UTILIZATION OF REMOTE SENSING AND GIS FOR THE CALCULATION OF EUCALYPTUS PRODUCTIVITY AT BKPH SUKUN

Lutfi Ailuul Waahidati[1], Eko Budiyanto[2]

[1]Geography Education, Faculty of Social Sciences and Law, State University of Surabaya
Ketintang Campus, Jl. Ketintang, Surabaya 60231

[2]Faculty of Social Sciences and Law, State University of Surabaya
Ketintang Campus, Jl. Ketintang, Surabaya 60231

Email corresponding: lutfiailuul19@gmail.com

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Abstract

The Sukun Forest Management Unit (BKPH) is the manager of both protection and production forest, which includes eucalyptus trees covering an area of 3,701 ha. One of the efforts to optimize eucalyptus production is to estimate the productivity of eucalyptus. Advances in remote sensing technology and geographic information systems (GIS) can provide fast and accurate specific data to be able to estimate the production of eucalyptus leaves. The purpose of this research is to build a model for calculating eucalyptus production based on remote sensing data and to estimate the amount of eucalyptus production by applying remote sensing data. This research uses remote sensing and geographic information system (GIS) with Soil Adjusted Vegetation Index (SAVI) and the number of trees of eucalyptus as parameters to analyze the productivity of eucalyptus leaves. The results showed that the spectral value of SAVI and the number of trees were able to explain the yield of eucalyptus leaves with an accuracy of 98%. Estimation of eucalyptus production can be done through multiple linear regression models between the variable number of trees and the SAVI spectral value. The result showed an accuracy of 78% with the equation $y = 0.405 + 1.190x_1 + 0.001x_2$ *and the Standard Error of Estimate is 0.052. The highest production estimate is 1.239 tonnes/pixel, while the lowest estimate is 0.633 tonnes/pixel.*

Keywords*: Eucalyptus plant, SAVI, Remote Sensing, Geographic Information System*

INTRODUCTION

Eucalyptus plants (Melaleuca cajuputi) is a type of non-timber forest plant native to Indonesia derived from the family Myrtaceae. Domestic demand for eucalyptus oil reaches 2,500 tons per year, but this is not offset by the production capability of eucalyptus oil which is only 2,000 tons per year (KLHK, 2019). One of the areas producing eucalyptus is Ponorogo Regency. The management of eucalyptus plants in Ponorogo is managed by the Sukun Forest Stakeholder Unit (BKPH). BKPH Sukun is a sub-unit of the Madiun Forest Stakeholders Union (KPH) located in the East Ponorogo region which includes four sub-districts namely Siman, Mlarak, Pulung, and Jenangan subdistricts.

Optimization of eucalyptus production requires the right target of eucalyptus leaf production by paying attention to the sustainability of plants and the potential of eucalyptus leaves. The concept of setting based on the estimation of results will be better based on the data and information of the end of resources and the estimation of the maximum value of the sustainable harvesting process (Vanclay, 1995). Remote sensing and geographic information systems can provide specific data as a reference for data collection without requiring a lot of fieldwork with fast and accurate results (Purhantanto, Daenoedoro, & Wicaksono, 2019). Remote sensing is an important technique that can be used in the management of natural resources in terms of time, cost, and measurement eligibility more easily. The purpose of remote sensing in the field of forestry can be done by combining field data, remote sensing data, and cross-testing the results of image analysis with field data (Howard, 1996).

The utilization of remote sensing can be used to monitor vegetation productivity in a large area and facilitate the estimation of crop productivity such as eucalyptus plants. The utilization of remote sensing makes it easier for BKPH Sukun to be able to maintain the quantity of eucalyptus. The use of sensing is much more effective and efficient for forest crops than using conventional methods. Convetional methods are conducted by directly studying eucalyptus plantations and calculating productivity after harvesting eucalyptus leaves. Conventional methods take a long time and cost a lot. The use of remote sensing can reduce cost and time issues in conventional methods.

Vegetation productivity can be seen from the reflection of vegetation chlorophyll in an area through the vegetation index. Vegetation index is a mathematical algorithm to produce a representative image to present aspects that are closely related to vegetation and is carried out by involving several channels at once (Danoedoro, 2012). The application of remote sensing data on plant growth using vegetation index can show the growth of plants temporally and spatially and is a tool on a field scale that is proven to estimate the production of a plant (Wójtowicz, Wójtowicz, & Piekarczyk, 2016).

Currently, there are various transformations of the vegetation index developed by remote sensing experts to find the index value of vegetation including SAVI. SAVI (Soil Adjusted Vegetation Index) is one of the vegetation indexes that can suppress the background of the soil. SAVI is suitable for areas with sparse plants where the plant canopy cannot mask the background effect of the soil. SAVI is appropriately applied in the area of eucalyptus plantations in BKPH Sukun where the planting distance of eucalyptus is 3x1 m and the eucalyptus canopy cannot cover the background of the soil. Studies on the use of SAVI for vegetation have been conducted among others by Rondeaux, et al., (1996) who tested and compared the sensitivity of the SAVI vegetation index. Rondeaux, Steven, & Baret, (1996) proved the value of parameter X is very important to use in minimizing soil effects.

The utilization of remote sensing is inseparable from geographic information systems (GIS). GIS plays an important role in displaying spatial data where it will be very useful when applied in the processing of spatial data obtained through remote sensing (Liu & Mason, 2009). GIS provides convenience for users in managing remote sensing data to the point of data formation.

METHODS

This research is a survey research with a quantitative descriptive approach. The research location is in the Sukun KPH Madiun Forest Management Unit (BKPH) which includes four sub-districts, namely Siman, Mlarak, Pulung, and Jenangan District. BKPH Sukun has five Forest Management Resorts (RPH) consisting of Depok, Sidoharjo, Ngalayang, Sukun and Tambaksari.

The research sample used is the taking of a measuring plot to find out the number of eucalyptus trees and the production of eucalyptus leaves. Measuring plots used as many as 10 sampling plots with an area of 30mx30m or 900m^2 measured from each center point of the plot. Sampling techniques in this study using purposive sample techniques. The determination of the sample is done by overlaying on the slope, eucalyptus distribution, and SAVI index. The overlay is done to determine the point with high conformity to build a measuring plot with consideration of ease in terms of accessibility and the value of the distribution of the SAVI index.

The data used in this study are primary data and secondary data. Primary data obtained from field data in the form of field measurement data, namely the number of trees and the amount of eucalyptus leaf production (tons) in each measuring plot. Secondary data in the form of Landsat 8 OLI image data and DEM data from USGS, slope maps processed from imagery data, and eucalyptus distribution maps processed from the Public Works and Spatial Office of Ponorogo Regency. The data analysis technique used is regression statistical analysis processed using IBM SPSS 25 software application. Statistical analysis is used to determine the relationship of the vegetation index value, the number of trees, and leaf production of each measuring plot is a multiple regression analysis. The estimated amount of leaf production in the field compared to leaf production by the plant used regression model accuracy test with Standard Error of Estimate.

RESULTS AND DISCUSSION

Slope

Eucalyptus plants do not require specific planting requirements. This plant can grow in areas with diverse slopes. The slope analysis in this study focused more on the ability of researchers to achieve the appropriate measuring plot. Slope analysis is used to prevent landslide hazard disturbances. Slope level can be classified into 5 classes as follows:

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Table 1. Slope Area

Slope Level	Category	Area (Ha)	Percentage (%)
0-8%	Flat	19,24	0,45
8-15%	Ramps	3.522,82	83,09
15-25%	A Bit Steep	301,00	7,10
25-40%	Steep	380,26	8,97
>40%	Very Steep	16,45	0,39
Total area		4.239,78	100

Source: Data Processing, 2021

Table 1 shows the variation of slope in BKPH Sukun divided into five categories namely flat with a slope rate of 0-8%, ramps with a slope rate of 8-15%, rather steep with a slope rate of 15-25%, steep with a slope rate of 25-40% and very steep with a slope rate of >40%. The slope can be seen more clearly in Figure 1.

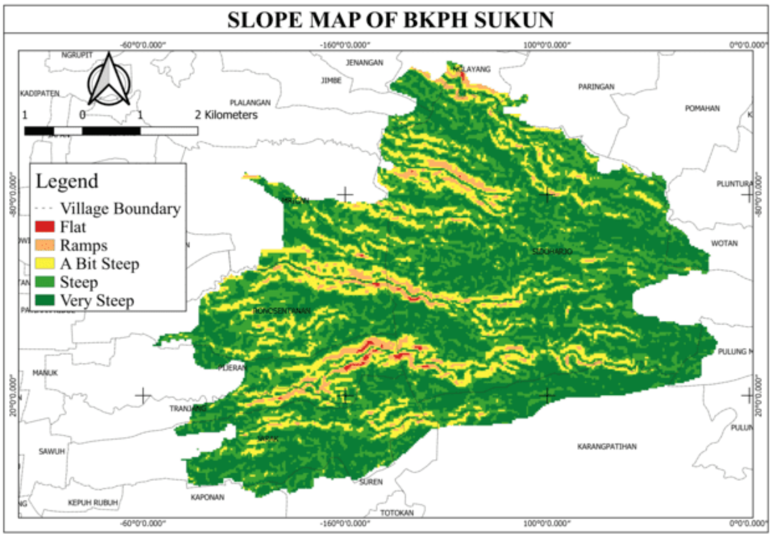

Figure 1. Slope Map (Source: Data Processing, 2021)

Figure 1 shows the slope in BKPH Sukun dominated by the slope of the ramp of 3,522.82 ha or 83.09% of the total area indicated by the orange hue. The slope of the slope is rather steep indicated by a yellow hue with an area of 301.00 or 7.10% of the total area. The slope category of steep slopes is indicated by a green hue with an area of 380.26 or 8.97 of the total area. The slope category of very steep slopes is indicated by a dark green hue with an area of 16.45 Ha or 0.39% of the total area. The flat category is indicated by a red hue with an area of 19.24 Ha or 0.45% of the total area.

SAVI Vegetation Index

SAVI transformation is an algorithm of vegetation index transformation that can suppress the background of the soil. This transformation resulted from a comparison of red waves (Red) and Near Infrared (NIR) using single-channel imagery of band 5 and band 4. SAVI value is used to know the density of eucalyptus plants and as a reference in determining sample points in the field. The SAVI transformation value is classified into 5 classes as follows:

Table 2. SAVI Vegetation Index Area

Value	Category	Area (Ha)	Persentase (%)
-1 s/d -0,03	Unclassified land	405,12	9,56
-0,03 s/d 0,15	Very low greenery	1.587,82	37,45
0,16 s/d 0,25	Low greenery	1.169,91	27,59
0,26 s/d 0,35	Medium green	772,20	18,21
0,36 s/d 1,00	High greenness	304,72	7,19
Total Area		4.239,78	100

Source: Data Processing, 2021

Table 2 shows the variation of the SAVI vegetation index in BKPH Sukun which is divided into five categories namely unclassified land with a range of -1 to -0.03, very low greenness with a range of -0.03 to 0.15, low greenness with a range of 0.16 to 0.25, medium greenness with a range of 0.26 to 0.35 and high greenness with a range of 0.36 to 1.00. The density of the SAVI index in BKPH Sukun can be seen more clearly in Figure 2.

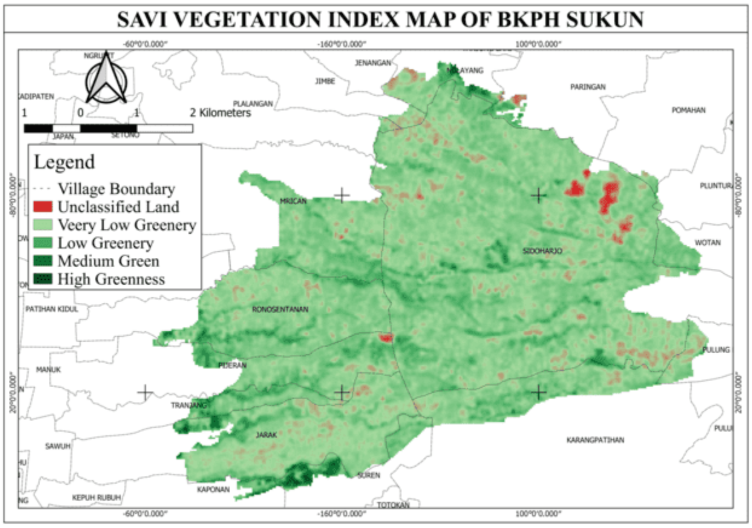

Figure 2. SAVI Vegetation Index Map (Source: Data Processing, 2021)

Figure 2 shows the classification of SAVI vegetation index in BKPH Sukun dominated by a very low greenish category indicated by a green hue with an area of 1,587.82 ha or 37.45% of the total area. The low greenish category is indicated by a yellow hue with an area of 1,169.91 ha or 27.59% of the total area. The greenish category is being shown by an orange hue with an area of 772.20 Ha or 18.21% of the total area. The high greenish category is indicated by a red hue with an area of 304.72 ha or 7.19% of the total area. The unclassified land category is indicated by a dark green hue with an area of 405.12 ha or 9.56% of the total area.

The research location is Eucalyptus Class Forest in Ponorogo Regency. The research location is surrounded by residential areas that have many interactions with eucalyptus plantations and forests. The SAVI transformation cannot differentiate between vegetation and non-vegetation, so it is necessary to differentiate land use between eucalyptus and non-vegetation. Land use in BKPH Sukun is classified into 5 classes as follows:

Table 3. Land area of Sukun BKPH

Category	Area (Ha)	Persentase (%)
Rice fields	191,44	4,16
Settlement	170,19	4,52
Shrubs	176,44	4,01
Eucalyptus Plantation	3.701,7	87,31
Total Luas	4.239.78	100

Source: Data Processing, 2021

Table 3 shows the variation of land use in BKPH Sukun divided into four categories, namely rice fields, settlements, shrubs, and eucalyptus plantations. The distribution of eucalyptus plants can be seen more clearly in Figure 3.

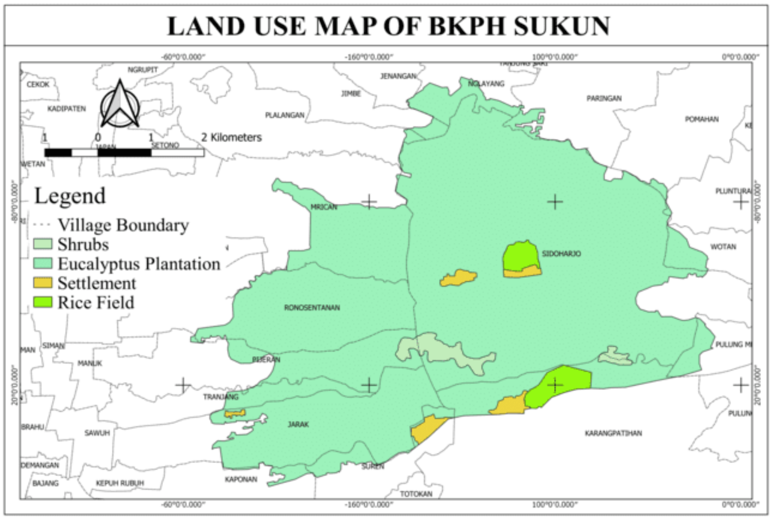

Figure 3. Land Use Map (Source: Data Processing, 2021)

Figure 3 shows the classification of land use in BKPH Sukun dominated by the category of eucalyptus plantations indicated by a green hue with an area of 3,701.7 ha or 87.21% of the total area. The category of rice fields is indicated by a pink hue with an area of 191.44 ha or 4.16% of the total area. The category of settlements is indicated by a light brown hue with an area of 170.19 ha or 4.52% of the total area. The category of shrubs is indicated by a light green hue with an area of 176.44 ha or 4.01% of the total area.

Determination of Field Samples

The field sample was determined from the results of the classification of the SAVI vegetation index value, the classification of the slope, and the distribution of eucalyptus plants. The slope of the slope aims to determine the appropriate sampling from an accessibility point of view. Slope classification can be divided into 5, namely flat, gentle, rather steep, steep, and very steep. The vegetation index uses SAVI analysis because SAVI is suitable for use in areas where the soil factor is not covered by a vegetation canopy. The SAVI classification is divided into 5 classes which aim to see the distribution of objects in the form of unclassified land, vegetation with very low greenness, low greenness, medium greenness, and high greenness. The distribution of eucalyptus is used to differentiate the appearance of land cover in the form of forest and non-forest.

The classification results of the SAVI vegetation index, the classification of slopes, and the distribution of eucalyptus plants were overlaid as a reference for sampling in the field. There are 10 measuring plots used as samples in the field with each measuring plot spread over the BKPH Sukun area. The distribution of the measuring plots used as the research sample can be seen in Figure 4.

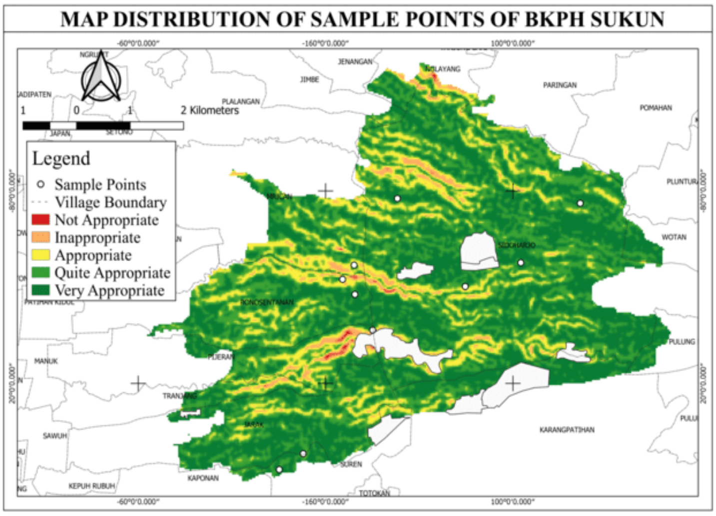

Figure 4. Map of the Distribution of Sample Points (Source: Data Processing, 2021)

Figure 4 shows the overlay results between the classification of the slope, SAVI index, and distribution of eucalyptus plants in BKPH Sukun. The overlay results are used as a reference for the distribution of the measuring plots used as samples in the field. Figure 4 shows the distribution of the 10 measuring plots marked with blue dots. The measuring plots used are spread over 2 measuring plots of very low vegetation density, 3 measuring plots of low vegetation density, 3 measuring plots of moderate vegetation density, and 2 measuring plots of high vegetation density.

Field Measurement

The number of measuring plots used in this study was 10 samples spread over very low, low, medium, and high vegetation densities. This measuring plot measures 30x30 m^2 or have an area of $900m^2$. The size of the measuring plot used is by the image pixel size where one pixel represents 30x30 m^2 in actual conditions. Determination of the location of the measuring plot is determined using a purposive sample technique where the sample is taken based on the special characteristics determined by the researcher.

The measuring plot is made in the area that has been selected using an analysis of the slope overlay, the distribution of eucalyptus, and the SAVI index value. Productivity calculations were carried out by measuring the number of trees and the yield of eucalyptus leaves for each plot. The results of field measurements on each measuring plot are presented in the following table:

Table 4. Field Measurement

Vegetation Density	Coordinate		Spectral Value	Number of Trees	Leaf Production (Tons)
	X	Y			
Very low	111°33’08” E	7°52’47” S	0,104	170	0,633
	111°35’14” E	7°51’34” S	0,140	185	0,749
Low	111°34’00” E	7°52’18” S	0,187	200	0,724
	111°33’23” E	7°51’42” S	0,202	209	0,848
	111°32’57” E	7°52’26” S	0,255	179	0,849
Moderate	111°32’56” E	7°52’26” S	0,287	195	0,915
	111°32’27” E	7°54’02” S	0,302	185	0,908
	111°34’36” E	7°52’02” S	0,335	184	0,940
High	111°32’49” E	7°52’16” S	0,391	200	1,064
	111°32’10” E	7°54’09” S	0,577	212	1,239

Source: Data Processing, 2021

The sample plots used as observation plots were taken from each density class. Plot one is very low density, plot four is low density, plot seven is medium density, and plot ten is high density. The SAVI index value on each plot is different even though in general each plot has the number of trees per plot with a small difference which can be seen in Table 4. The difference in index values is due to different eucalyptus plant health plots that can be seen from the color of eucalyptus leaves. Green eucalyptus leaves indicate healthy eucalyptus plants while yellow eucalyptus leaves indicate unhealthy eucalyptus plants and are not optimal for harvesting because they contain little essential oil.

Plot one is classified as very low green with a SAVI value of 0.104 and consists of 170 eucalyptus trees. This plot is dominated by unhealthy eucalyptus plants and there are several healthy eucalyptus plants. Plot four is classified as low green with a SAVI value of 0.202 and consists of 209 eucalyptus trees. This plot has a large number of trees when compared to other measuring plots. The eucalyptus trees on this plot are dominated by unhealthy eucalyptus. Plot four has a higher density than plot one because eucalyptus trees are evenly distributed and there are fewer unhealthy trees than plot one. Plot seven is classified as medium green with a SAVI value of 0.302 and consists of 185 eucalyptus trees. Plot seven is dominated by healthy eucalyptus plants, although there are still a few unhealthy eucalyptus plants. Plot ten is included in high greenness with a SAVI value of 0.577 and consists of 212 eucalyptus trees. Plot ten is dominated by evenly distributed healthy eucalyptus trees. The number of trees in each plot varies. The small number of trees and the unevenness causes the neutral value to be low and vice versa, the large and even number of trees make the SAVI spectral value high.

The results of field measurements of the number of trees and the amount of eucalyptus leaf production on 10 measuring plots obtained the number of plants between 170-212 trees with an average = 192 trees/pixel, standard deviation = 13.5, and total leaf production between 0.633-1.239 tonnes/pixel with mean = 0.891 ton/pixel, standard deviation 0.173. Eucalyptus leaf production is closely related to standing density. High stand density has a positive correlation with leaf yield

Statistic analysis

The statistical analysis used in this study is multiple regression using the IBM SPSS 25 software. The value of the SAVI vegetation index as the independent variable (x_1) and the number of trees as the independent variable (x_2) while the amount of leaf production as the dependent variable (y).

The regression results of the SAVI vegetation index and the number of eucalyptus trees on eucalyptus leaf production showed the value of R2 = 0.980 and SE = 0.394. The regression results showed that the SAVI vegetation index value and the number of trees had a simultaneous effect on the amount of eucalyptus production by 98%. The r and SE values are then used as the basis for making an estimation model for eucalyptus production with the regression equation:

$$y = 0.405 + 1.190x_1 + 0.001x_2$$

The regression analysis showed that the number of trees and the SAVI index value had a strong relationship with the yield of eucalyptus leaves. It is shown that the R2 value of 0.980 means that 98% of the yield of eucalyptus leaves in the field can be explained by the number of leaves and the SAVI index value. Low regression value can be caused by low eucalyptus plant health which generally occurs in plants with yellow leaves. Unhealthy leaf structure affects the spectral reflection in eucalyptus plants unlike the spectral reflection in healthy plants. Healthy eucalyptus plants reflect the near-infrared more highly because they can absorb red waves from sunlight. Unhealthy eucalyptus plants reflect red waves because their leaf structure is not like healthy eucalyptus plants.

The results of the regression analysis of the SAVI vegetation index using the NIR and Red channels have a strong value on the yield of eucalyptus leaves. This is because the NIR and Red channels are sensitive to chlorophyll content so that they can describe the chlorophyll content of eucalyptus vegetation which has an important effect on production yields. The spectral reflection that occurs is influenced by the absorption of waves in the leaf structure chlorophyll that occurs in the mesophyll tissue.

The SAVI spectral value and the results of observations of eucalyptus leaf production in the field were regressed to find the correlation of these variables. The results of the regression analysis show the Determinant Coefficient (R2) value of 0.957 which indicates a relationship between the spectral value of SAVI and leaf production which can be seen in Figure 5.

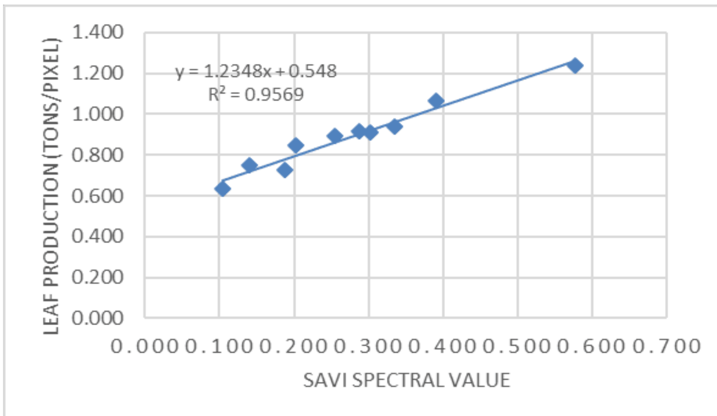

Figure 5. Graph of the SAVI Vegetation Index Regression (Source: Data Processing, 2021)

The results showed that the production of eucalyptus leaves had a close relationship with the spectral value where a high spectral value indicated a high production value which can be seen in Figure 5. The results of regression analysis between the spectral value of SAVI and leaf production showed an R2 value of 0.9569, which means 95 69% of the value of leaf production in the field can be explained by the pixel value of the SAVI transformation with the equation y = 1.2348x + 0.548 where y is the value of leaf production and x is the value of the SAVI index.

The results of this study are consistent with the research of (Darmawan, 2012) which states that the higher the leaf chlorophyll content the higher vegetation index value. Then indirectly the value of the vegetation index affects the production of eucalyptus. A high vegetation index value also indicates a high vegetation density wherein the study area is characterized by a large number of trees. This result is in line with the results of research by Nugroho, (2017) which states that a high vegetation index value is followed by a high vegetation density.

Calculation of Eucalyptus Production based on Remote Sensing Data

The productivity value is influenced by tree density where the more the number of trees in an area, the higher the productivity of the area. Tree growth through the process of photosynthesis produces biomass which is allocated to leaves, twigs, stems, and roots which increases tree height. The greenness factor that can be measured using the vegetation index is a determinant of production yields.

The SAVI index processed from Landsat 8 imagery can show plant growth conditions in the study area from varying greenness with sparse vegetation density where soil factors can be seen because it is not covered by a eucalyptus tree canopy. The results of this study are consistent with the research of Rondeaux, et al., (1996) who tested and compared the sensitivity of the SAVI vegetation index and proved that the SAVI index was able to minimize soil effects. Lintang, Sanjoto, & Tjahjono, (2017) stated that the transformation of the SAVI vegetation index has a difference of one pixel from the NDVI transformation that occurs in line with the presence of ground background disturbances. Andana, (2015) studied the development of image data in horticultural plant areas showing a very strong correlation value. The results of Andana (2015) indicate that SAVI can provide accurate horticultural plant density information.

The SAVI transformation utilizes band 4 with a red channel (Red) with a channel length of 0.636-0.673 μm and a band 5 NIR (near-infrared) with a channel length of 0.851-0.879 μm. Red and NIR channels are sensitive to the chlorophyll content of plants. In theory, the photosynthetic active vegetation will reflect the near-infrared higher, while the less healthy or dead plants reflect the red waves. Absorption of red waves and reflection of near-infrared waves occurs in the leaf mesophyll tissue causing the brightness value received by the sensor to differ between Red and NIR (Sudiana & Diasmara, 2008). The spectral properties of Red and NIR channels in eucalyptus plants are influenced by leaf cell structure and leaf water content. Red channel indicates a plant with high greenness characterized by absorption of the spectrum of high incident waves and low reflection. In the NIR channel, plants with high greenness are characterized by very high reflection and transmission while low absorption is due to strong water absorption. The difference in the absorption of the wave spectrum makes the lower the greenness of the plant, the lower the SAVI value.

The calculation of the estimated production of eucalyptus in this study was carried out by utilizing remote sensing. Estimation of eucalyptus production is carried out from the regression equation which describes the relationship between the spectral value and the yield of eucalyptus leaves. The regression equation shows the degree of relationship between the SAVI vegetation index value on the amount of eucalyptus leaf production per pixel in the field. The total estimated leaf production can be seen from the number of leaf production and the number of pixels where each pixel has an area of 900 m^2 so that the average eucalyptus leaf production per pixel and the estimated leaf production can be known. The amount of eucalyptus productivity can be known by multiplying the area and the production value of each pixel which can be shown in Table 5.

Table 5. Eucalyptu Production Accuracy of Leaf Estimates

Vegetation Index	Field Production (Tons/Year)	Estimated Production (Tons/Year)	Percentage of Accuracy
SAVI	10.113,036	7.851.071	78%

Source: Data Processing, 2021

The estimation results using the regression equation are sufficient to show the actual situation in the field. The distribution of productivity results refers to the results of research in the field with tree height and SAVI spectral value as the main reference. Field production produced a total of 10,113,036 tons while the estimated production resulted in a total of 7,851,071 tons with an accuracy of 78% which can be seen in Table 5. The results of this study are consistent with the research of Purhantanto, et al., (2019) to estimate the production of eucalyptus leaves using imagery Sentinel-2A show 76.44% accuracy with factory production results of 3,120,750 tonnes while the estimated production is 2,385,550 tonnes.

The next stage is carried out by testing the accuracy to compare the value of leaf production in the field and production estimates using the Standard Error of Estimate method. The accuracy test value indicates the estimated production value used is above or below the accuracy-test value. The results of the calculation of the accuracy-test show an accuracy value of 0.052 which indicates good accuracy. Based on the calculation model, an estimate is made to calculate the value of leaf production in the study area. The map of the estimation results of eucalyptus leaf production is made based on the multiple regression model equation with the independent variables SAVI spectral value and the number of trees shown in Figure 6.

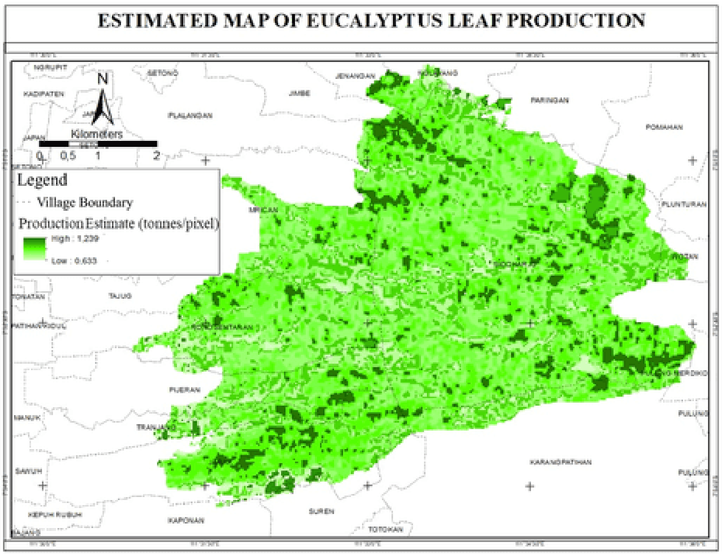

Figure 6. Estimated Map of Eucalyptus Leaf Production (Source: Data Processing, 2021)

Figure 6 is a map of the final results of the estimated production of eucalyptus leaves at BKPH Sukun. A darker green color indicates a higher leaf production value compared to a lighter green hue. The highest estimated distribution of eucalyptus production is 1.239 tonnes/pixel, while the lowest value is 0.633 tonnes/pixel. The spectral value of eucalyptus is uneven in each pixel due to differences in greenness and the number of eucalyptus plants for each plot in the field. The clustered and uneven distribution of eucalyptus plants affects the estimated map of eucalyptus leaf production.

Data collection in this study was carried out when the harvesting process occurred, namely October-December, while harvesting began in July. The difference in harvesting time and data collection causes some areas to have been harvested first, which has an impact on the estimated production results. The total estimated leaf production can be seen from the number of leaf production and the number of pixels where each pixel has an area of 900 m^2 so that the average eucalyptus leaf production per hectare is obtained and the estimated leaf production can be known.

CONCLUSION

Eucalyptus productivity calculations can be done based on the number of eucalyptus trees and the SAVI spectral value on the measuring plot. Measurement plots were determined in areas with characteristic slope, eucalyptus distribution, and SAVI spectral value. The regression results show the value of R2 =

0.980 and SE = 0.394, which means that the SAVI vegetation index value and the number of trees have a simultaneous effect on the amount of eucalyptus production by 98%. The septal value of SAVI can explain the value of eucalyptus production because it utilizes the Red and NIR channels which are sensitive channels to plant chlorophyll content.

Estimation of eucalyptus production can be done through multiple linear regression models between the variable number of trees and the SAVI spectral value with the amount of production in the field with the equation $y = 0.405 + 1.190x_1 + 0.001x_2$ and SE = 0.052. Eucalyptus production estimates with an accuracy of 78% produce 7,851,071 tons/year while field production produces 10,113,036 tons. The estimated distribution obtained is that the highest production estimate is 1.239 tons/pixel, while the lowest production estimate is 0.633 tons/pixel.

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