closer. At this age the appearance of the image of the SPOT 6 oil palm trees are still visible individually but more closer than at 3- 4 year. At the age of 8 and 9 years old, the diameter of canopy reach more than 10 meters. The number of leaves become more lush so the ground under canopy become no sunlight, the leaves become dark green color. This causes the appearance of the image become dark green. At age 9 years, the oil palm on SPOT 6 image become difficult to be separated individually, because the canopy has been more closed each other. Lastly, for age 15 years, the diameter of canopy of oil palam is more than 14 meters . Most of the leaves begin old and dry and then fall to the ground, but in general still lush. This condition causes to the appearance of the image of the SPOT 6 become blackish color due to the shadow effect of the tree and dark green leaves.

Spectral analysis was done to explore quantitatively the sensitivity of each band of SPOT 6 to the age difference of oil palm. Age data obtained from observations and measurements in the field. Figure 3-2 shows the results this analysis. it shows that every band gives different response for each of oil palm age, but not significantly. Channel 4 (the NIR wavelength channels from 0.760 to 0.890 υm) give considerable significance (55%) for the difference spectral values. Figure 3-2 shows the each graphic and equation (growth model) of each band spectral (reflectance) to age of oil palm.

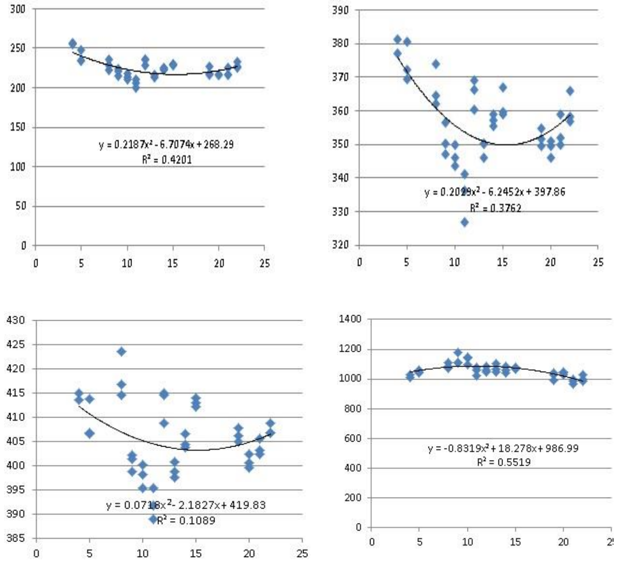

Figure 3-2: Profile Growth Palm Oil for each band of SPOT- 6, where x=age (year), y = reflectance

To obtain a value that can provide a significant difference, convertion of specral value to NDVI was done by using formula (1). Furthermore, model of oil palm growth was built by using this index for oil palm at age of 1 year to 22 years. Regression analysis results that the profile of oil palm growth follows quadratic equation as Figure 3-3, with R2 reach 0.66. The equation of oil palm growth profile is: y = -0.0004x2 + 0.0107x + 0.3912, where x is the age and Y is NDVI of SPOT 6.

This equation shows that the age of oil palm can be used in PTP N 3 to estimate the age of oil palm and to investigate the health condition of oil palm trees. To estimate the age by using SPOT 6, the other equation was built. This sedond equation only was built by data in range from 3 years to 11 years old, because this age is the peak of productivity oil palm as well (table 1). Figure 3-4 shows the equation of age estimation of oil palm by using SPOT 6, where R^2 = 0.89. The equation can be used to estimate the age of oil palm for age under 12 years old.

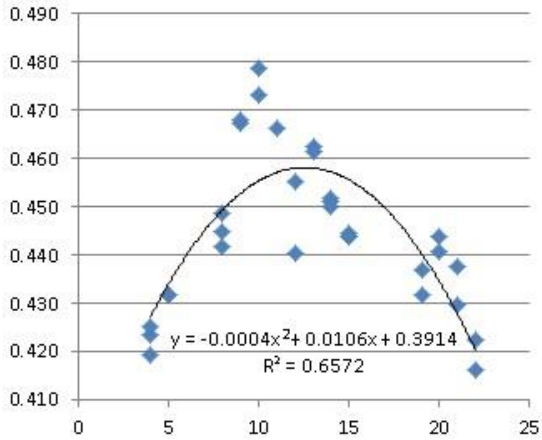

Figure 3-3: Profile of oil palm growth by using SPOT6 for Tebing Tinggi, North Sumatera, where x= age (year) and y = NDVI

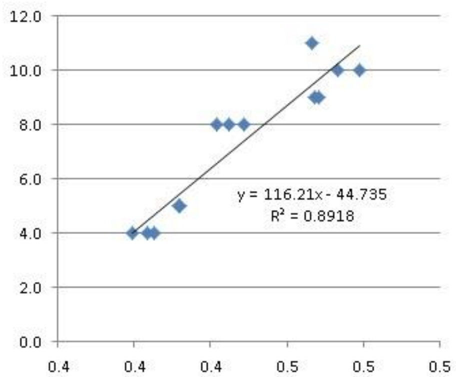

Figure 3-4: Age Estimation Equation for oil palm in PTP N 3 Tebing Tinggi, North Sumatera, where x = NDVI and y = age (year)

4 CONCLUSION

From the processing of SPOT 6 and auxiliary data, the study concluded that the growth profile of oil palm follows quadratic equation with maximum value of NDVI become the biggest value at age around 11 and 12 years. The equation of this growth profile is: Y = -0.0004 X^2 + 0.0107 X + 0.3912, where X is the age and Y is NDVI of SPOT 6. The equation that can be used for estimating age of oil palm under 12 years old is Y= 116.21 X – 44.74, where X = NDVI and Y = age (years)

ACKNOWLEDGEMENT

Authors give sincere gratitude to the Director of Remote Sensing Applications Center of LAPAN and the Director of PTP N 3, as well as the Director of PPKS (Indonesian Oil Palm Research Institute) for giving us the chances to carried out this study, and for providing facilities and/or funds that authors got during the study and field survey.

REFERENCES

Fadli, (1995), Pengaruh Umur Tegakan Kelapa Sawit terhadap Nilai Kecerahan pada Data Digital SPOT Multispektral di Kebun Sawit Serbrang, Sumatera Utara. Yogyakarta: Universitas Gadjah Mada.

https://kotatebingtinggi.wordpress.com/profil-kota/profil-umum-kota-tebing-tinggi/.

Koh, LP, (2011), Remotely Sensed Evidence of Tropical Peatland Conversion to Oil Palm. In Proceedings of the National Academy of Sciences of the United States of America 108 (12).

Lukman F., Poeloengan Z., (1996), Application of Remote Sensing Technique for Oil Palm Plantation, Management. In Proceedings of the 1997 PORIM International Palm Oil Congress-Competitiveness for the 21st Century: 460-467.

Morrow J., (2001), Linear Regression Modelling for the Estimation of Oil Palm Age from Landsat-TM. Journal of Remote Sensing: 2243-3364.

Salunkhe DK, Chavan JK, Adsule RN, Kadam SS, (1992), World Oilseeds. Chemistry, Technology, and Utilization. New York.

Silleos, N., (2006), Vegetation Indices: Advances Made in Biomass Estimation and Vegetation Monitoring in the Last 30 Years. Geocarto International 21(4).

Sitorus J., (2004), Pengembangan Model Estimasi Umur Tanaman Sawit dengan Menggunakan Data Landsat-TM. Jurnal Penginderaan Jauh dan Pengolahan Data Digital. 1(1): 14-19.

Sutarta, ES, and Rahutomo, S., (2013), New Standard for FFB Yield of IOPRI's Planting Materials Based on Land Suitability Class. Medan.

Wahid BO, Nordiana AA, Tarmizi AM, (2005), Satellite Mapping of Oil Palm Land Use. MPOB Information Series, MPOB TT No. 255, ISSN 1511 – 7871.