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Land Use Changes in Batang Suliti Watershed using ArcGIS

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ABSTRACT

The ArcGIS application can process satellite imagery data into a land use map and calculate the area of each land use type. This study analyzes land use changes in the Batang Suliti watershed from 2013 to 2022 using ArcGIS. The study employs supervised classification and cloud masking techniques to enhance accuracy. The results indicate that forest area decreased by 4.47% with an annual change rate of 0.50%, followed by a 2.55% reduction in rice fields, while residential areas increased by 1.21%. These changes are mainly driven by population growth and agricultural expansion. The findings highlight the need for sustainable land use management policies to mitigate environmental degradation in the watershed.

Keywords: *Land Use; ArcGIS; Watershed Management; Remote Sensing.*

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INTRODUCTION

A watershed is a land area where rainwater flows into a main river[1]. The Batang Suliti watershed plays a crucial role in water supply and ecological balance. However, rapid land use changes, including deforestation and agricultural expansion, have affected the hydrological cycle, increasing surface runoff and flood risks. Previous studies have analyzed land use changes using remote sensing; however, research focusing on the Batang Suliti watershed using the latest classification methods remains limited.

Land use changes have a direct impact on watershed hydrology, including changes in surface runoff and groundwater infiltration [2]. GIS and remote sensing technologies have become increasingly important tools for analyzing land use change patterns and their environmental impacts[3], [4], [5]. Demonstrated that GIS and Cellular Automata models can be used to monitor and predict land use change patterns[6]. Highlighted that changes from natural ecosystems to residential areas need to be monitored to prevent adverse environmental impacts[7].

This study aims to analyze land use changes in the Batang Suliti watershed from 2013 to 2022 using ArcGIS and evaluate their impact on surface runoff. The findings of this research will provide insights for policymakers in managing land resources sustainably.

METHOD

Research Location
This research was conducted in Batang Suliti Watershed, South Solok Regency (-1°23'25.3" S, 100°59'8.6" E), covering approximately 25,478 hectares.
Data Collection

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Data Collection

The data used in this study consists of secondary data obtained from relevant agencies:

- Topographic Map: Contains route, distance, vegetation, and contour information.
- Digital Elevation Model (DEM): Obtained from USGS (Earth Explorer).
- Land Use Map: Processed using ArcGIS 10.7.1 from USGS satellite imagery (Landsat 8 and 9).

Data Processing in ArcGIS

- Preprocessing: Image correction and cloud masking.
- Classification: Supervised Maximum Likelihood Classification to identify land use changes.
- Validation: Ground truth comparison.
- Analysis: Land use change detection.

The flow of this research can be seen in the chart below:

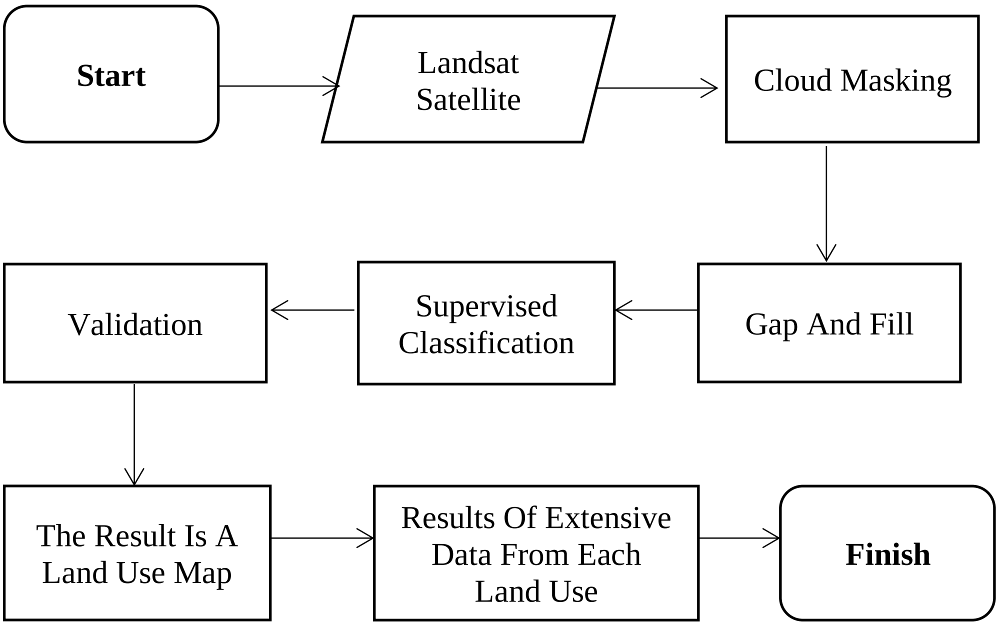

Figure 1. Research Chart

Image Correction

Satellite image data is downloaded from the USGS website which consists of several bands that need to be combined, this combination can be seen in table 4. Satellite image data for 2013 and 2017 uses Landsat 8, for 2022 satellite image data uses Landsat 9, there is no difference between the two, still using the same system, Landsat 9 is the newest satellite from Lansat. Satellite image data still contains clouds, which hinders the satellite image classification process, therefore the cloud detection process is carried out manually, namely by marking the clouds.

Land Use Classification

Land use classification follows SNI 7645-1:2014, which categorizes land into forests, shrubs, open land, rice fields, and built-up areas. Data analysis involves:

- Satellite Image Processing
- Cloud Masking and Gap Filling
- Land Use Classification using Maximum Likelihood Classification in ArcGIS

Validation

Validation is carried out by direct observation in the field by matching the coordinate points in the satellite image with the real coordinate points in the field. If the coordinate points in the image show that the area is a rice field then when matching the coordinates in the field it must also be rice fields.

Analysis

After carrying out a guided classification based on SNI 7645-1:2014. then the area of each land use such as forest, shrubs, settlements, open land and rice fields can be seen in the open attribute table. How to choose: Right click on the classification results layer and select open attribute table, then the area of each land use will appear

RESULTS AND DISCUSSION

Table 1. Criteria for percentage of vegetation cover

Percentage of Vegetation Cover (%)	Criteria
>80	Very Good
61-80	Good
41-60	Moderate
21-40	Bad
<20	Very Bad

Table 2. Land use classification

Land Use	Description
Forest	Forests that grow in dry land habitats in areas ≥300 m for high areas and ≤300 m for low areas.
Shrubs	The vegetation formation or structure is a collection of shrubs with a height of between 50 cm to 2m, dominated by woody vegetation, interspersed with very short trees with a height of <= 5m Or: Dry land areas that have been overgrown with various heterogeneous and homogeneous natural vegetation with sparse to dense density levels. The area is dominated by low vegetation Note: shrubs in Indonesia are usually former forest areas and usually no longer show logging scars or spots
Open Land	Open land with relatively wide coverage,
	which is processed by digging to extract stones, sand and soil
Wetland annual plants (rice fields)	Wetland annual plants include all types of annual plants that require irrigation and flooding during their growth phase, for example wetland rice and sugar cane. The category of rice land use includes classes of rice fields with continuous rice crops, rice crops interspersed with secondary crops or fallow/no crops, or other crops that require flooding.
Building area	Areas that have experienced substitution of natural or semi-natural land cover with artificial land cover which is usually well watertight, both permanent and semi-permanent

SNI 7645-1:2014

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Table 3. Landsat 8 and Landsat 9 Spectrum

Band	Type	Spectral (µm)	Resolution (m)
Band 1	Coastal Aerosol	0.43 - 0.45 µm	30
Band 2	Blue	0.450 - 0.51 µm	30
Band 3	Green	0.53 - 0.59 µm	30
Band 4	Red	0.64 - 0.67 µm	30
Band 5	Near-Infrared	0.85 - 0.88 µm	30
Band 6	SWIR 1	1.57 - 1.65 µm	30
Band 7	SWIR 2	2.11 - 2.29 µm	30
Band 8	Panchromatic	0.50 - 0.68 µm	30
Band 9	Cirrus	1.36 - 1.38 µm	30

Source: USGS,2013

Table 4. Combinations of Landsat 8 and Landsat 9

functions	Combinations Band
Natural Color	4 3 2
False Color (urban)	7 6 4
Color Infrared (vegetation)	5 4 3
Agriculture	6 5 2
Atmospheric Penetration	7 6 5
Healthy Vegetation	5 6 2
Land/Water	5 6 4
Natural With Atmospheric Removal	7 5 3
Shortwave Infrared	7 5 4
Vegetation Analysis	6 5 4

esri, 2013[8]

Table 5. Changes in Land Use

NO	**Land Use**	**2013**	**2017**	**2022**	**PERUBAHAN TATA GUNA LAHAN**					
					2013-2017		**2017-2022**		**2013-2022**	
		HA	**HA**	**HA**	**HA**	**%**	**HA**	**%**	**HA**	**%**
1	Forest	16929.00	16527.66	15791.38	401.33	1.58	736.29	2.89	1137.62	4.47
2	Shrubs	4773.24	4781.04	4871.23	-7.80	-0.03	-90.19	-0.35	-97.99	-0.38
3	Rice field	3361.39	3732.10	4010.55	-370.71	-1.46	-278.45	-1.09	-649.16	-2.55
4	Open land	1.62	4.40	83.26	-2.77	-0.01	-78.87	-0.31	-81.64	-0.32
5	Building area	401.15	421.20	709.98	-20.05	-0.08	-288.78	-1.13	-308.83	-1.21
		25466.40	25466.40	25466.40						

Information
: (-) Land use reduce
(+) Land use increase

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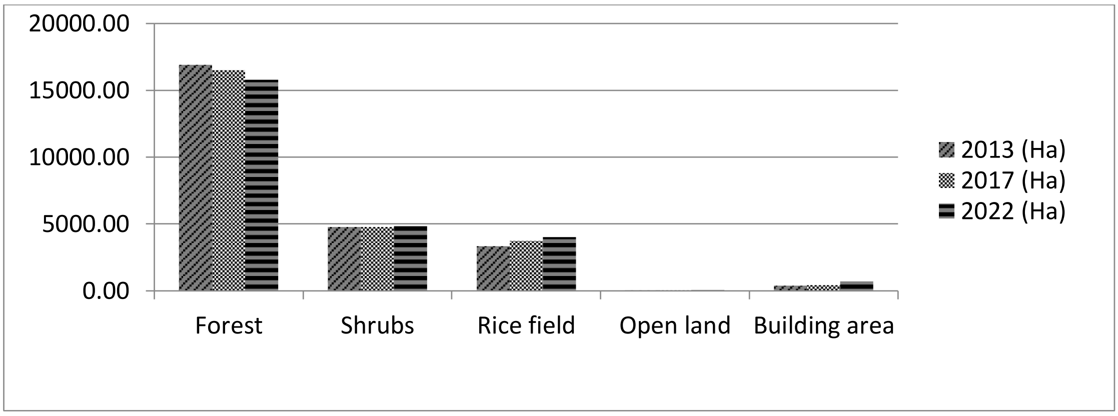

Figure 2. Land Use Changes

Table 6. Percentage Vegetation Cover (PVC) in 2013, 2017 and 2022

Year	No	Land use	Area (HA)	TOTAL AR	PVC (%)	CATEGORY
2013	1	Forest	16929	0.00	85.21	Very good
	2	Shurbs	4773.238			
Vegetation Area			21702.24			
2017	1	Forest	16527.66	0.00	83.67	Very good
	2	Shurbs	4781.036			
Vegetation Area			21308.7			
2022	1	Forest	15791.38	0.00	81.13	Very good
	2	Shurbs	4871.225			
Vegetation Area			20662.6			

Figure 3. Batang Suliti watershed

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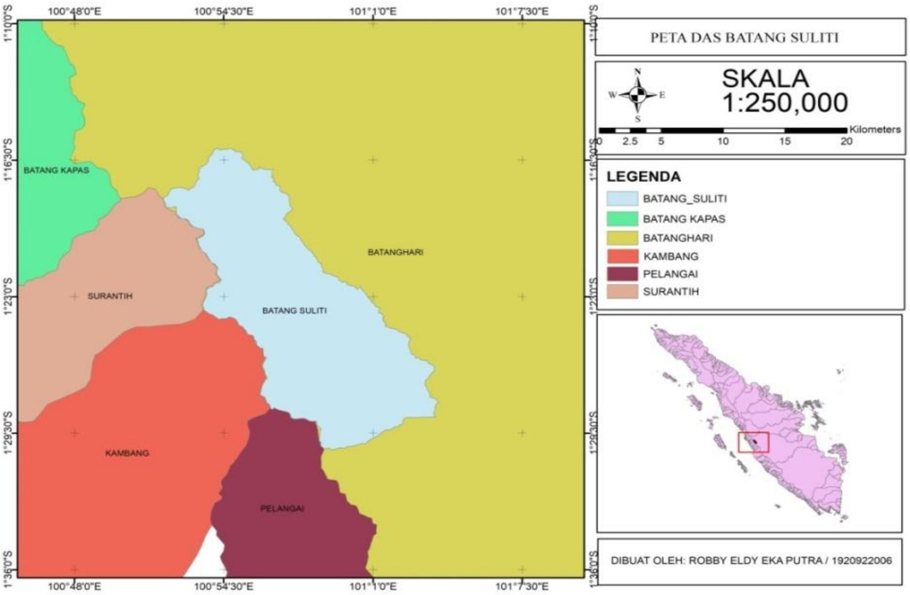


Figure 4. Watershed maps around the batang suliti watershed

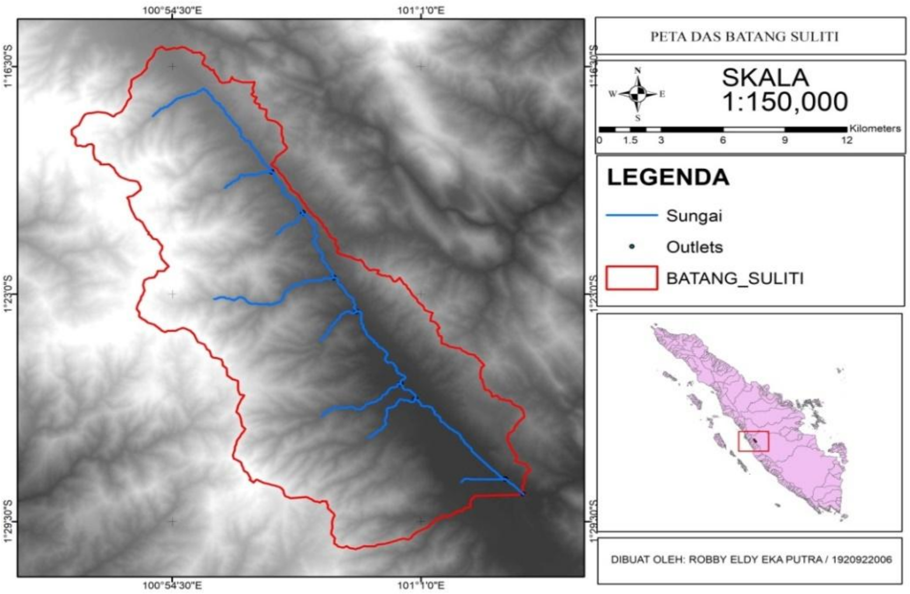
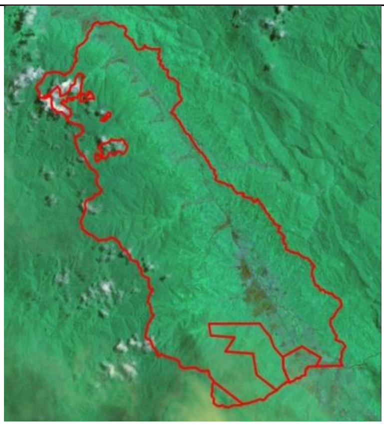
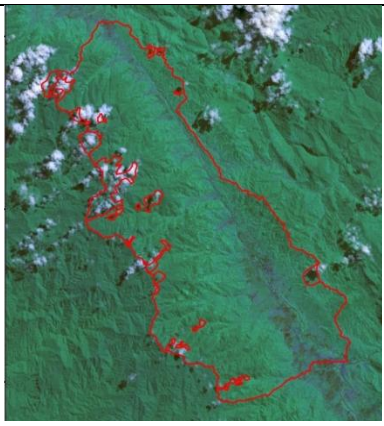
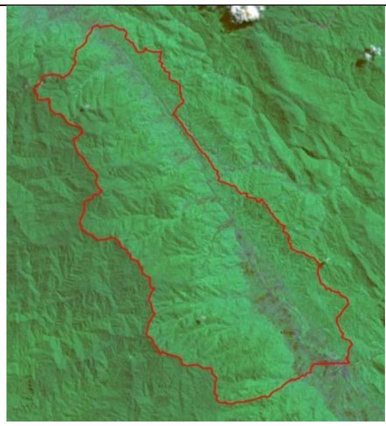


Figure 5. Results of the delineation process

		
2013 image before subtracting	2017 image before subtracting	Image of 2022 before

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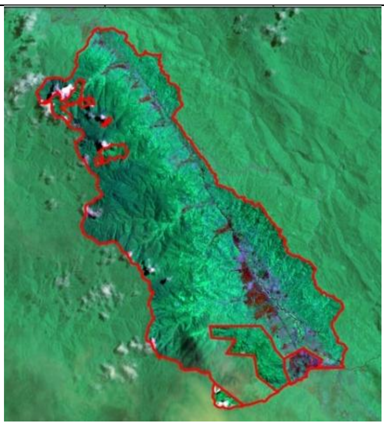
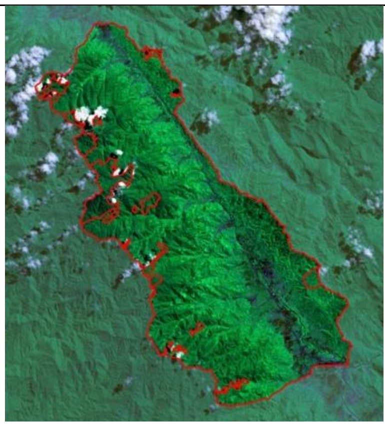
clouds	clouds	subtracting clouds
		
2013 image after subtracting clouds	2017 image after subtracting clouds	2022 image after subtracting clouds

Figure 6. results of the Cloud Masking and Gap Filling process

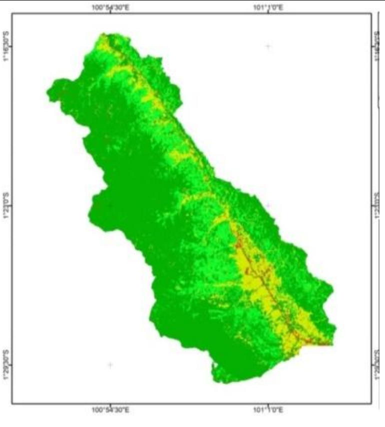
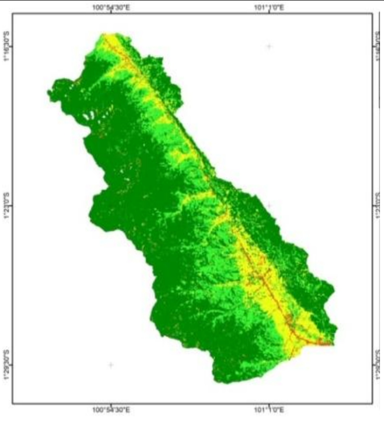
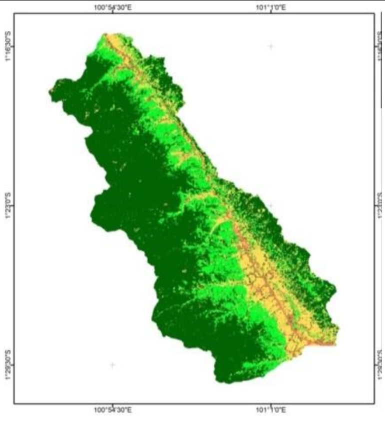
		
2013	2017	2022

Figure 7. Land use planning 2013, 2017 and 2022

A study of vegetation cover in a watershed is very necessary as an assessment of conditions in the watershed. Vegetation cover assessment is classified based on Decree of the Director General of RRL No. 041/Kpts/V/1998 with the following equation.

$$PVC = \frac{AVC}{A_{DAS}} X100\% \qquad (1)$$

PVC = Percentage of vegetation cover
AVC = Area of vegetation cover
A_{DAS} = Watershed area

Land Use Changes

From table 5 it can be seen that the results show that the most significant land use changes occurred in forests which experienced a decline of 4.47% due to the expansion of agriculture and settlement. Rice fields decreased by 2.55%, while residential areas increased by 1.21%.

Comparative Analysis with Previous Studies.

To provide a broader context, we compared our findings with similar studies:
A study on land use changes in the Batang Kuranji watershed Definnas found a 62% decrease

in forest area, leading to increased runoff during the rainy season and reduced water availability during the dry season due to settlement expansion[9].

An analysis of land use changes in the Sub-DAS Way Pubian, Lampung Tengah Qur'ani observed forest reduction by 6.44% between 2012 and 2017 and an additional 5.37% loss from 2017 to 2022, with settlement areas increasing[10]. A study on land use in Kabupaten Bandung Barat Christian found that 11,000 hectares underwent land use transformation within seven years, mainly due to rapid urbanization and agricultural conversion[11].

A research on land use changes in the Tuban-Bojonegoro border region Rif'ati applied GIS and Cellular Automata models to predict that by 2038, urban and industrial land cover would expand significantly[6]. Niu used FLUS and ARIMA models to predict land use changes in the Yellow River Basin, China. They found that the economic growth scenario led to increased conversion of agricultural and forest land to organizational land. This study is relevant to conditions in the Batang Suliti watershed, where conversion of agricultural land and forests has also occurred in recent years[12]. Borzì, in a study on the impact of land use in coastal areas of Italy, found that the conversion of natural habitats into urban areas accelerates coastal erosion [7].

Jiang studied land use change in the Central Plains Urban Agglomeration, China, using the CA-Markov and Coupling Coordinated Models. The results indicate that environmental changes driven by human activities and climate change accelerate the conversion of rural land into urban areas. This is relevant to this study, as the increase in residential areas in the Batang Suliti watershed also reflects the impact of population growth and development[13].

Jurnal "The Nexus Between Spatiotemporal Land Use/Land Cover Dynamics and Ecosystem Service Values" also shows similar trends in Ethiopia, where forests have declined due to agricultural expansion and settlements[14].

These findings align with author's study in that forest and agricultural land continue to decline while urban areas grow. However, the percentage of change varies based on the region's economic development, land policies, and conservation efforts.

CONCLUSION

This study analyzed land use changes in Batang Suliti Watershed from 2013 to 2022 using ArcGIS. The most significant changes include:

- 4.47% decrease in forest cover, mainly due to deforestation and land conversion.
- 2.55% reduction in rice fields, attributed to land-use intensification.
- 1.21% increase in residential areas due to urban expansion.

The findings highlight the importance of land conservation strategies to mitigate environmental impacts. Compared to similar studies, our research aligns with broader trends in land use changes across different watersheds in Indonesia. Further analysis, including hydrological modeling, would enhance our understanding of how these changes affect water resources and flood risks.

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