Journal of Sylva Indonesiana

Journal homepage: https://talenta.usu.ac.id/jsi

Analysis of Land Cover Change: Case Study in Concession Area of PT. GRUTI Unit Tele I North Sumatra

Siti Latifah[1,2*], Zulkarnain Batubara[1], Anita Zaitunah[1], Seca Gandaseca[3]
[1]*Faculty of Forestry, Universitas Sumatera Utara, Medan, 20353, Indonesia*
[2]*PuskaTrop Universitas Sumatera Utara, Medan, 20353, Indonesia*
[3]*School of Biology, Faculty of Applied Sciences, Universiti Teknologi MARA, Malaysia*
[*]Corresponding Author: sitilatifah@usu.ac.id

ARTICLE INFO

Article history:
Received April 19th, 2025
Revised September 26th, 2025
Accepted December 29th, 2025
Available online Februari 28th, 2026

E-ISSN: 2622-5093
P-ISSN: 2622-5158

How to cite (IEEE):
S. Latifah, Z. Batubara, A. Zaitunah and S. Gandaseca, "Analysis of Land Cover Change: Case Study in Concession Area of PT. GRUTI Unit Tele I North Sumatra", *Journal of Sylva Indonesiana*, Vol. 09, No. 01, pp. 163-172, Feb. 2026, doi: 10.32734/jsi.v9i01.20138

http://doi.org/ 10.32734/jsi.v9i01.20138

ABSTRACT

Changes in cover are the result of human activities and natural phenomena. Land cover in an area always changes over time. This study aims to identify and analyze the condition of land cover in 2013 and 2023 in the concession area of PT. GRUTI Unit Tele I obtained through guided classification using ArcGIS 10.4 software and Microsoft Excel. The results of the study showed that throughout 2013-2023 in Unit Tele I there was a change in the area of forest from 14,468.85 ha to 14,138.91 ha. In non-forest areas, there is an increase in area from 443.43 ha to 874.98 ha, and open areas have decreased from 410.22 ha to 402.21 ha. Changes in land cover are dominated by land occupation by the community due to a lack of supervision from concession managers and the absence of production activities in the area.

Keywords: Forest, GIS, Land Cover, Supervised Classification, Tele

1. Introduction

Land cover is one of the strategic data and information of the Ministry of Environment and Forestry that is always experiencing rapid and dynamic changes. Changes can occur due to several factors, including land conversion, opening of plantation land, population growth, economic growth, and changes in the function of forest areas into areas for other uses [1]. Population growth, natural disasters such as earthquakes and tsunamis can also result in changes in land cover [2].

PT. Gunung Raya Utama Timber Industries commonly known as PT. GRUTI is a company that has obtained a PBPH (Forest Utilization Business Permit) permit. One of PT. GRUTI's concession areas are in Tele I which includes Dairi, Pakpak Bharat, and Samosir Regencies. Previously there were no operational activities in the Tele I, Tele II, and Lae Ordi concession areas. Production activities only focused on the South Nias Regency area. In the Tele I, Tele II, and Lae Ordi areas there were only land rehabilitation activities, so the area lacked supervision.

Land is a natural resource that is vital for human survival [3], therefore, its changes are very important to monitor and evaluate. Land cover changes have become quite a serious problem in the world. Specifically [4]

illustrates the increasing need for land in Indonesia, not only due to population growth but also due to the expansion of rice fields and other agricultural crops as well as the transmigration program. Changes in land cover are greatly influenced by human activities and global climate change [5]. Despite providing social and economic benefits, this land cover change has an impact on various sectors, including the hydrological conditions of river basins [6] and increased greenhouse gas (GHG) emissions, especially carbon dioxide [7].

According to [6], the accuracy of land cover information can help in monitoring changes in land cover. In making land cover maps, remote sensing technology and Geographic Information Systems (GIS) can be utilized and processed using software [8]. The occurrence of changes in land cover is not realized by the company so spatial monitoring is needed to determine how much forest land has been opened and which areas have experienced changes in land cover. Land cover analysis is basically aimed at detecting changes that occur in each class of land cover [9].

Through land cover maps, information can be obtained on the types of land cover, the area of each type of land cover, and the distribution of space utilization in a region. Research on Land Cover Change Analysis in PT. GRUTI Unit Tele I Area has never been done before. The results of this research are expected to be used as a tool for better monitoring so that land clearing does not become more widespread

2. Research Method

2.1. Study Area

The research was conducted in the Concession area of PT. Gunung Raya Utama Timber Industries (PT.GRUTI) in Tele I (Dairi, Samosir, and Pakpak Bharat Regencies) North Sumatra. This research was conducted from 19 August to November 2024. The materials used in the research are Landsat 8 satellite imagery in 2013 (June 7, 2013 path row 129/058) for Tele I; Landsat 8 satellite imagery in 2023 (February 27, 2023 path row 129/058) for Tele I; and Business work plan documents and SHP map files. The map of the research location are presented in Figure 1.

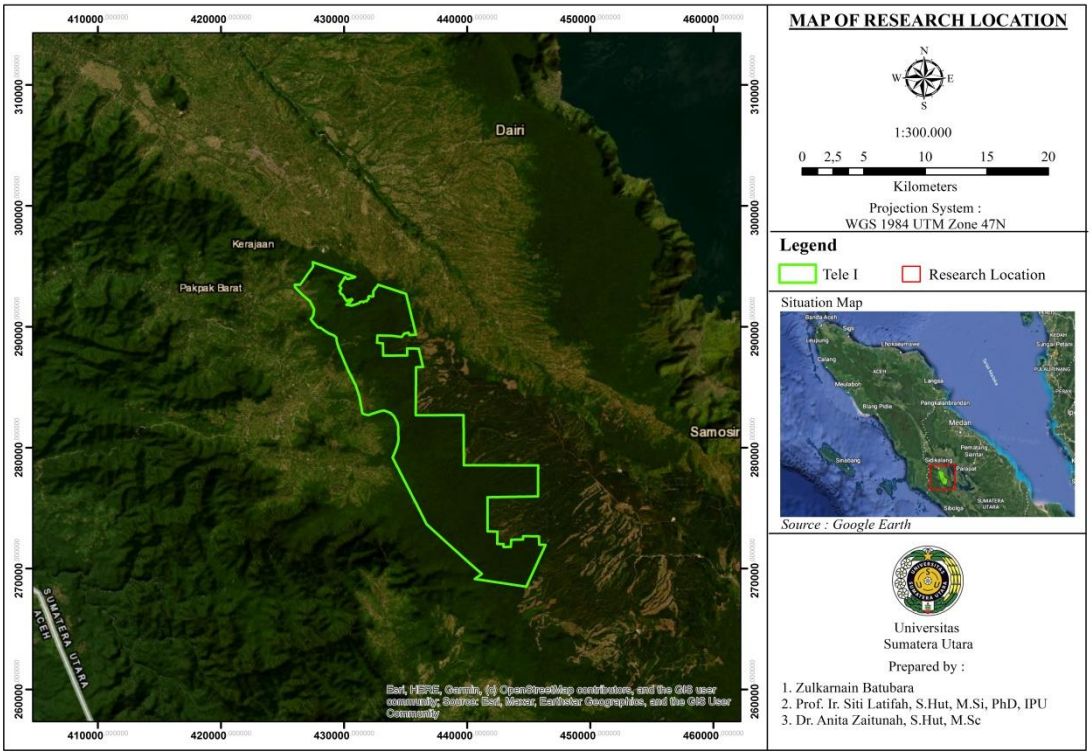


Figure 1. Research location map of the PT.GRUTI in Tele I

2.2. Data Collection

Primary data collection was carried out by identifying land and ground checkpoints processed in ArcGIS.Secondary data is supporting data in conducting the research, such as Business work plans, SHP map files, and Land cover maps, as well as Google Earth to help verify the results of the assessment points. Field

checking is done to validate objects that appear ambiguous during the visual interpretation process of the image.

According to [10] According to this field checking was carried out on several land cover class points. Furthermore, image interpretation was carried out to identify and assess the importance of objects and their symptoms [11]. Interpretation Visual imagery was conducted to determine the form of land cover changes in the period 2013 and 2023.

2.3. Data Analysis

Analysis of land cover data using the supervised classification method with the following stages and can be seen in Figure 2:

a. *Download Image*
   The satellite imagery itself is downloaded through the earthexplorer.usgs.gov website. The satellite images downloaded are Landsat 8 images dated June 7, 2013 path row 129/058, February 27, 2023 path row 129/058, and September 7, 2023 path row 129/058.
b. *Image Cropping*.
   Image cropping is done to limit the study area that will be the focus of the research using the clip raster tool in ArcGIS 10.4 software.
c. Radiometric Correction
   Radiometric correction aims to improve the visual quality of an image, which functions to correct pixel values to match what they should be [12]
d. Image merging (Composite band).
   Composite band is the process of combining two or more overlapping bands to produce a representative and continuous image [13]. This study uses bands 4, 3, and 2, which are commonly called the Red, Green, and Blue bands [14]
e. Image Classification
   Image classification in this study uses the Interactive Supervised Classification (ISC) supervised classification method [15]
f. On-Screen Digitization/ Supervised Classification
   The on-screen digitizing process is a digitizing process carried out on a computer monitor screen using various types of geographic information system software such as Arc View, Map Info, and AutoCAD Map [15]
g. Accuracy Calculation
   Accuracy testing is carried out using the kappa accuracy calculation method which can be done after compiling an error matrix (confusion matrix). Manually it can be calculated using the following formula:

$$\text{User' s Accuracy} = \frac{Xii}{X+1} \text{ x } 100\ \% \quad (1)$$

$$\text{Producers' s Accuracy} = \frac{Xii}{Xi+} \text{ x } 100\ \% \quad (2)$$

$$\text{Overall Accuracy} = \frac{Xii}{Xi+} \text{ x } 100\ \% \quad (3)$$

Information:
Xii = diagonal value of the contingency matrix of the ith row and i-th column
Xi+ = number of pixels in the i-th row
X+I = number of pixels in the ith column

Mathematically, kappa accuracy is presented as follows:

$$\text{Kappa Accuracy} = \frac{\sum_i^r Xii - \sum_i^r (Xi+X+i)}{N^2 - \sum_i^r (Xi+X+i)} \text{ X } 100\% \quad (4)$$

Information :
Xii: Diagonal value of the contingency matrix of the i-th row in the i-th column
X+i : Number of pixels in the ith column
Xi+: Number of pixels in the i-th row
N: Number of pixels in the sample

h. Field Survey (Ground Check**)**
   A field survey (ground check) is conducted to see the field directly and see the similarities between the interpretation data that has been obtained and the field results [16]-[18]

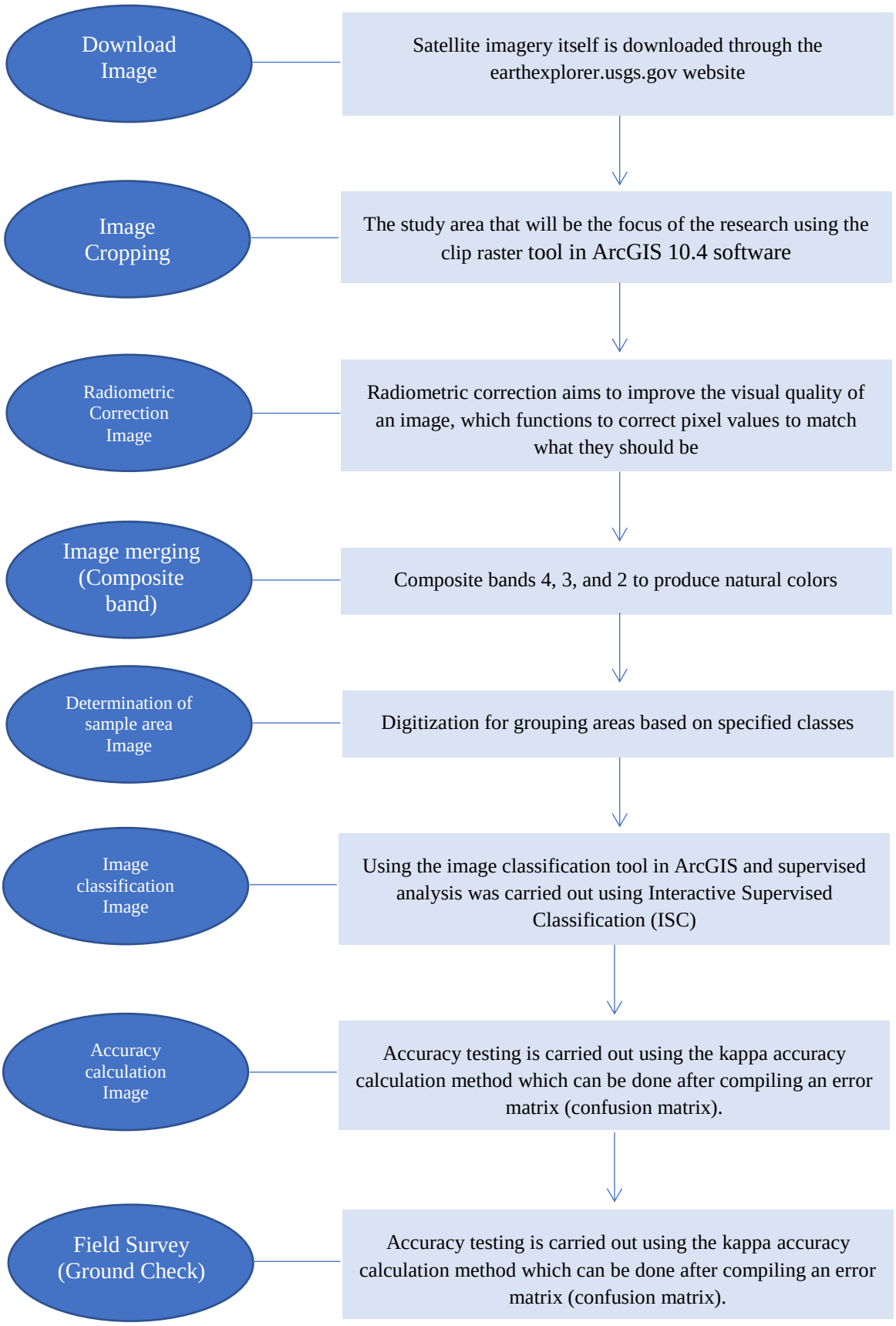


Figure 2. Analysis of land cover data using the supervised classification method

3. Result and Discussion

3.1. Radiometric correction

According to [19] the radiometric correction process includes correction of sensor-related effects to increase the contrast of each pixel of the image so that the recorded object is easy to analyze to produce correct data/information according to field conditions. The atmospheric effect causes the reflection value of objects on the earth's surface recorded by the sensor to be not the original value (especially at shorter waves), but becomes larger due to scattering or smaller due to the absorption process [12]. In this study, the radiometric correction was carried out using the DN radiometric calibration method into reflectance to produce DN data into TOA (Top of Atmospheric) reflectance.

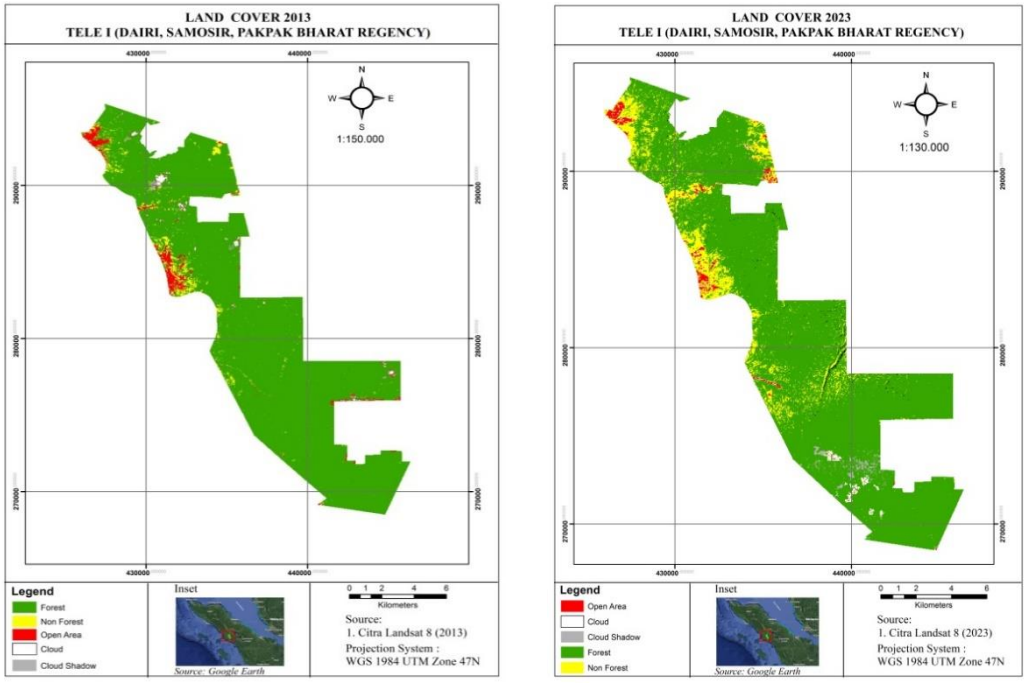
Based on the results of radiometric correction processing, the reflectance value of each band has met the error requirements. A radiometric correction because the reflectance value is not less than 0 and not more than 1 (Table 1). According to [19] value the correct radiometric image can be seen from the reflectance value which is in the range of 0-1.

Table 1. Reflectance values of Landsat 8 images dated 07/06/2013 and 27/02/2023

	Reflectance Value	
Tele I	**2013**	**2023**
Band 4	0.0444774 - 0.370058	0.0631092 - 0.277398
Band 3	0.0426501 - 0.36266	0.0661647 - 0.279796
Band 2	0.00748717 - 0.340042	0.0365258 - 0.259676

3.2. Identification of land cover changes

Based on the results of Landsat 8 image analysis using Supervise classification, there was a change in land cover over 10 years, namely from 2013-2023 in the Tele I area of Dairi, Samosir, and Pakpak Bharat Regencies, is presented in Figure 3.



Year 2013 Year 2023

Figure 3. Land cover map for 2013 and 2023 in Tele I

Based on the map in Figure 3, land cover change data can be compiled which is presented in Table 2. The Tele I unit area has a change in forest area from 14,468.85 ha to 14,138.91 ha. In non-forest areas, there was an increase in area from 443.43 ha to 874.98 ha, open areas decreased from 410.22 ha to 402.21 ha. The part

covered by clouds in the 2013 image is 127.08 ha and in the 2023 image is 44.19 ha, Cloud Shadow in the 2013 image is 31.32 ha, and in the 2023 image is 20.61 ha.

The non-forest area has an additional area of 431.55 ha, after conducting a confusion matrix analysis, the area non-forest areas become non-forest areas amounting to 329.94 ha. Changes in open areas to non-forest areas amounted to 8.01 ha. Therefore, the increase in area that occurred in non-forest areas was 337.95 ha (Figure 4)

Based on the analysis results, there was a significant increase in non-forest land cover areas. Non-forest areas increased by 431.55 ha. After conducting a confusion matrix analysis, the actual changes that occurred can be seen. Open areas have become non-forest areas such as oil palm and community gardens, the area is 8.01 ha. Because the 8.01 ha open area has changed to non-forest, the change in the non-forest area is +431.55 plus 8.01 to 439.56 ha so that the actual non-forest area is 882.99 ha. The area covered by clouds and cloud shadows is still a forest area where the change that occurred in the forest area is -329.94 plus 64.80 is 265.14 ha, so the actual forest area is 14203.71 ha. The actual open area is 394.2 ha.

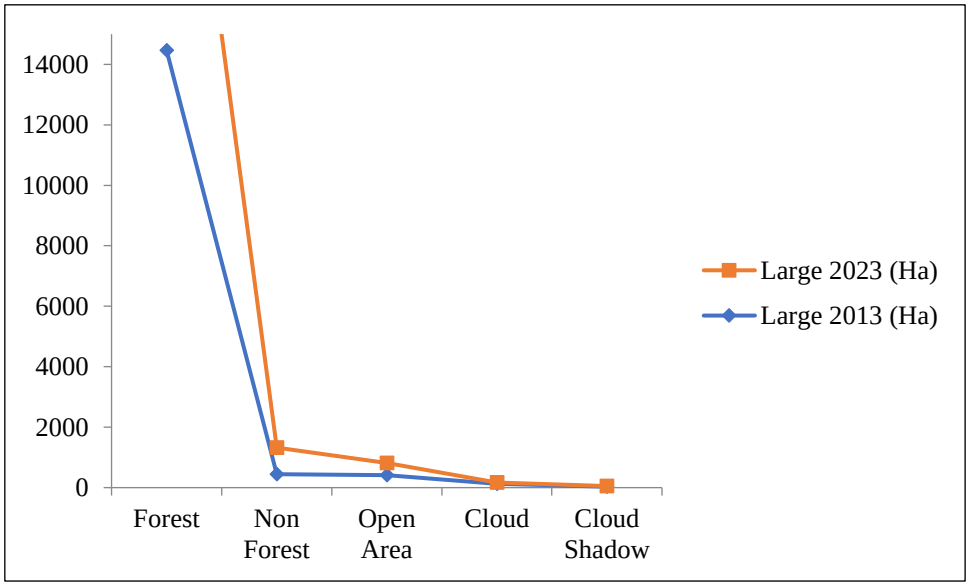


Figure 4. Land cover change data 2013-2023 in Tele I

Table 2. Kappa Analysis Tele I (2023)

No.	Class Value	Forest	Non-Forest	Open Area	Cloud	Total	U Accuracy	Kappa
0	Forest	230	1	0	0	231	0.995	0
1	Non-Forest	2	12	0	0	14	0.857	0
2	Open Area	0	1	2	2	5	0.4	0
3	Cloud	0	0	0	0	0	0	0
4	Total	232	14	2	2	250	0	0
5	P Accuracy	0.991	0.857	1	0	0	0.976	0
6	Kappa	0	0	0	0	0	0	0.827

Based on the results of the Kappa analysis, it shows that the accuracy value of the Tele I image analysis is very good because it is more than 0.80 (Table 2). The kappa accuracy value shows that the results of the land cover classification in this study are included in the very good value range and can be accepted for further analysis [20].

Based on the results of identification and verification in the field, it shows that the results of the image analysis are in accordance with the conditions in the field, where there has been a change in land cover in the Tele I area. The open area has become a village, with empty land, and roads, while non-forests are in the form of bushes, community plantations, and oil palm plantations.

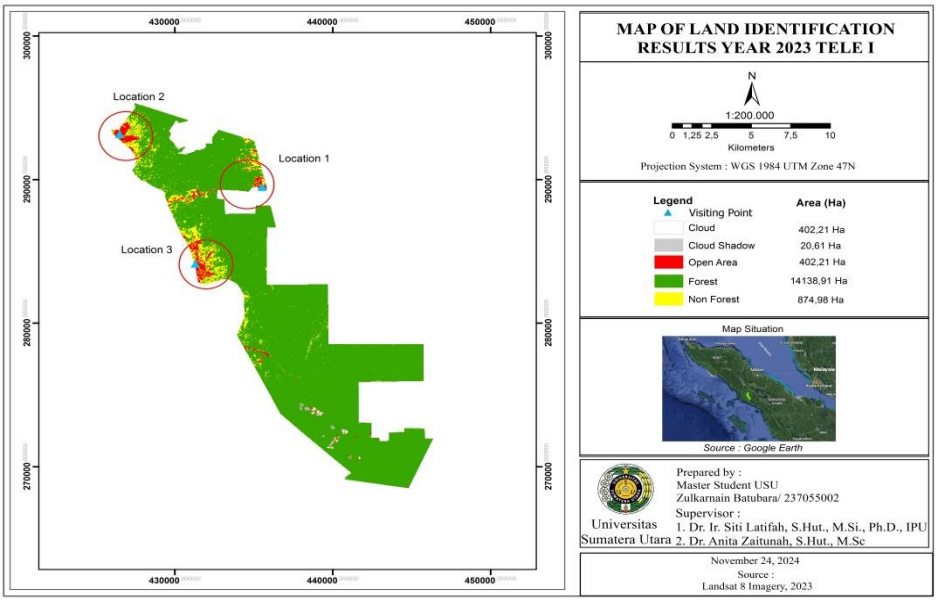


Figure 5. Identification results map

Ground Check to Tele I was conducted at Points of Interest (POI) 1, 2, and 3 (Figure 5). The condition of the land at POI 1 has partly become a cornfield and bushes (Figures 6 and 7). Residential housing around the area is also still small but there is already an asphalt road that is easy to pass. This is in accordance with the results of image analysis where the area has partly become non-forest and open land.

Figure 6. Bushes at POI 1, Tele I

Figure 7. Cornfield at POI 1Tele I

The land POI 2 at Tele I was changed to a non-forest and open area. The identified open areas are villages, there are already many houses of residents at POI 2 which can be seen in Figures 8 and 9. Likewise, non-forest areas have been identified There are already many lands that have become community gardens can be seen in Figure 9. The results of the identification are in accordance with the results of the image analysis. The results of the image analysis carried out show the accuracy of what happened where in POI 2 there was still forest detected even though only a little (Figures 10 and 11).

Figure 8. Community House at POI 2, Tele I

Figure 9. Community fields at POI 2, Tele I

The condition of the area in Tele I at POI 3 is almost the same as in POI 2. The location has become a village and community fields, rice fields and corn fields can be seen in figure 12 and 13. The change in land cover occurred due to land occupation by the community. The land occupation occurred due to the lack of supervision carried out by the company at that time. The lack of supervision by the company began with the absence of production activities in the area. The activities carried out were for rehabilitation activities. Over time, when rehabilitation activities were to be carried out in the area, it turned out that many areas had become oil palm fields and plantations. The absence of operational activities by Forest Concession Rights (HPH) concession holders in the field followed by the absence of security for the protection of forest areas, indirectly provided opportunities for encroachers to enter, occupy, and use forest areas.

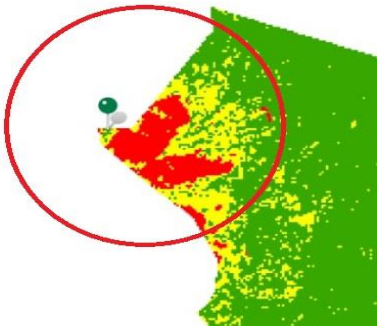


Figure 10. Avenza Map

Figure 11. Forest area at POI 2, Tele I

Figure 12. Community fields at POI 3, Tele I

Figure 13. Corn fields at POI 3

If this happens, the web GIS application is very supportive in monitoring Forest Concession Rights concessions [21]. In addition to monitoring activities by employees assigned to the area, involving the community in monitoring activities is the best thing in forest supervision.

4. Conclusion

The radiometric correction value meets the criteria in the range of 0-1. The classification results have very high accuracy with a kappa value above 0.80. Tele I has a kappa value of 0.827. The largest change in land cover occurred in non-forest areas of 337.95 ha. Changes in land cover that occurred during the 2013-2023 period in Tele I, in general, were changes in land use and reduction in forest area to plantations, bushes, and settlements.

Acknowledgments

We would like to thank the Ministry of Education, Culture, Research, and Technology for providing us with financial assistance for the Master's Thesis Research Program Research Funding Scheme for the 2024 fiscal year. We would also like to thank PT. GRUTI for providing the opportunity to conduct research at its location.

Conflict of Interest

There is no Conflict of Interest between the authors.

References

[1] E. Kesaulija, S. Moeljono, A. Murdjoko. "Analysis of Land Cover Changes in South Manokwari Regency," *Cassowary*, vol. 3, pp. 141-152, 2020.

[2] I. F. Dzakiyah, I. Prasasti. "Analysis of Land Cover Changes Due to Natural Disasters Using Landsat 8 Imagery," *National Seminar on Sustainable Infrastructure 2019 in the Era of the Industrial Revolution* 4.0, pp. 19-26, 2019.

[3] G. Abebe, D. Getachew, A. Ewunetu. "Analyzing land use/land cover changes and its dynamics using remote sensing and GIS in Gubalafito district, Northeastern Ethiopia," *SN Applied Sciences*, vol. 4, pp. 1-15, 2022.

[4] R. Tsujino, T. Yumoto, S. Kitamura, I. Djamaluddin, D. Darnaedi. "History of forest loss and degradation in Indonesia," *Land Use Policy*, vol. 57, pp. 335-347, 2016.

[5] B. Hao, M. Ma, S. Li, Q. Li, D. Hao, J. Huang, Z. Ge, H. Yang, X. Han. "Land Use Change and Climate Variation in the Three Gorges Reservoir Catchment from 2000 to 2015 Based on the Google Earth Engine," *Sensors (Switzerland)*, vol. 19, pp. 2001-2020, 2019.

[6] R. Permatasari, Arwin, D. K. Natakusumah. "The effect of land use change on the hydrological regime of the watershed (Case Study: Komering Watershed)," *Civil Engineering Journal*, vol. 24, pp. 91-98, 2017.

[7] G. Setiawan, L. Syaufina, N. Puspaningsih. "Estimation of carbon stock loss from land use changes in Bogor Regency," *Journal of Natural Resources and Environmental Management*, vol. 5, pp. 141-147, 2015.

[8] D. D. Dewa, A. W. Sejati. "The effect of land cover changes on GHG emissions in fast-growing areas in Semarang City," *Indonesian Journal of Remote Sensing*, vol. 1, pp. 24-31, 2019.

[9] A. Madasa, I. R. Orimoloye, O. O. Ololade. "Application of geospatial indices for mapping landcover/use change detection in a mining area," *J. Afr. Earth Sci*., vol. 175, pp. 104-108, 2021.

[10] D. Phiri, J. Morgenroth. "Developments in Landsat land cover classification methods: A review," *Remote Sensing*, vol. 9, pp. 967-992, 2017.

[11] H. F. Agoes, F. A. Irawan, R. Marlianisya. "Interpretation of Remote Sensing Digital Imagery for Making Rice Field Maps and Estimating Rice Harvest Results," *INTEKNA Journal: Technical and Commercial Information*, vol. 18, pp. 24-30, 2018.

[12] N. Sulistiyono, T. Nifrody, P. Patana, A. Susilowati. "Estimation of Forest Degradation Distribution Using Landsat Satellite Imagery in Besitang Forest Landscape," *IOP Conference Series: Earth and Environmental Science*, vol. 374, pp. 012031, 2019.

[13] S. Latifah, R. Samsuri. "Introduction to Spatial Analysis with ArcGIS," USU Press, p. 116, 2018.

[14] P. Soeprihanto. "Forestry Business - Forestry Multi-Enterprise," *STANDARD: Better Standard Better Living*, vol. 1, pp. 38-43, 2022.

[15] D. Kosasih, M. B. Saleh, L. B. Prasetyo. "Interpretasi visual dan digital untuk klasifikasi tutupan lahan di Kabupaten Kuningan, Jawa Barat," *Jurnal Ilmu Pertanian Indonesia (JIPI)*, vol. 24, pp. 101-108, 2022.

[16] Purwanto, S. Latifah, Yonariza, Farid Akhsani, Eva Indra Sofiana, Mohammad Riski Ferdiansah. "Land cover change assessment using random forest and CA Markov from remote sensing images in the protected forest of South Malang, Indonesia," *Remote Sensing Applications: Society and Environment*, vol. 32, pp. 101061, 2022.

[17] S. Latifah, Agus Purwoko, Jeffry William Siregar. "Exploration of Species and Spatial Distribution Non-Timber Forest Products Using Geographic Information System (GIS)," *Journal of Sylva Indonesiana (JSI)*, vol. 6, pp. 1-9, 2023.

[18] S. Latifah, Yonariza, Purwanto. "Study of Community Forest Management (HKm) on Socio-Economic Sustainability Several Regions of Indonesia," *IOP Conference Series: Earth and Environmental Science*, vol. 1188, pp. 012026, 2023.

[19] S. H. Sinaga, A. Suprayogi, Haniah. "Analysis of green open space availability using the normalized difference vegetation index and soil adjusted vegetation index methods using sentinel-2A satellite imagery (Case Study: Demak Regency)," *Undip Geodesy Journal*, vol. 7, pp. 202-211, 2018.

[20] S. S. Rwanga, J. M. Ndambuki. "Accuracy Assessment of Land Use / Land Cover Classification Using Remote Sensing and GIS," *International Journal of Geosciences*, vol. 8, pp. 611-622, 2017.

[21] A. Y. Mabrur, A. Noraini, I. S. Kumala. "Making WebGIS as a Village Potential Information Visualization," *ENMAP (Environment & Mapping) Journal*, vol. 4, pp. 1-6, 2023.