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Spatial Analysis of Land Cover Changes in the Tepo Asa Aroa KPH Working Area

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Abstract: **The aim of this research based on the formulation of the research problem is to determine the rate of deforestation, the level of land cover change in Lembo District and Petasia Timur District in the work area of KPH Tepo Asa Aroa during the period 2013 - 2022 through spatial analysis. Forests are natural assets that provide important benefits for life both ecologically and economically. However, if not managed properly, forest use can cause damage, one of which is through deforestation, namely the conversion of forests to other uses with canopy cover below 10 percent. Deforestation can be caused by natural factors such as climate change or disasters, as well as human factors such as logging activities and land conversion for agriculture or development. In Indonesia, deforestation continued to increase from 2009-2015, with its peak occurring in 2014-2015. Many human activities cause deforestation, such as illegal logging, plantations and mining. One effort to overcome deforestation is through the formation of Forest Management Units (KPH), which aims to manage forest areas sustainably. However, in the Tepo Asa Aroa KPH area, changes in forest function have occurred due to land conversion by the community, which was triggered by an increase in population and increasing demand for land. Land cover changes that occurred in KPH Tepo Asa Aroa (KPHP Unit agriculture (Pk, Pc and Pt (plantations, mixed dry land farming and dry land farming)) covering an area of 5,526.90 ha; open land/open land and mining (T and Tm) covering an area of 1,441.17 ha; bushes (B) covering an area of 4,393.59 ha; and cloud/non data (Aw) covering an area of 4,298.65 ha. The factors that dominate the rate of deforestation at the research location are changes in land cover that was originally forested into agricultural land/community plantations, as well as community land that has not been cultivated so that it becomes bushes and the clearing of mining land.**

Keywords: **deforestation, spatial analysis, climate change, forest.**

I. INTRODUCTION

Forests are a natural resource that provides many benefits for living creatures, both ecologically and economically. However, if forest utilization is not done properly, it can cause forest damage. One of the causes of forest destruction is deforestation. Deforestation according to[1]is the conversion of forests to other uses with canopy cover below 10 percent.

Deforestation occurs due to two factors, namely natural factors in the form of climate change or disasters and human activity/disturbing factors (anthropogenic). Deforestation occurs due to natural events, including extreme weather events, droughts and forest fires. Human activity is one of the main causes of deforestation and can be directly related to the actors or perpetrators [2]. However, the causes of deforestation by human activities are not solely based on a single agent/actor but rather there tends to be a link between actors and an underlying cause [2], [3]. Deforestation that occurs as a result of human activities is caused by an increase in population which causes many changes in the function of forest areas.

According toSolomon[4]in the 2018 environmental and forestry statistics book, it was stated that deforestation continued to increase from 2009-2015. The highest total deforestation in Indonesia occurred in 2014-2015 at 1.09 million hectares

and the largest deforestation occurred in forest areas, namely 815.6 thousand hectares or 74.7 percent. In the 2018 Ministry of Environment and Forestry statistical data, it is also stated that activities that cause deforestation are permits for the utilization and use of forest areas, including planting activities, plantations, land clearing, mining operations, and so on.

One of the efforts made to overcome deforestation is to form Forest Management Units (KPH) as forest area management institutions at the site level.F.A.Odefines a Forest Management Unit as an area whose land cover is dominated by forest and has clear boundaries, and is managed to meet a series of objectives explicitly defined in accordance with a long-term forest management plan[1].

Conditions occurring in the forest area in the Tepo Asa Aroa Forest Management Unit (KPH) area have experienced changes in forest function due to land use. Community activities in converting forest areas are one of the factors causing deforestation. One of these factors occurs due to an increase in population so that the need for land also increases(RPHJP KPH Tepo Asa Aroa, 2018).

Sumitro and Astika in their book argue that the fundamental factor that causes forest looting is the poverty of the people around the forest area[5], [6]. Apart from that, the cause of forest looting is the increase in population in the working age group but this is not balanced by providing employment opportunities. This causes an increase in illegal logging activities for the reason of meeting their subsistence needs[7]. This condition can encourage the conversion of forests into agricultural land and settlements.

Explanation of deforestation and the role of the Sivia Patuju forest management unit (KPH) in overcoming it. Based on the results of research on deforestation rates at KPH Sivia Patuju, it shows that the highest deforestation occurred in the 2017-2019 period. In the 2009-2011 period there was deforestation covering an area of 896.09 ha with a deforestation rate of 448.05 ha/year (0.52% per year). In the 2011-2013 period, deforestation occurred on an area of 1,558.88 ha with a deforestation rate of 779.44 ha/year (0.91% per year). In the 2013-2015 period, deforestation occurred on an area of 618.27 ha with a deforestation rate of 309.14 ha/year (0.25% per year). In the 2015-2017 period, deforestation occurred on an area of 425.11 ha with a deforestation rate of 212.56 ha/year (0.25% per year). And the 2017 - 2019 period had the largest deforestation rate, namely 1,689.44 ha with a deforestation rate of 844.72 ha/year (1.02% per year).[8]

Spatial model of deforestation for the period 2000-2013 in KPHP Poigar, North Sulawesi. He stated in his research that the area that was still covered by forest from 2000 to 2007 at KPHP Poigar had changed to plantation cover (25%), bushes (6%) and open land (1%). The biggest changes occurred in the conversion of forests into plantations and bushes, namely 5,878.72 hectares and 1,778.26 hectares respectively. The second period in the deforestation analysis in this study, namely the 2007 and 2013 periods, showed a decrease in the area deforested, namely 11 percent (4,735.19 ha) so that the total decrease in forest cover area up to the 2013 period was 12,668.2 hectares. The decrease in the area of deforestation was caused by the decreasing area of forest because it had been lost in the previous period and forest locations that were difficult to reach due to topography and unavailability of roads. Cover in the form of bushes and open ground occurs in areas where land clearing has been carried out but has not been cultivated by the community and can also be in the form of wood collection places[3].

Dariono (2018),spatial analysis of deforestation and degradation in the Kerumutan wildlife reserve, Riau Province. Presenting an analysis of deforestation in SM Keumutan shows that in the period 1996 to 2006 there was deforestation of 1,746.66 ha with a deforestation rate of 174.67 ha/year (0.195% per year). In the 2006 - 2016 period, there was deforestation of 1,133.07 ha with a deforestation rate of 113.41 ha/year (0.12% per year), so that for 20 years the SM Kerumutan forest area experienced deforestation of 2,879.73 ha with a deforestation rate of 143.99 ha/year or 0.15% per year. The rate of forest degradation over the last 20 years was 15,604.92 ha with an annual rate of 0.83% per year. Deforestation and forest degradation in SM Kerumutan are influenced by six driving factors such as population density, forest distance from roads, forest distance from rivers, forest distance from settlements, forest distance from agricultural land and forest distance from industrial plantation forests.

Analysis of deforestation rates in the BAH Bolon watershed based on geographic information systems. Land use in the 2015-2017 period in the Land Use Area was as large as land use occurring in Water Bodies was 895.94 ha (2.71%), Protected Forest was 7,383.73 ha (22.31%), in Production Forest amounting to 21908.1 ha (66.2%), and in Limited Production Forests amounting to 2901,206 ha (8.76%) the total land area used in the 2011-2013 period was 33,088.97 ha, Land Use in the period 2013-2015 is the same as the 2011-2013 period. Calculating the rate of deforestation that occurred in the Bah Bolon watershed, it can be concluded that the highest deforestation occurred in the 2011-2013 period amounting to 1130.47 ha and the lowest in the 2009-2011 period amounting to 67.59 ha. From the period from 2009-2017 where the largest rate of

deforestation occurred in 2011-2013 amounting to 1,130.47 ha and in Production Forests the greatest damage occurred every year in Production Forests amounting to 1,014.00 ha in a period of 4 years[9].

Utilization of remote sensing data in the form of multi-temporal satellite imagery can help in analyzing deforestation. Spatial modeling of deforestation using logistic regression needs to pay attention to the factors causing deforestation which are variables in a spatial model, namely the proximate causes and underlying causes.(Eckert et al, 2015).Logistic regression is used to assess the level of influence of explanatory variables on forest change and to see the opportunity for deforestation to occur (Kumar et al, 2014). Analysis of deforestation caused by human activities (anthropogenic) is influenced by variables from nearby factors including the distance of the forest from the road (accessibility), the distance from houses and residential centers, transportation infrastructure in the form of roads and river networks and the biophysical characteristics of the land including the level of soil fertility, topography, availability of water sources and vegetation conditions[3], [10].

This problem can be one of the causes of deforestation. The impacts caused by deforestation cause a decline in forest function, loss of biodiversity and destruction of the natural habitat of endemic flora and fauna. Considering the large impact caused by deforestation. This study is aimed at providing spatial data to determine the rate of deforestation in the Tepo Asa Aroa KPH (Forest Management Unit) area.

II. RESEARCH METHODS

Analysis Method

Image Pre Processing

Image pre-processing stages are carried out before further analysis. In general, the image pre-processing stages in this research include radiometric correction, image composite, image mosaic, and image cutting.

Radiometric correction is carried out to correct errors in the image caused by internal sensor errors or atmospheric disturbances as the main source of error. In this research, radiometric correction was carried out on land cover classification by converting the digital number (DN) value into a spectral radiance (Lλ) value.[11].

Making a composite image is carried out by merging some of the bands in the sentinel 2 image according to research needs. The band composition used in this analysis is as presented in Table 1.

Table 1. Image Band Combinations

Image Type	Path/Row	Land Classification (Band B, R, G and NIR)
Sentinels 2a	113/062	Bands 2, 3 and 4
Landsat 8	113/062	Bands 3, 4 and 5

Next, the Landsat image was cut according to the boundaries of the research area (study area), using vector data from the administrative boundaries of Lembo District and East Petasia District, North Morowali Regency.

Land Cover Classification

At the image classification process stage, a land cover classification will be produced. The classification used in this research is a guided classification using a training area.

a. Training area

The training area is a training area in the form of a set of pixels created to represent each land cover class. Sampling of land cover classes is based on visual observations and field surveys as a reference for determining classes. The land cover classes that will be determined are Forest, Agriculture (Paddy Fields, Fields, Plantations), open land, built-up land and water bodies.

b. Classification process

Classification was carried out on the results of the sampling training area using the Maximum Likelihood Classifier method. This method considers the spectral similarity to the dominant spectral maximum of an object which will be included in one class and if the spectral value is far from the maximum it will be included in another class.

This classification will obtain land cover classes for 2013 - 2022 as well as the percentage of land cover for each class. Overlay analysis is used to determine changes in land cover.

c. Testing Image Classification Results

The results of the image classification are tested for accuracy to assess how much conformity the classification results have with actual conditions in the field.

Sample selection used a stratified random sampling method so that each land cover class could be represented. The number of sample points will be adjusted to the area of each land cover.

Accuracy testing of land classification results is carried out by calculating overall accuracy and kappa accuracy based on the classification error matrix. The equation for calculating overall accuracy is as follows:

$$\text{Overall Accuracy} = \frac{\Sigma_{i=1}^{r} X_{ii}}{N} \; x \; 100\ \%$$

Meanwhile, the kappa accuracy equation is written as follows:

$$K = \frac{N\Sigma_{i=1}^{r} X_{ii} - \Sigma_{i=1}^{r} (X_{i+}.X_{+i})}{N^2 - \Sigma_{i=1}^{r} (X_{i+}.X_{+i})}$$

Information:

K = Kappa value

Xii =The number of i-th land cover types resulting from the interpretation that corresponds to the land use results from the verification

Xi+ =Number of verification results points for the i-th land cover type

X+i =Number of interpreted points for the i-th type of land cover

N =Number of sample points

r =Number of land cover classes

If the accuracy test results are in accordance with the confidence standard of ≥80%, the research is declared complete, but if the confidence level is <80%, one field test is carried out followed by rules and systems. If the results of the system redesign have not yet produced a value of ≥80%, the research is declared complete by entering the final value into the classification of land objects of medium capacity.[12].

Creating an error matrix will be carried out to determine overall accuracy and kappa accuracy (usually referred to as error matrix, confusion matrix or contingency table) as follows:

Table 2. Classification error matrix

Land Cover Class		Reference					
		P1+	P1+	P1+	….	Pr+	Amount
Classification Results	P1+	Xii					X+i
	P1+		Xii				X+i
	P1+			Xii			X+i
	….				Xii		X+i
	Pr+					Xii	X+i
Column Totals		Xi+	Xi+	Xi+	Xi+	Xi+	N

Information : Correct classification (commission)
: Incorrect classification

Deforestation Rate Analysis

To determine the level of land cover change from year to year after the KPH was formed by conducting an overlay land cover analysis starting from 2013 - 2022 (Dariono, 2018). The formula used to determine the rate of deforestation is as follows:

$$r = \frac{A_1 - A_2}{t_2 - t_1}$$

Note: r = deforestation rate (ha/year); t2 = year at end time; t1 = year at initial time; A2 = forest area at final time; A1 = forest area at initial time.

Meanwhile, for the percentage of annual deforestation rate, use the formula:

$$r = \frac{A_1 - A_2/t_2 - t_1}{A_1} \; x \; 100\%$$

Note: V = deforestation rate (%/year); A1 = first year forest area; A2 = second year forest area; t2 = year at final time; t1 = year at initial time.

III. RESULT AND DISCUSSION

2013 Landsat 8 Imagery

In this research, deforestation analysis first carried out land cover analysis at the research location in the working area of KPH Tepo Asa Aroa in three time periods, namely 2013, 2018 and 2022 using Landsat 8 ETM imagery and sentinel 2A imagery. The research was conducted in two sub-districts, namely Lembo Sub-district and Petasia Timur Sub-district using composite band 543. The method used was supervised classification in which pixel classification and identification were carried out through a training area. The classification results in the form of a land cover classification table using 2013 Landsat 8 imagery can be seen in table 3 below.

Table 3. Results of Supervised Classification of Land Cover 2013

No.	Land Cover	Symbol	Area (Ha)	Percentage (%)
1	Cloud	Wow	2,925.04	7.67
2	Forest	H	31,238.42	81.91
3	Agriculture	Pt, Pc, Pk	2,289.50	6.25
4	Shrubs	B	359.47	0.94
5	Open land/open land	Q	1,233.78	3.23
	Amount		**38,136.21**	**100**

Source: Results of processed Landsat 8 imagery in 2013

In the results of land cover classification with an area of 38,136.21 ha, the most dominated by forest (H) = primary dry land forest (Hp) and secondary dry land forest (Hs)) covering an area of 31,238.42 or 81.91%, followed by agriculture with an area of 2,289 .50 ha or 6.25% (dry land farming (Pt); mixed dry land farming (Pc) and plantations (Pk)), while open land/open land (T) is 1,233.78 ha or 3.23% (open land or open land in the form of moorland) and shrubs (B) covering an area of 359.47 ha or 0.94%, while the results that cannot be identified due to cloud cover (Aw) are 2,925.04 ha or 7.67%.

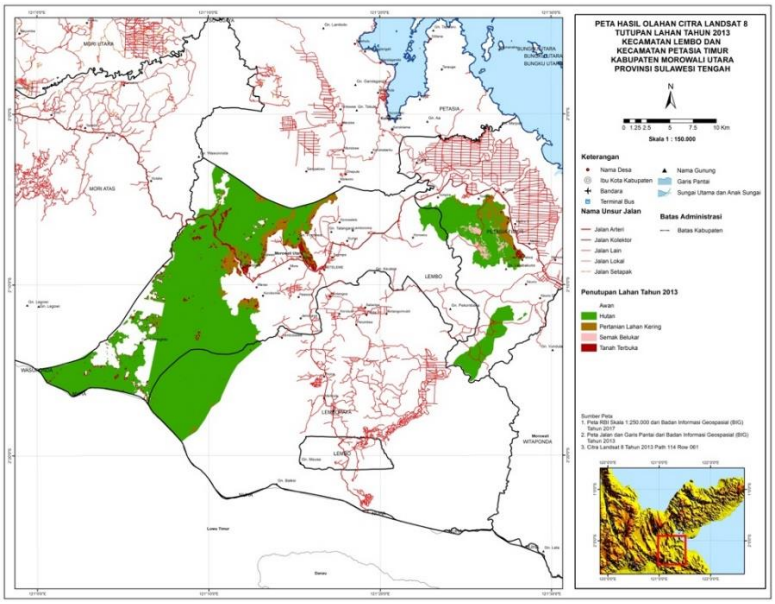

Figure 1. 2013 Landsat 8 ETM Image Classification Results

2018 Sentinel 2A Imagery

The 2A sentinel image classification was carried out to determine the type of land cover in two sub-districts, namely Lembo Sub-district and Petasia Timur Sub-district, North Morowali Regency in the working area of KPH Tepo Asa Aroa using composite band 432. The method used is supervised classification which is carried out classification and identification of pixels through training areas. The classification results in the form of a land cover classification table using 2018 sentinel 2A imagery can be seen in table 4 below.

Table 4. Results of Supervised Classification of Land Cover 2018

No.	Land Cover	Symbol	Area (Ha)	Percentage (%)
1	Cloud	Wow	3,155.87	8.27
2	Forest	H	26,537.18	69.58
3	Agriculture	Pt, Pc, Pk	5,788.94	15,18
4	Shrubs	B	1,092.64	2.86
5	Open land/open land	Q	1,561.58	4.11
	Amount		**38,136.21**	**100**

Source: Processed image of sentinel 2A

In the results of land cover classification with an area of 38,136.21 ha, the most dominated by forest (H) = primary dry land forest (Hp) and secondary dry land forest (Hs) covering an area of 26,537.18 or 69.58%, followed by agriculture with an area of 5,788, 94 ha or 15.18% (dry land farming (Pt); mixed dry land farming (Pc) and plantations (Pk)), while open land/open land (T) is 1,561.58 ha or 4.11% (land open or open land in the form of moorland) and bushes (B) covering an area of 1,092.64 ha or 2.86%, while results that cannot be identified due to cloud cover (Aw) are 3,155.87 ha or 8.27%.

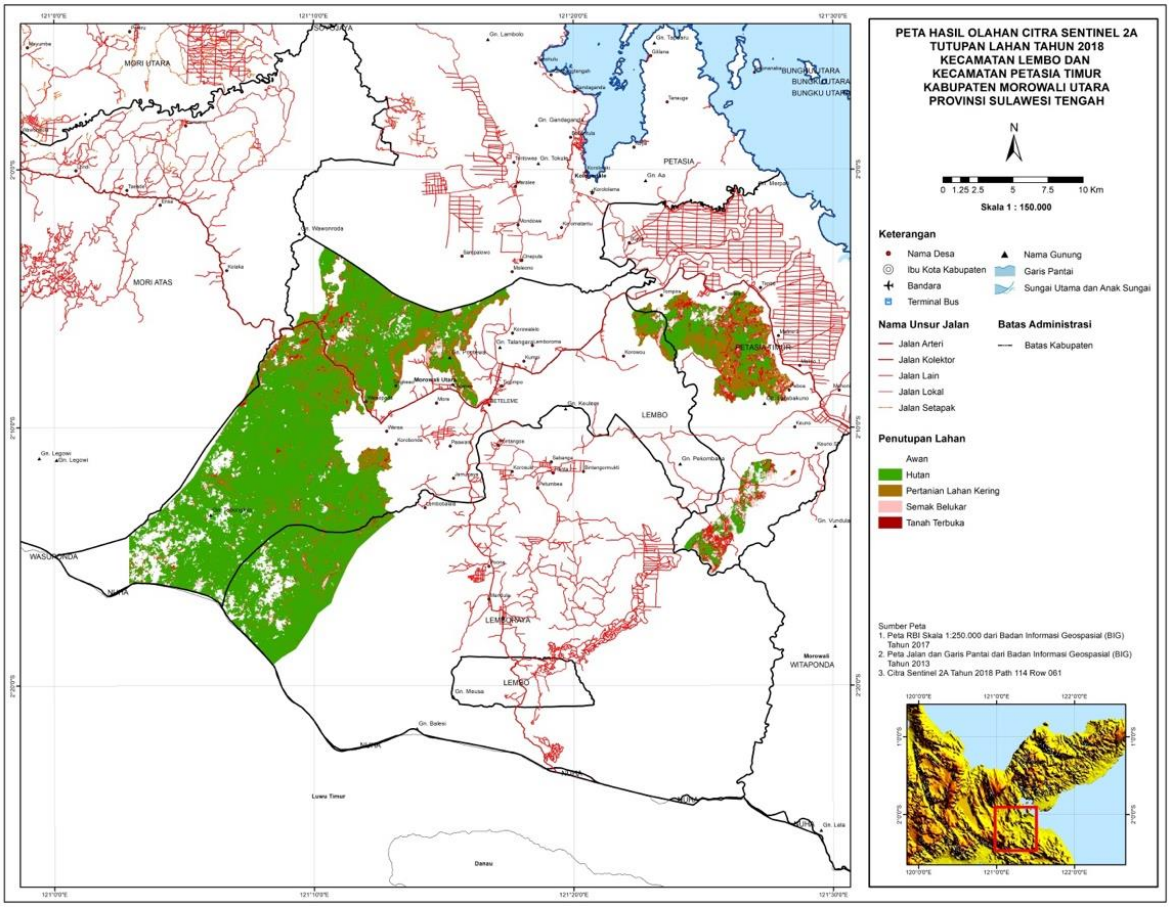

Figure 2. 2018 Sentinel 2A Image Classification Results

2022 Sentinel 2A Imagery

The 2A sentinel image classification was carried out to determine the type of land cover in two sub-districts, namely Lembo Sub-district and Petasia Timur Sub-district, North Morowali Regency in the working area of KPH Tepo Asa Aroa using composite band 432. The method used is supervised classification which is carried out classification and identification of pixels through training areas. The classification results in the form of a land cover classification table using sentinel 2A imagery for 2022 can be seen in table 5 below.

Table 5. Results of Supervised Classification of Land Cover 2022

No.	Land Cover	Symbol	Area (Ha)	Percentage (%)
1	Cloud	Wow	4,298.65	11.27
2	Forest	H	22,475.91	58.94
3	Agriculture	Pt, Pc, Pk	5,526.90	14.49
4	Shrubs	B	4,393.59	11.52
5	Open land/open land and mining	T, Tm	1,441.17	3.78
	Amount		**38,136.21**	**100**

Source: Processed image of sentinel 2A

In the results of land cover classification with an area of 38,136.21 ha, the most dominated by forest (H) = primary dry land forest (Hp) and secondary dry land forest (Hs) covering an area of 22,475.91 or 58.94%, followed by agriculture with an area of 5,526, 90 ha or 14.49% (dry land farming (Pt); mixed dry land farming (Pc) and plantations (Pk)), while open land/open land (T) is 1,441.17 ha or 3.78% (land open or open land in the form of moorland) and bushes (B) covering an area of 4,393.59 ha or 11.52%, while results that cannot be identified due to cloud cover (Aw) cover an area of 4,298.65 ha or 11.27%.

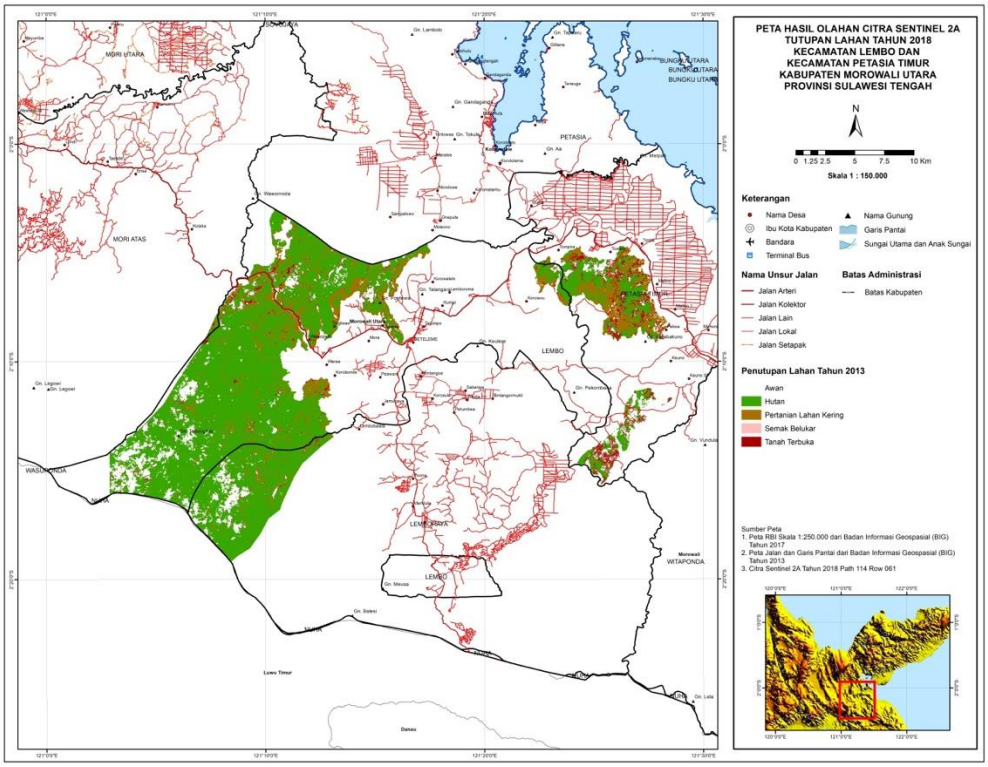

Figure 3. 2022 Sentinel 2A Image Classification Results

Accuracy Test

The accuracy test aims to test the level of accuracy in image processing, in this case also using the confusion matrix testing method to determine the accuracy of data processing and become a reference in checking or ground checking so that the

calculations are carried out manually, by matching the classification results with conditions in the field and matrix calculations are carried out to find out how accurate the reference data in the field is with the image interpretation results.

According to Jaya in Wahyuni [13], [14]Using a map producer (producer's accuracy) is obtained from dividing correctly classified pixels by the total number of pixels in the training area per class, in producer's accuracy errors will occur in the form of omissions which are called (omission errors). On the other hand, the user side of the map (user's accuracy) is obtained from dividing each correctly classified pixel by the total number of pixels classified in that class. In user's accuracy, an addition error (commission) will occur which is called a commission error.

The number of pixels that represent 1 coordinate sample is 4 pixels (Jaya, 2014). The results of the accuracy test using a confusion matrix or error matrix of land cover results using Landsat 8 imagery and Sentinel 2A imagery using three different recordings, namely 2013, 2018 and 2022. The location of this research is in two different sub-districts, namely Petasia Timur and The district Lembo is located in is presented in table 6 as follows.

Table 6. Classification Error Matrix

Classification Results	Field Survey Data					Total	OA (%)
	H	B	T, Tm	Wow	Pt, Pc, Pk		
H	28	4	0	0	0	**32**	
B	0	12	0	0	0	**12**	
T, Tm	0	0	58	4	2	**64**	**90.00**
Wow	0	0	0	0	0	**0**	
Pt, Pc, Pk	0	6	0	0	46	**52**	
Total	**28**	**22**	**58**	**4**	**48**	**160**	
K (%)	**85.96**						

Description: H (Forest); B (Bush); T and Tm (open land/open land and mining); Aw (Cloud); P (Agriculture, Plantation and Mixed Land Farming); OA (overall accuracy); K (kappa accuracy or kappa accuracy).

Based on the results of the error matrix calculation (confusion matrix), the overall accuracy level obtained was 90.00%, which was the result of image processing based on accuracy calculations and was declared good, and was in two, namely Lembo District and Petasia Timur District, Regency. North Morowali from 40 sampling points in the field. According to Witoko[15]Overall accuracy is calculated by the sum of the diagonals divided by the total observation points. The calculation results based on the kappa accuracy value were obtained at 0.8596 or 95.96%. Based on the results of kappa accuracy, the results obtained were 85.96%, meaning that the land cover classification results were declared feasible and good. This is in accordance with Afandi's statement[3]if an acceptable classification process result is a classification process that has a kappa accuracy value of more than or equal to 85%.

Deforestation Rate Analysis

Deforestation analysis is carried out by looking at changes in land cover. To see changes in land cover, land cover classes are then classified into forest and non-forest. There are five classes in the research location, namely, forest (H); agriculture (Pk, Pt and Pc); bush (B); open ground/open land (T and Tm) and clouds (Aw). The results of the analysis regarding the rate of deforestation of land cover in Lembo District and Petasia Timur District can be seen in more detail in table 7 as follows.

Table 7. Land Cover Deforestation Rates from 2013, 2018 and 2022

Land Cover 2013	Land Cover 2018	Land Cover 2022	Wide (Ha)
Forest	Cloud	Cloud	877.21
		Forest	1,174.43
		Agriculture	134.77
		Open land/open land	160.03
		Shrubs	81.32
	Forest	Cloud	1,979.26
		Forest	14,931.54
		Agriculture	1,682.87

		Open land/open land	411.74
		Shrubs	2,547.45
	Agriculture	Cloud	195.08
		Forest	1,451.17
		Agriculture	1,239.53
		Open land/open land	168.33
		Shrubs	910.63
	Open land/open land	Cloud	180.51
		Forest	309.43
		Agriculture	392.21
		Open land/open land	191.66
		Shrubs	112.51
Forest	Shrubs	Cloud	151.02
		Forest	182.68
		Agriculture	287.83
		Open land/open land	129.96
		Shrubs	109.64
Agriculture	Cloud	Cloud	1.92
		Forest	2.92
		Agriculture	4.29
		Open land/open land	5.38
		Shrubs	0.87
	Forest	Cloud	54.89
		Forest	417.37
		Agriculture	322.01
		Open land/open land	61.94
		Shrubs	117.31
	Agriculture	Cloud	18.04
		Forest	130.25
		Agriculture	692.48
		Open land/open land	60.92
		Shrubs	181.75
	Shrubs	Cloud	3.66
		Forest	1.77
		Agriculture	50.24
		Open land/open land	9.97
		Shrubs	11.73
	Open land/open land	Cloud	9.95
		Forest	6.07
		Agriculture	61.20
		Open land/open land	41.56
		Shrubs	7.98
Open land/open land and mines	Cloud	Cloud	28.39
		Forest	32.12
		Agriculture	8.52
		Open land/open land	7.27
		Shrubs	3.53
	Forest	Cloud	51.63
		Forest	320.61
		Agriculture	50.29
Open land/open land and mines	Forest	Open land/open land	8.78
		Shrubs	47.44
	Agriculture	Cloud	7.79

		Forest	60.43
		Agriculture	237.32
		Open land/open land	24.01
		Shrubs	60.02
	Open land/open land	Cloud	6.16
		Forest	19.60
		Agriculture	67.44
		Open land/open land	56.34
		Shrubs	9.25
	Shrubs	Cloud	3.92
		Forest	8.42
		Agriculture	52.83
		Open land/open land	10.15
		Shrubs	17.65
Shrubs	Cloud	Cloud	2.14
		Forest	0.84
		Agriculture	0.13
		Open land/open land	0.34
		Shrubs	0.04
	Forest	Cloud	26.51
		Forest	29.06
		Agriculture	7.21
		Open land/open land	17.71
		Shrubs	5.26
	Agriculture	Cloud	10.50
		Forest	65.43
		Agriculture	110.43
		Open land/open land	7.39
		Shrubs	29.23
	Open land/open land	Cloud	4.67
		Forest	3.01
		Agriculture	15.84
		Open land/open land	4.88
		Shrubs	2.56
Shrubs	Shrubs	Cloud	0.74
		Forest	0.26
		Agriculture	12.75
		Open land/open land	0.43
		Shrubs	1.53
Cloud (non data)	Forest	Cloud	479.88
		Forest	1,458.88
		Agriculture	39.93
		Open land/open land	33.45
		Shrubs	81.67
	Agriculture	Cloud	19.76
		Forest	55.15
		Agriculture	12.42
		Open land/open land	4.70
		Shrubs	11.16
	Open ground	Cloud	8.45
		Forest	25.11
		Agriculture	5.28
		Open land/open land	10.06

		Shrubs	3.75
	Shrubs	Cloud	11.32
		Forest	20.58
		Agriculture	3.93
		Open land/open land	1.84
		Shrubs	4.05
	Cloud	Cloud	159.20
		Forest	420.71
		Agriculture	12.64
		Open land/open land	7.01
		Shrubs	25.33

Based on the results of the analysis of the rate of deforestation, changes in land cover in the period 2013, 2018 and 2022 at the research location in the working area of KPH Tepo Asa Aroa show a decrease in land cover. Forests included in primary dry land forest and secondary dry land forest (H) cover an area of 22,475.91 ha; agriculture (Pk, Pc and Pt (plantations, mixed dry land farming and dry land farming)) covering an area of 5,526.90 ha; open land/open land and mining (T and Tm) covering an area of 1,441.17 ha; bushes (B) covering an area of 4,393.59 ha; and cloud/non data (Aw) covering an area of 4,298.65 ha. This change occurred as a result of the increasing needs of local communities and increasing land clearing.

In several studies, the rate of deforestation is one of them being the increase in population. Indonesia is a developing country with extensive forests, deforestation will continue to occur along with economic growth and population growth[16].

In line with Nahib's statement that increasing population has consequences for economic development which requires land for settlements, industry, infrastructure and services, so that it will have an impact on the rate of deforestation[17].

The diagram of land cover changes from 2013 to 2018 using Idrisi Selva can be seen in greater detail in the diagram in Figure 4 as follows.

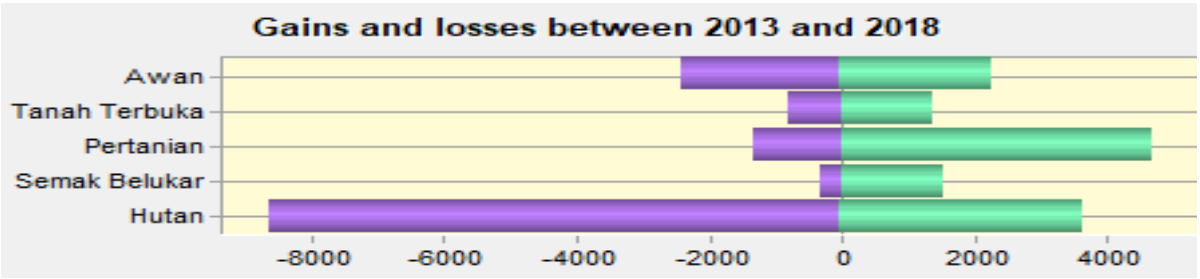

Figure 4. Diagram of land cover changes from 2013 to 2018

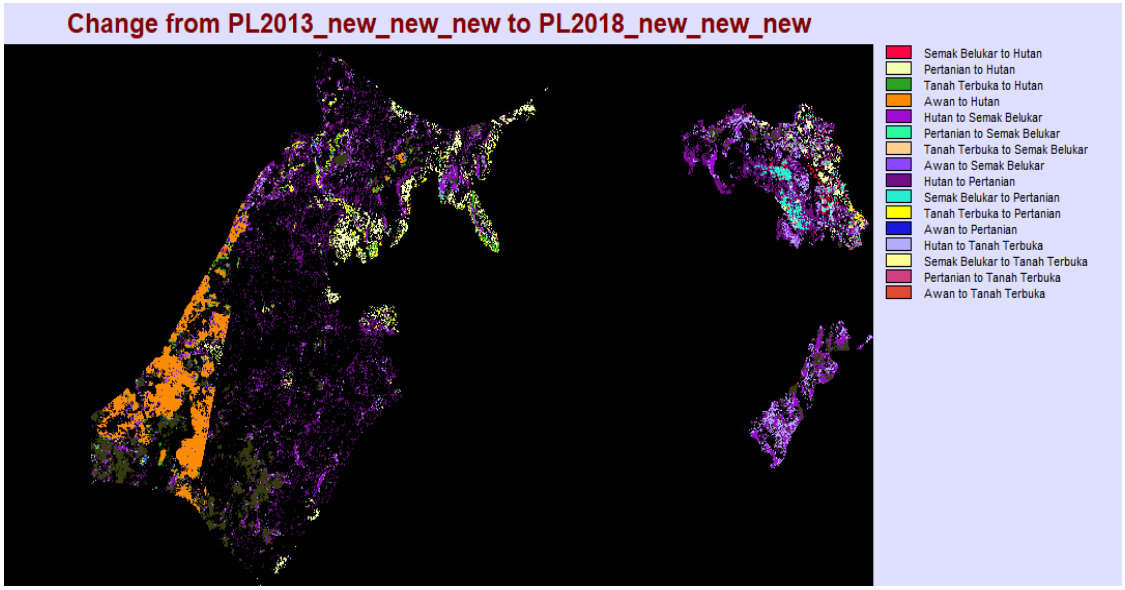

Figure 5. Rate of Land Cover Change from 2013 to 2018

In accordance with the image processing results in 2013 - 2018 there were changes due to deforestation in the work area of KPH Tepo Asa Aroa which was dominated by the clearing of agricultural land of around 5,788.94 Ha (15.18%) due to the clearing of land that was originally forested into agricultural land. Land in the form of bushes becomes agricultural land, as well as newly cleared land or land opened by the community becomes agricultural land. This is followed by open land/open land of around 1,561.58 ha (4.11%) resulting from the clearing of new land to be used as agricultural land and for mining activities.

The land cover change diagram from 2018 to 2022 using the Idrisi Selva application can be seen in Figure 6 as follows

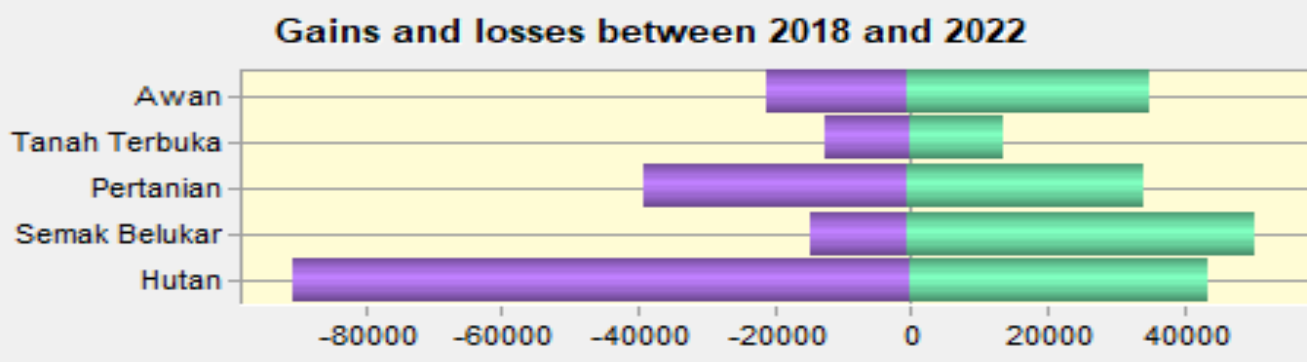

Figure 6. Diagram of land cover changes from 2018 to 2022

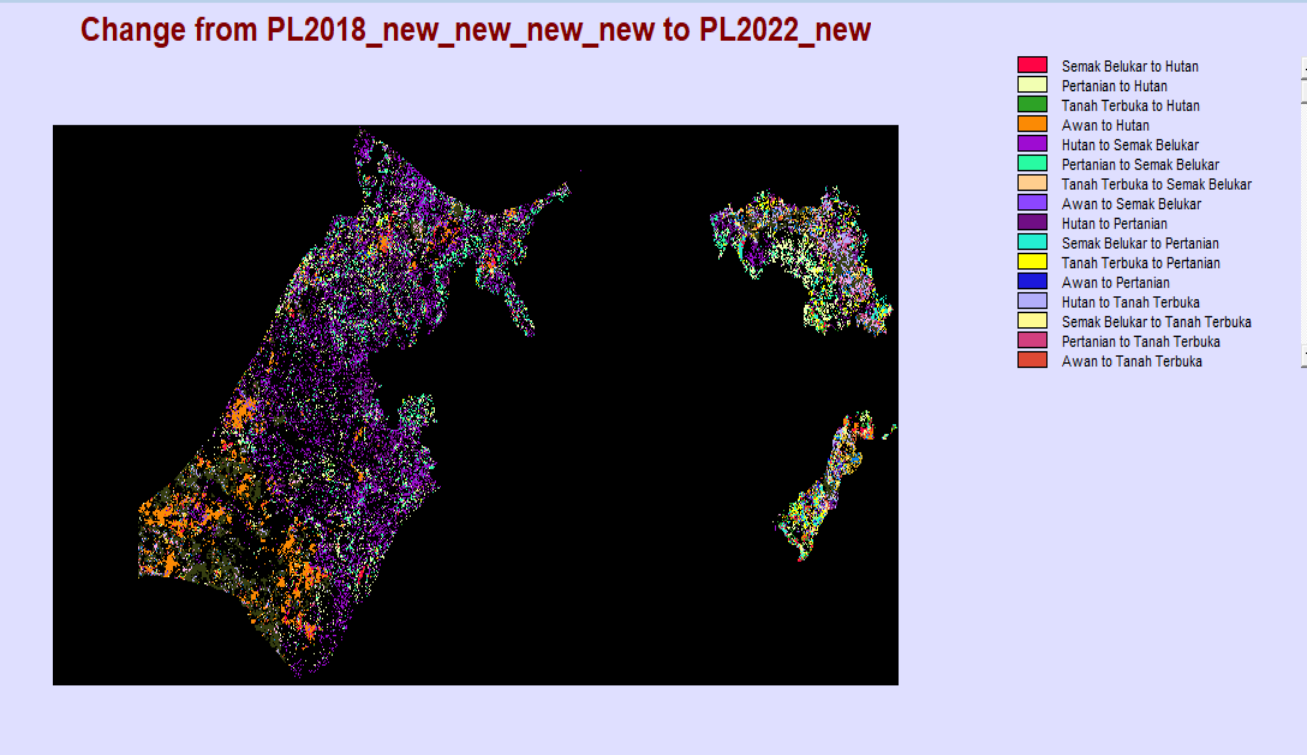

Figure 7. Rate of Land Cover Change from 2018 to 2022

In accordance with the image processing results in 2018 - 2022 there were changes due to deforestation in the work area of KPH Tepo Asa Aroa which was dominated by the clearing of agricultural land of around 5,526.90 Ha (14.49%) due to the clearing of land that was originally forested into agricultural land. Land in the form of bushes becomes agricultural land, as well as newly cleared land or land opened by the community becomes agricultural land. This is followed by bushes of around 4,393.59 ha (11.52%) caused by locations that were initially unproductive being abandoned without being processed at all, and clearing new land in forest areas without being processed at all due to inadequate road access. , as well as open land that has been cleared without being cultivated so that it is overgrown with bushes. The open land area is 1,441.17 ha (3.78%) resulting from legal mining land clearing.

A more detailed diagram of the changes that occurred during 2013 – 2022 can be seen in figure 8 and the map can be seen in figure 9 as follows

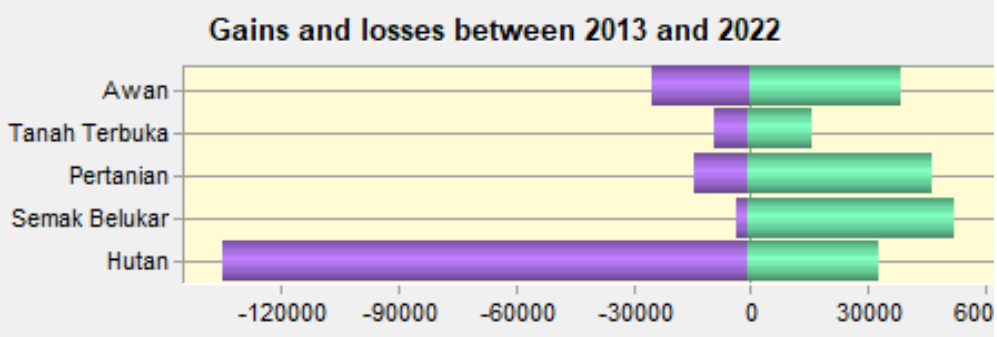

Figure 8. Diagram of land cover changes from 2013 to 2022

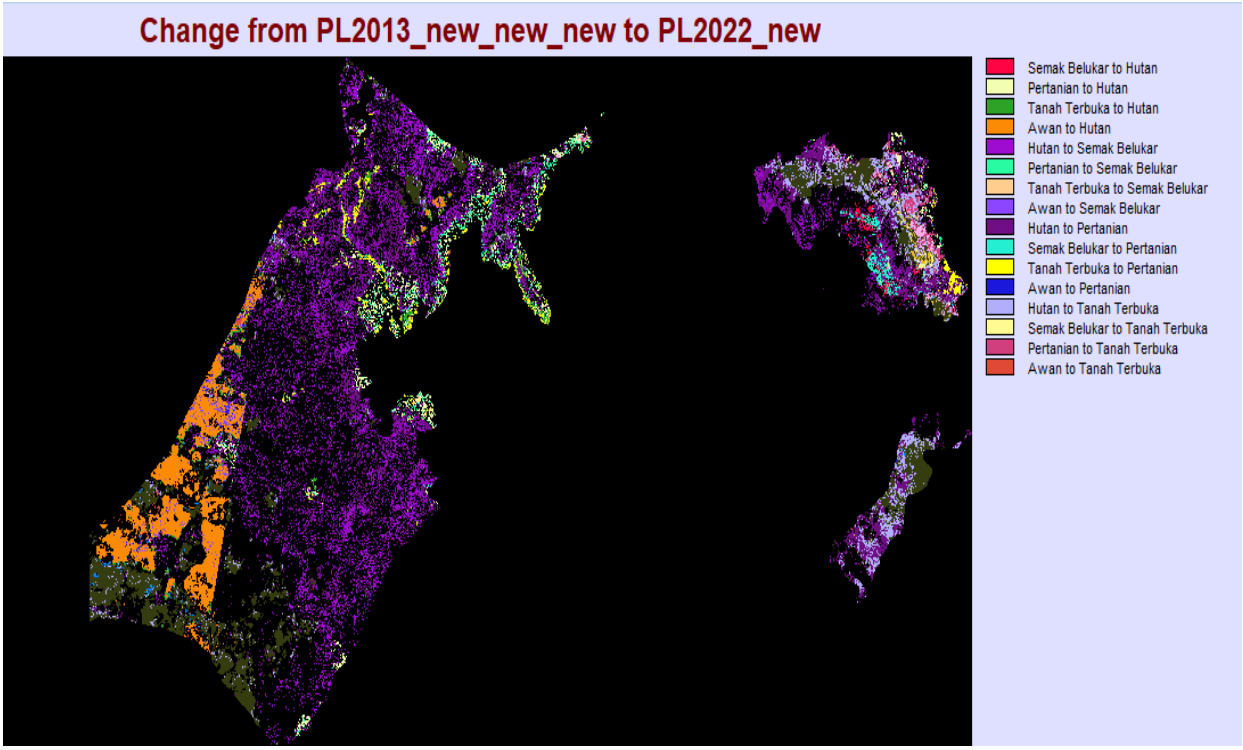

Figure 9. Map of Land Cover Changes from 2013 to 2022

Based on the processed results of all images from 2013 – 2022, it is dominated by the clearing of agricultural land of around 5,526.90 Ha (14.49%), followed by bushes of around 4,393.59 ha (11.52%) and open land of 1,441.17 ha (3.78%). This incident occurred due to the increasing population and inadequate employment opportunities for elderly workers.

IV. CONCLUSIONS

The conclusions that can be drawn from this research are:

1. Land cover changes that occurred at KPH Tepo Asa Aroa (KPHP Unit XV), namely Forests included in primary dry land forest and secondary dry land forest (H) cover an area of 22,475.91 ha; agriculture (Pk, Pc and Pt (plantations, mixed dry land farming and dry land farming)) covering an area of 5,526.90 ha; open land/open land and mining (T and Tm) covering an area of 1,441.17 ha; bushes (B) covering an area of 4,393.59 ha; and cloud/non data (Aw) covering an area of 4,298.65 ha.

2. The factors that dominate the rate of deforestation in the research location arechanges in land cover that was originally forested into agricultural land/community plantations, as well as uncultivated community land becoming bushes and clearing of mining land.

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