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Spatial Analysis of Changes in Normalization Differences Vegetation Index in Protected Forest Areas of South Lore District, Poso Regency

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Abstract

Detection of changes in vegetation density generally uses the vegetation index parameter. The value of the vegetation index can provide information on the proportion of vegetation cover, live plant index, plant biomass, cooling capacity, and estimation of carbon dioxide absorption. This study aims to analyze changes in the level of vegetation density using Sentinel 2-A imagery in the protected forest area of South Lore District. This study used the method of calculating the Normalized Difference Vegetation Index (NDVI) to identify changes in density over 5 years. The results of the NDVI analysis are the largest in the range of -0.92960 to 0.871725. The vegetation density class in the Protected Forest Area of South Lore District in 2017 is in the dense class with an area of 15,322.24 Ha or around 47.66%, while the smallest in the non-vegetation class, which is 103.11 Ha or 0.32%, while the largest vegetation density class is in the Protected Forest Area of South Lore District in 2022, namely in the medium/quite dense class with an area of 19,948.18 Ha or 62.01% while the smallest in the non-vegetation class of 219.17 Ha or 0.68%. The largest increase in area was in the moderate/quite dense class of 4,892.33 Ha or 15.20% while the largest decrease in area was in the dense class with an area of 6,651.16 Ha or 20.67% of the total area of the Protected Forest Area of South Lore District.

Keywords: Vegetation Density, Normalized Differenced, Vegetation Index, NDVI

1. INTRODUCTION

The Vegetation is a community of plants or all types of plants found in a certain area with spatial and temporal distribution patterns. So one plant is the only vegetation involved, and ecosystems form when other physical and biological elements are integrated into the vegetation. The presence of vegetation in the landscape has a positive effect on the balance of the ecosystem on a larger scale. In general, the role of vegetation in ecosystems is related to regulating the balance

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of CO_2 and O_2 in the air, improving the physical, chemical, and biological properties of the soil, and regulating groundwater management [1]. Remote sensing has the ability to cover large areas of the earth's surface in a single record. Remote sensing methods are used to obtain information data by recording reflected energy and processing it in the form of interpretation. The spectrum is the result of reflection between electromagnetic energy from objects on the earth's surface and electromagnetic energy recorded by satellite sensors with different characteristics. Therefore, the spectral value of the image can provide information about the conditions and processes that occur on the earth's surface. By using remote sensing techniques, areas on the earth's surface can be covered efficiently in a relatively short time, producing results that can be described in terms of accuracy [2].

Vegetation Index is an algorithm applied to satellite imagery to emphasize aspects of vegetation density and density-related aspects such as biomass, leaf area index (LAI), and chlorophyll concentration. In more practical terms, a vegetation index is a mathematical transformation that includes multiple channels simultaneously to generate new, more representative images when representing aspects related to vegetation [3]. The vegetation index is an index of the greenness of vegetation obtained by digital signal processing from brightness value data of multi-channel satellite sensor data [1]. Absorption and reflection of red light by chlorophyll near infrared light that passes through the mesophyll tissue found in leaves cause a large difference in the brightness value received by the satellite sensor in that channel. Areas without vegetation, such as water bodies, residential areas, open brownfields, and areas with degraded vegetation, do not have a high (minimum) ratio value. On the other hand, in areas with very dense vegetation, the ratio of the two channels is very high (maximum) under healthy conditions [4].

The Normalized Difference Vegetation Index (NDVI) method using Sentinel-2 satellite image data is very effective and useful for analyzing vegetation conditions, especially in urban areas [5]. NDVI measures the reflectance difference between red and infrared light in the measured area. Healthy, green-leaved plants will absorb more red light and reflect more infrared light, while land areas without vegetation will absorb less red light and reflect less infrared light [6]. In addition, Sentinel-2 satellite image data with the NDVI method can also be used for monitoring potential natural disasters, such as forest fires or floods [5]. In this case, vegetation index analysis can help in predicting the likelihood of natural disasters and taking preventive measures before it is too late. In conclusion, the use of Sentinel-2 satellite image data with the NDVI method is very helpful in analyzing the vegetation index in urban areas. In the context of sustainable urban development, vegetation index analysis can help in maintaining the balance between urban growth and the preservation of the environment and vegetation in the city. The imagery data produced by Sentinel-2 MSI is very useful for remote sensing applications, including vegetation monitoring, land use mapping, water

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quality monitoring, and so on. Level-2A is a processing level of Sentinel-2 MSI image data that has been processed and corrected radiometrically and atmospherically to produce higher-quality images. Level-2A data has been calibrated and corrected for factors such as illumination, atmosphere, and geometry, providing more accurate results that can be used for analysis and mapping [7].

Previously [8], had conducted an NDVI analysis using Landsat 8 imagery data which had a spatial resolution of 30 meters as a result of data processing. Previous studies certainly have differences with this study, where this research uses Sentinel-2 imagery data which has a spatial resolution of 10 meters which is certainly better than Landsat imagery. Kaimuddin, said that encroachment on forest areas is currently often found in areas directly adjacent to forest areas, due to the narrower land used for agricultural and plantation cultivation, the pressure on forest areas is increasing [9].

The continuous forest encroachment activity has affected the change in vegetation density in the protected forest area in South Lore District, Poso Regency, which has decreased. This is in line with what was explained by Arnanto, that if there is disturbance or damage to a group of vegetation, it will cause a change in the balance of the ecosystem where the vegetation is located [10]. Based on these conditions, it is necessary to conduct research on the Analysis of Changes in Vegetation Density in Protected Forest Areas of South Lore District, Poso Regency due to community activities around the forest, so that the latest information is obtained regarding changes in vegetation density.

2. METHODS

2.1 Time and Place

This research was conducted from July to November 2022. The research was carried out in the protected forest area of South Lore District, which is administratively included in the Poso Regency, Central Sulawesi Province. South Lore District is located at coordinates 1°45'05" – 2°03'41" South Latitude and 120°06'25" – 120°29'33" East Longitude with a total area of 32.172,47 Ha. This study uses MSI Sentinel-2 image data: Multi Spectral Instrument, Level-2A recorded in 2022.

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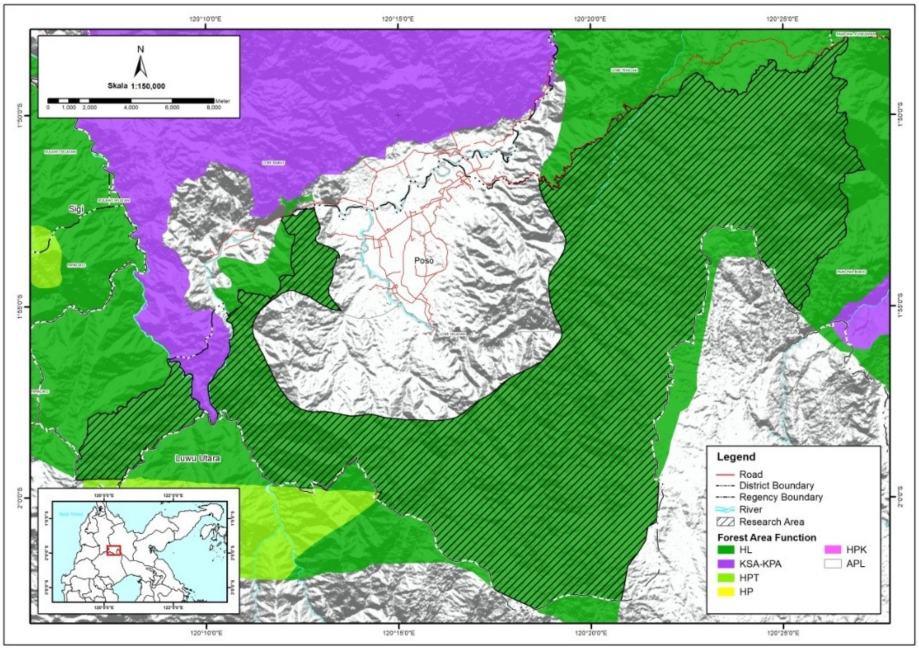

Figure 1. Map of Research Locations in the protected forest area of South Lore District

At this time remote sensing has been widely used to map resources. In this case, monitoring the vegetation index value using high spatial resolution with the image having the band needed in determining the vegetation index calculation algorithm [11]. The vegetation index itself is the greenness value of vegetation obtained from digital signal processing of data values for the brightness of several satellite sensor bands. Vegetation index information is needed to identify the level of vegetation density against forest damage in areas with large forests. Information on changes in vegetation density can be known from the information displayed by two or more satellite imagery data with certain differences in the recording years, namely satellite imagery data for the recording years of 1999, 2005, and 2010 [12].

In monitoring vegetation density, red bands, and nir bands are used [1]. In determining the vegetation index accurately, the Normalized Difference Vegetation Index (NDVI) method can be used to determine areas of forest vegetation and non-forest vegetation. Because by using this method, the high or low density of vegetation such as forests can be known [13].

2.2. Data Analysis

The results of the transformation of the vegetation index produced a vegetation density map which in this study was. In general, research is carried out in several

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stages, namely: image pre-processing, Normalized Difference Vegetation Index, classification class, ground checks, overlay and change in vegetation density.

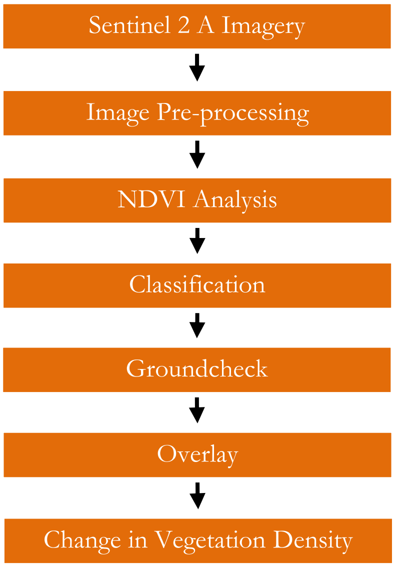

Figure 2. Workflow

1) Image pre-processing
Image pre-processing is the first step in processing satellite images. Several steps in image processing include data importing, composite bands, image sharpening, image cropping, and image coordinate transformation.

2) Normalized Difference Vegetation Index
The NDVI (Normalized Difference Vegetation Index) method is a remote sensing method for measuring the amount and quality of vegetation using satellite or aircraft image data that measures light in various spectra [14]. This method is based on the reflectance difference between the red and near-infrared spectra emitted by the Earth's surface [6]. The NDVI method calculates the difference between the reflectance of light in the red spectrum (which is produced by chlorophyll in plants) and the near-infrared (which is produced by plant cells that reflect light). This method uses a simple formula that has previously been used by researchers, previous researchers [5], [7], [14], [15], [16], [17]. In determining the vegetation index, the following equation can be used:

$$NDVI=\frac{Band\ NIR\ -Band\ Red}{Band\ NIR\ +Band\ Red} \tag{1}$$

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Information:
NDVI = Normalized Difference Vegetation Index
NIR = Spectral reflectance values in the near infrared band
Red = Spectral reflectance value in the red band

Sentinel 2A image data recorded in 2017 and 2022 obtained from the USGS were then analyzed using ArcGIS 10.8 software using a raster calculator using equation (1) to produce NDVI (Normalized Difference Vegetation Index) values.

3) Analysis and Clasiffication
Image classification is a process of arranging, or grouping all pixels (contained in the image band in question) into several classes based on a criterion or object category, thereby producing a "thematic map" in raster form. According [18], the classification of density levels is classified into five density classes to make it easier to see changes in vegetation density [18]. Then classified into five classes, namely non-vegetation, low vegetation, medium vegetation, high vegetation and very high vegetation. The classification of vegetation density is as shown in Table 1.

Table 1. Canopy Density Class based on Vegetation Index Value

NDVI Value	Class Density
$-1 \leq NDVI \leq 0.25$	Non Vegetation
$0.25 \leq NDVI \leq 0.35$	Low Vegetation
$0.35 \leq NDVI \leq 0.45$	Moderate Vegetation
$0.45 \leq NDVI \leq 0.50$	High Vegetation
$0.50 \leq NDVI \leq 1$	Very High Vegetation

4) Field Survey (Ground Check)
Field surveys were carried out to check and identify vegetation density levels, taking coordinate points, after carrying out image analysis in the ArcGIS 10.8 application.

5) Overlay
The implementation technique compares and overlays layer data for 2017 and 2022. From this technique a map of changes in vegetation density levels can be obtained.

6) Changes in Vegetation Density
Analysis of changes in vegetation density is by comparing the classification results of images at two separate times. This method can determine the type and extent of changes in density levels that occur. The result of this process is data on changes in vegetation density along with the area of each density class level.

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3. RESULTS AND DISCUSSION

3.1. NDVI Protected Forest Areas of South Lore District in 2017

The results of the transformation of the vegetation index produced a vegetation density map which in this study was divided into 5 vegetation density classes, namely non-vegetation, low vegetation density, medium vegetation density, dense vegetation density, and very dense vegetation density (Table 2). The results of image processing in 2017 using NDVI analysis in the protected forest area of South Lore District can be seen in Figure 3.

Table 2. Vegetation Density Level in 2017

Class Density	NDVI Value	Area (Ha)	percent	Information
Non Vegetation	-1 – 0.25	103.11	0.32	Water
Low Vegetation	0.25 – 0.35	256.79	0.80	Open Land, Bush
Moderate Vegetation	0.36 – 0.45	15,055.85	46.80	Shrubs
High Vegetation	0.46 – 0.50	15,322.24	47.66	Secondary Dryland Fores
Very High Vegetation	0.50 – 1	1,424.49	4.43	Primary Dryland Forest
Total		**32,172.47**	**100**	

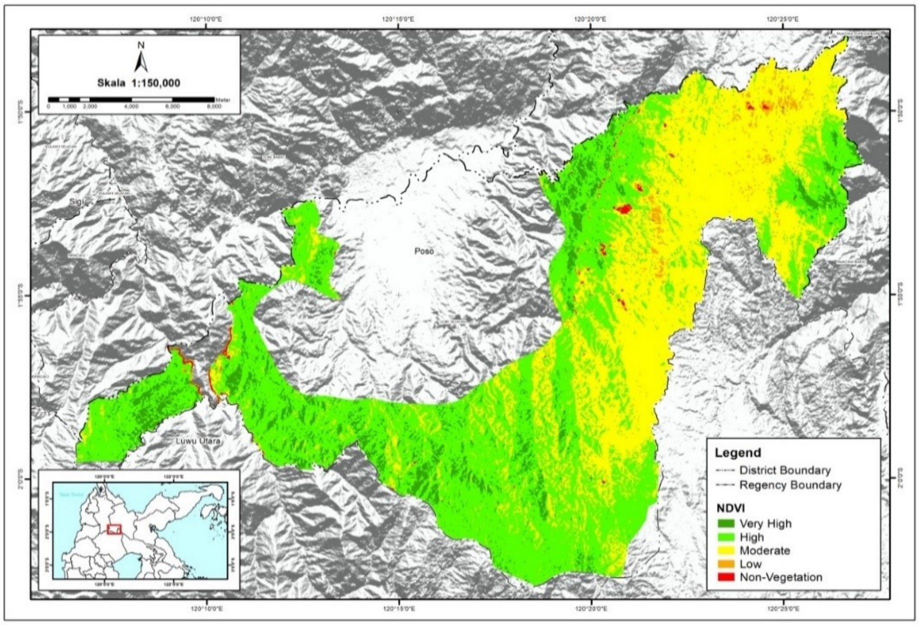

Figure 3. Vegetation Density Level in the Protected Forest Area of South Lore District in 2017

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From the table above it is known that the results of the classification on Sentinel 2A in 2017 show the percentage of vegetation density showing that 47.66% of the protected forest area of South Lore District is a densely vegetated area. Furthermore, 46.80% is dominated by medium vegetation, then followed by very dense vegetation density, which is equal to 4.43%, and sparse vegetation density of 0.80%. Meanwhile, non-vegetation density has a much lower percentage, which is equal to 0.32%. The high percentage of medium and dense vegetation density indicates that the condition of the forest in the protected forest area of South Lore District is still very well maintained.

3.2. NDVI Protected Forest Areas of South Lore District in 2022

The results of the transformation of the vegetation index produced a vegetation density map which in this study was divided into 5 vegetation density classes, namely non-vegetation, low vegetation density, medium vegetation density, dense vegetation density, and very dense vegetation density (Table 3). The results of image processing for 2022 using NDVI analysis in the protected forest area of South Lore District can be seen in Figure 4.

Table 3. Vegetation Density Level in 2022

Class Density	NDVI Value	Area (Ha)	percent	Information
Non Vegetation	-1 – 0.25	219.17	0.68	Water
Low Vegetation	0.25 – 0.35	1,751.36	5.44	Open Land, Bush
Moderate Vegetation	0.36 – 0.45	19,948.18	62.01	Shrubs
High Vegetation	0.46 – 0.50	8,671.08	26.95	Secondary Dryland Fores
Very High Vegetation	0.50 – 1	1,582.68	4.92	Promary Dryland Forest
Total		**32,172.47**	**100**	

From Table 3 it is known that the results of the classification on Sentinel 2A in 2022 show the percentage of vegetation density indicating that 62.01% of the protected forest area of South Lore District is a moderately vegetated area. Furthermore, 26.95% was dominated by dense vegetation, then followed by sparse vegetation density, which was 5.44%, and very dense vegetation density, 4.92%. Meanwhile, non-vegetation density has a much lower percentage, which is equal to 0.68%. The high percentage of medium and dense vegetation density indicates that the condition of the forest in the protected forest area of South Lore District is still very well maintained.

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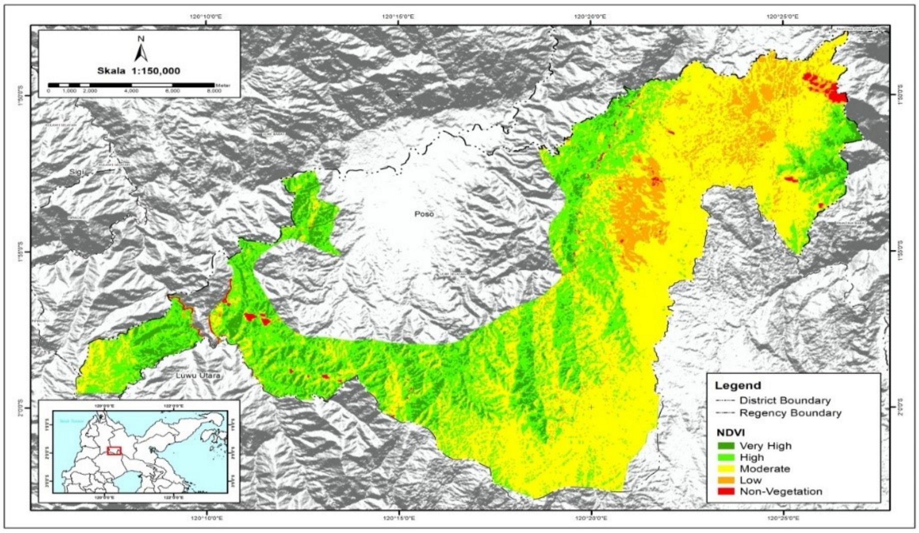

Figure 4. Vegetation Density Level in the Protected Forest Area of South Lore District in 2022

3.3. Changes in Vegetation Density Levels in 2017 and 2022

Changes in the area of Vegetation density in the Protected Forest Area of South Lore District were obtained by overlaying the 2017 and 2022 maps. Changes were obtained by comparing the results of the NDVI analysis on the 2017 and 2022 maps (Figure 5).

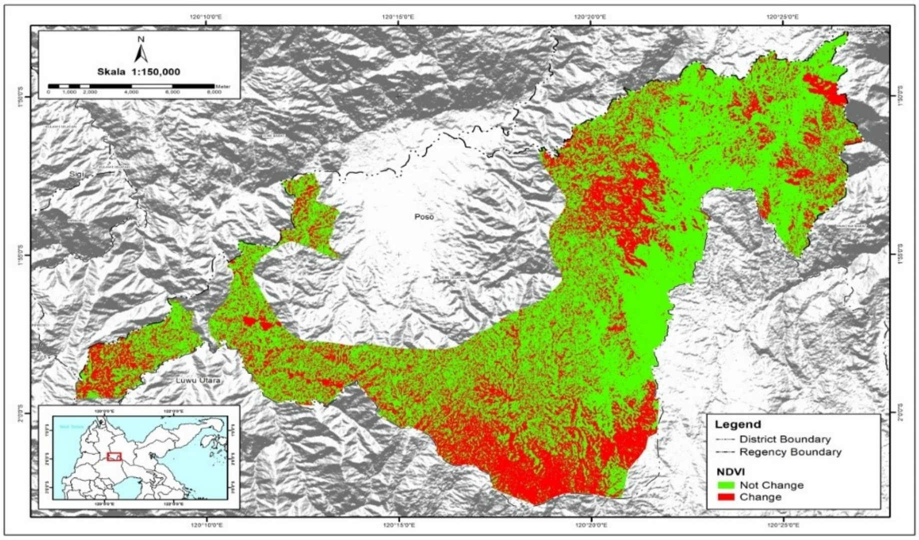

Figure 5. Map of Changes in Vegetation Density Levels

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Changes in the area of vegetation density, namely in the form of increasing and decreasing the area of vegetation density in accordance with the area of vegetation density. Changes in vegetation density in the Protected Forest Area of South Lore District can be seen in Table 4.

Table 4. Changes in Vegetation Density in the Protected Forest Area of South Lore District

Class Density	2017		2022		Change
	Area (Ha)	percent	Area (Ha)	percent	
Non Vegetation	103.11	0.32	219.17	0.68	116.06
Low Vegetation	256.79	0.80	1,751.36	5.44	1,494.57
Moderate Vegetation	15,055.85	46.80	19,948.18	62.01	4,892.33
High Vegetation	15,322.24	47.66	8,671.08	26.95	*6,651.16
Very High Vegetation	1,424.49	4.43	1,582.68	4.92	158.19
Total	**32,172.47**	**100**	**32,172.47**	**100**	

Description (*) : Has decreased

From Table 4 it can be seen that there has been a change in vegetation density in 2017 and 2022. The area of vegetation density in the Protected Forest Area of South Lore District in 2017 with the highest area in the dense vegetation density class with an area of 15,322.24 Ha or around 47.66%. In 2022 the area of vegetation density in the dense class will decrease to 8,671.08 Ha with a decrease in the area of vegetation density to 6,651.16 Ha or around 20.67% of the total area. Meanwhile, the vegetation density class rarely experiences an increase in area in 2022, namely 1,494.57 Ha or 4.64%, and the vegetation density class is quite dense in 2022, namely 4,892.33 Ha or 15.21%. The data was obtained from the difference in the area of sparse and quite dense vegetation in 2022, namely rare 256.79 Ha and quite dense 15,055.85 Ha in 2017, namely rare 1,751.36 Ha and quite dense 19,948.18 Ha. In addition, the very dense vegetation density class also experienced an area increase of 158.19 Ha or 0.49%. Changes in vegetation density occur due to land use experts where vegetated land is used for plantations which causes reduced land for vegetation and reduced area for water absorption in the Protected Forest Area of South Lore District. From the data it can be seen that the rare class and quite dense class experienced an increase in area in 2022. Meanwhile, the meeting class in 2017 experienced a decrease in area in 2022.

The results of ground check also confirm that changes in vegetation density are affected by changes in land use where there are many changes in land use that affect vegetation density. According to Dwi Yanti, et al the NDVI method has succeeded in displaying various vegetation indicators in many studies regarding land degradation and deforestation [19]. The Protected Forest Area of South Lore

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District itself is an area in the south of Poso Regency where changes in land use can occur quickly and are dynamic. Land use from the results of field checks occurs where open land and vegetated land are used to build settlements and other conversion functions. The people who live around the Protected Forest Area of South Lore District still depend on nature for their livelihood, namely farmers. This situation affects the density of vegetation in the Protected Forest Area of South Lore District which depends on land use and utilization. The vegetation index value is affected by the greenish color of the recording which is obtained from the greenness value emitted from the component recorded by the image, this is in accordance with the statement of Sudiana and Diasmara, that the vegetation index is the greenness value of the vegetation obtained from processing digital signal data values. brightness from multiple channels of satellite sensor data [20].

4. CONCLUSION

Based on the results of the research that has been done, it can be concluded that the value of Vegetation Density (NDVI) in the Protected Forest Area of South Lore District is in the range of -0.92960 to 0.871725. The largest vegetation density class in the Protected Forest Area of South Lore District in 2017 occurred in the dense class with an area of 15,322.24 Ha or around 47.66%, while the smallest was in the non-vegetation class which was 103.11 Ha or 0.32%. while the largest vegetation density class is in the Protected Forest Area of South Lore District in 2022, namely in the moderate/quite dense class with an area of 19,948.18 Ha or 62.01% and the smallest in the non-vegetation class of 219.17 Ha or 0.68%. The largest increase in area was in the Protected Forest Area of South Lore District in the medium/quite dense class of 4,892.33 Ha or 15.20% while the largest decrease in area was in the dense class with an area of 6,651.16 Ha or 20.67% of the total area.

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