A spatial study of rubber plant health using sentinel 2-A imagery in Cibungur Plantation, Sukabumi, West Java

T R Putri and S Supriatna
1 Department of Geography, Faculty of Mathematics and Natural Sciences, Universitas Indonesia, Depok 16424, Indonesia
tineziariyantika@gmail.com

Abstract. Rubber plants are one of the plantation commodities which occupy an important position as a source of non-oil and gas foreign exchange for Indonesia. Rubber production is currently experiencing a decline due to reduced productivity in rubber plantations. Rubber plantation problems related to land resources require effective and efficient technological input to determine the health of rubber plants so that they can increase rubber production. Remote sensing technology is one input that can be used as a decision maker to decide problems spatially and quickly, accurately, and dynamically. This study aims to determine the health condition of rubber plants in Cibungur Plantation, Sukabumi, West Java by using high-resolution satellite imagery, namely Sentinel 2-A images processed using the NDVI (Normalized Difference Vegetation Index) method in monitoring the spatial health of rubber plants. The results of this study indicate that the level of distribution of NDVI values in Cibungur Plantation is quite high and rubber plants with very good health conditions have the largest area of 5,365.98 hectares. The NDVI method and Sentinel 2-A image processing used in this study can be used to determine the health of rubber plants in Cibungur Plantation.

1. Introduction
Rubber (Hevea brasiliensis) is an important plantation crop, both in the context of the community's economy and a source of non-oil and gas foreign exchange earners for the country. Rubber plants come from the tropics of the Brazilian Amazon basin with rainfall 2000-3000 mm/year and rainy days between 120-170 days/year [1]. Climate is an important limiting factor in achieving production [2]. Climate elements that affect production include rainfall patterns, apparent motion of the sun, temperature and humidity [3].

The health of rubber plants can affect the production of rubber that will be produced. Remote sensing imagery is useful in many applications, especially for obtaining land-cover information at lower cost and lesser time [4]. NDVI value can be used to see the health condition of rubber plants by using high-resolution satellite imagery. The Normalized Difference Vegetation Index (NDVI) value is a standard method of comparing the greenness of vegetation on satellite data [5]. The high and low NDVI values are influenced by the density of vegetation or plants. The NDVI method describes the vegetation density with a mathematical combination between the red band and the NIR band (Near-Infrared Radiation) [6]. If the NDVI value is high, it can be estimated that a location has dense and healthy plants, and vice versa if the NDVI value is low, it can be estimated that the location is rarely or not densely populated [7].

The sensing image used for area observation in the plantation area is Sentinel 2A Image with a spatial resolution of 10-60 meters. The Sentinel 2A satellite is equipped with a 13 spectral channel multispectral...
instrument with a spatial resolution of 10 meters. The result is the Sentinel 2A image with NDVI algorithm in the study area matched by land use [8]. Various kinds of spectral transformations from Sentinel 2A images can be used to see the health of rubber plants. Plant health can be analyzed using the NDVI method as was done by Maulidyah, Cahyono, and Nugroho (2019) where in this study used Sentinel 2A images with a spatial resolution of 10 meters of spectral bands. Spatial analysis of rubber plant health using high-resolution remote sensing images can provide more accurate information.

Rubber plants are well known throughout Indonesia, one of which is in Sukabumi. Currently, there are many changes in land use or land-use change, including in Cibungur Plantation, Sukabumi. The rubber plantation in Cibungur Plantation which has an area of 5,890 hectares, some of which have changed the function of land to become companies, either into plantations/annuals such as oil palm or into food crops such as corn and others. The volatile global price of rubber plants and the widespread use of synthetic rubber in various industries have encouraged the implementation of land conversion for rubber plantations. The conversion of rubber plantations is also carried out to increase productivity in the oil palm commodity with more profitable production results. The land-use change that occurs can be due to the poor health condition of the rubber plants which causes rubber production to decline.

Plant health is important to increase productivity. Monitoring plant health is also important to understand that climate change can affect cropping patterns [9]. This study is adapting from several previous studies. The use of Sentinel 2-A imagery with high spatial resolution to see the health of rubber plants has not been done too much. Cibungur plantation has various types of plants, but there is no research related to the health of rubber plants. The use of Sentinel 2A satellite imagery can assist in temporal analysis of plant health at high resolution. Therefore, I am interested in conducting research entitled "A Spatial Study of Rubber Plant Health Using Sentinel 2A Imagery in Cibungur Plantation, Sukabumi, West Java". High-resolution image data with NDVI values were used in this study for modeling the health of rubber plants. This study aims to analyze the level of distribution of vegetation index values based on the NDVI (Normalized Difference Vegetation Index) algorithm using Sentinel 2-A imagery, to analyze the distribution of rubber plant health in 2020 in Cibungur Plantation, and to analyze the relationship between NDVI values and the health of rubber plants in Cibungur Plantation.

2. Methodology
This study area is located in Cibungur Plantation, Warungkiara District, at 6°57′6″ S latitude and 106°45′1″ L latitude. Cibungur Plantation Area is located at an altitude of 284-604 m with an average of 305 meter above sea level. Cibungur Plantation is one of the plantations owned by PT Perkebunan Nusantara VIII (PTPN VIII). This research tries to analyze the health of rubber plants in 2020 at Cibungur Plantation, Sukabumi Regency.

The distribution of rubber plantation land use can be detected using Sentinel 2-A Image which is a multispectral satellite image. There are several factors that affect the health of rubber plants. The distribution of NDVI values can produce the health level of rubber plants.

2.1. Sentinel 2-A Imagery
Sentinel-2 is a European optical imaging program launched in 2015. Sentinel 2 is the first satellite launched as part of the European Space Agency (ESA) Copernicus program. These satellites carry a high-resolution swathed multispectral imager with 13 spectral bands [10]. Sentinel-2 satellites have 3 different spatial resolutions, namely 10 m, 20 m, and 60 m [11].

2.2. NDVI Algorithm
The multi-spectral bands are combined for generating various vegetation indices. The raster data is being clipped with rubber plants polygons prior to the analysis with NDVI [12]. NDVI is the most frequently used vegetation index algorithm. The principle of this formula is that radiation from visible red is absorbed by leaf green chlorophyll so that it will reflect low, while radiation from near-infrared rays will be strongly reflected by the structure of the spongy mesophyll leaves. This index has a range of values from -1.0 to 1.0 [13]. Clouds, water, and non-vegetation objects have an NDVI value of less than
zero. If the index value is higher, it means that the vegetation cover is healthier [14]. The NDVI formula is as follows:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

A positive NDVI (+) value occurs when vegetation reflects more radiation at near-infrared wavelengths than visible light. Zero NDVI value (NDVI = 0) occurs when the reflected energy recorded by visible light wavelengths is the same as near-infrared waves. This often occurs in residential areas, land, non-vegetation land, clouds, and water surfaces. Meanwhile, a negative NDVI value (-) occurs when the cloud surface, water, reflects more energy at visible light wavelengths than near-infrared [15]. The calculation of the NDVI value is carried out using ENVI 5.3.

2.3. Relationship between rubber plant health and NDVI Value

The NDVI algorithm can be used to determine the density and greenness of vegetation in an area. In addition, the NDVI algorithm can be used to determine the level of plant health, one of which is rubber. Research conducted by Petersen in 2018 showed that NDVI can be used as an indirect measurement to determine plant health. Table 1 shows the relationship between NDVI values and plant health.

| Plant Health & Plant Density | NDVI Value       |
|-----------------------------|------------------|
| Very Good                   | 0.72 – 0.92      |
| Good                        | 0.42 – 0.72      |
| Normal                      | 0.22 – 0.42      |
| Bad                         | 0.12 – 0.22      |
| Very Bad                    | -0.1 – -0.12     |

(Source: http://endeleo.vgt.vito.be/dataproducts.html)

Understanding the difference in the intensity of electromagnetic radiation that is reflected and emitted, it will be able to identify tree species or forest stands, age, health, density, and humidity pressure of a forest group [16]. Clouds, water, and non-vegetation objects have an NDVI value of less than zero. If the index value is higher, it means that the vegetation cover is healthier [17].

3. Results and discussion

The Sentinel 2-A image used in this study was recorded on July 28th, 2020, with a resolution of 10 meter. In the Sentinel 2-A image, 2 bands are used to determine the NDVI value, namely band 8 and band 4. Band 8 is used as NIR (Near-Infrared) and band 4 as RED. The algorithm formula used is as follows:

$$NDVI = \frac{(NIR \text{ Band} \ 8) - \text{Red(Band} \ 4))}{(NIR \text{ Band} \ 8) + \text{Red(Band} \ 4))}$$

From the results of calculations based on this formula, the level of distribution of NDVI values in Cibungur Plantation is obtained. The NDVI value is spread from -0.996303 to 0.997944, this shows that the level of NDVI distribution in Cibungur Plantation is quite high. The rubber trees that are scattered in the Cibungur Plantation are quite extensive and show very good NDVI value. From the distribution of the NDVI value, five classifications of the relationship between the NDVI value and the health of rubber plants are then made:
Table 2. Relationship between NDVI value and rubber plant health.

| Plant health | NDVI value | Area (Ha) |
|--------------|------------|-----------|
| Very Good    | 0.72 – 0.92| 5,365.98  |
| Good         | 0.42 – 0.72| 3,377.94  |
| Normal       | 0.22 – 0.42| 459.79    |
| Bad          | 0.12 – 0.22| 58.02     |
| Very Bad     | -0.1 – 0.12| 78.13     |
| **Total**    |            | **9,339.86** |

From the classification results of the relationship between the NDVI value and the health of rubber plants, it was found that the health area was different for each class. The total health of rubber plants in Cibungur Plantation is 9,339.86 hectares. Of the total area, rubber plants with very poor health had an area of 78.13 hectares, rubber plants with poor health had an area of 58.02 hectares, rubber plants with normal health had an area of 459.79 hectares, rubber plants with good health had an area of 3,377.94 hectares, and plants Rubber with very good health have an area of 5,365.98 hectares. From the results of this classification, rubber plants with very good health had the largest area, namely 5,365.98 hectares. This shows that the relationship between the NDVI value and the health level of rubber plants in Cibungur Plantation is very good. Figure 1 represents the result of the health classification of rubber plants in Cibungur Plantation.

Figure 1. Rubber plant health in Cibungur Plantation.

4. Conclusion
Cibungur Plantation has various types of plants, one of which is rubber. From the results of data processing, rubber plants managed at Cibungur Plantation have a fairly wide distribution which can be seen from the NDVI value which ranges from -0.996303 to 0.997944. The classification of the relationship between NDVI values and the health of rubber plants shows that rubber plants with very
good health conditions have the largest area of 5,365.98 hectares, the NDVI method and Sentinel 2-A image processing used in this study can be used to determine the health of rubber plants in Cibungur Plantation.

Acknowledgements
Thanks to DRPM of Universitas Indonesia which has supported and funded this research grant PUTI 2020.

References
[1] Subrata, B A G and Setiawan B A 2018 Jurnal Ilmiah Pertanian 14(2) 1–13
[2] Djaenudin D, Marwan H Subagjo H and Hidayat A 2011 Petunjuk Teknis Evaluasi Lahan untuk Komoditas Pertanian
[3] Junaidi, Sembiring Y R V and Siregar T H 2015 Warta Perkaretan 34(2) 137–46
[4] Supriatna, Rokhmatuloh, Wibowo A, Shidiq I P A, Pratama G P and Gandharum L 2019 Int. J. GEOMATE 17(62) 101-06
[5] Wahyunto, Widagdo and Heryanto B 2006 Informatika Pertanian, 15, 853–69
[6] Khoirunnisa F, Supriatna and Wibowo A 2020 IOP Conf. Series: Earth and Environmental Science, 481 012064
[7] Nafi A Y 2017 Jurnal Geografi 14(1) 112–23
[8] Sahararini A F, Supriatna and Wibowo A 2020 IOP Conf. Series: Earth and Environmental Science 481 012056
[9] Ahsanullah and Zafar S 2018 Fuuast J. Biol. 8(2) 217–24
[10] Putri D R, Sukmono A and Sudarsono B 2018 Jurnal Geodesi Undip7(2) 85–96
[11] Sinaga S H, Suprayogi A and Haniah 2018 Jurnal Geodesi Undip 7(1) 202–11
[12] Supriatna, Rokhmatuloh, Wibowo A, Shidiq I P A 2020 IOP Conf. Series: Earth and Environmental Science 500 012033
[13] Kawamuna A, Suprayogi A and Wijaya A P 2017 Jurnal Geodesi Undip 6(1) 277–84
[14] Lillesand T, Kiefer R and Chipman J 2004 Geogr. J. 146
[15] Mukhoriyah M, Sari N M, Sharika M and Hanifati, L N 2019 Jurnal Planologi 16(2) 158–68
[16] Petersen L K 2018 Remote Sensing 10(11) 1–31
[17] Maulidiyah R, Cahyono B E and Nugroho A T 2019 J. Health Environ. Sci. 5(2) 41–7