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USE OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS FOR FOREST RESOURCE BALANCE MAPPING IN LEMBAH GUMANTI DISTRICT, SOLOK DISTRICT

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ABSTRACT: The forest resources balance sheet prepared for the implementation of law no. 41 of 1999 ratified article 13 paragraph (4), in the technical process of implementation it always refers to the decision of the Minister of Forestry no. 6444/kpts-ll/1999 regarding instructions for preparing forest resource balance sheets. The forest resource balance sheet is information that describes forest resource reserves, loss and use of forest resources so that at a certain time the trend of surplus or deficit compared to the previous period can be seen. Law. 41 of 1999, article 13 paragraph 4. Remote sensing offers great potential for the development of methods for calculating the balance of forest resources and changes in the forest sector and geographic information systems (SIG) which are used to provide digital form and analysis of the earth's geographic surface so as to form precise and accurate spatial information. This research uses quantitative analysis. This research aims to determine changes in forestry stocks in the Gumanti Valley district, and knowledge about forest balance in the Gumanti Valley region. The results of research based on data show that around -12,708 ha of land in the form of secondary forest has experienced a reduction or deficit in area. Apart from that, other land that has experienced a reduction in area is primary forest. Meanwhile, the land that has experienced the most significant increase in area is in the form of fields covering an area of +13,239 ha from 2017 to 2023.

Keywords: forest resources, mapping, remote sensing, geographic information system, Solok district

1. INTRODUCTION

Indonesia's forest resources have important and strategic implications for ongoing economic, social and environmental development and can even determine Indonesia's geopolitical position globally. In the 80s, the value of forest resources was the country's second largest source of foreign exchange after oil and gas, but this role began to decline in 1999 and in the 2000s the economic role of forest resources gradually declined. In 2010, its contribution was only 0.9 ri to national GDP. The decline in the economic value of forests causes a decline in the quality and quantity of forest resources, due to deforestation due to encroachment, over-exploitation, illegal logging, and infrastructure development, mining activities and illegal reforestation. (zulkifli hasan, 2022)

The forest resources balance sheet prepared for the implementation of law no. 41 of 1999 ratified article 13 paragraph (4), in the technical process of implementation it always refers to the decision of the minister of forestry no. 6444/kpts-ll/1999 regarding instructions for preparing forest resource balance sheets. The forest resource balance sheet is information that describes forest resource reserves, loss and use of forest resources so that at a certain time the trend of surplus or deficit compared to the previous period can be seen. Law. 41 of 1999, article 13 paragraph 4). The forest resource balance is a balance between forest resource assets and liabilities, both from calculating forest area and potential. In addition, forest resource balance sheets are used for policy or decision making. (kalimantan provincial forestry service, 2015)

Indonesia has the largest and most diverse rainforests in the world. Tens of millions of Indonesians directly depend on these forests for their livelihoods, either harvesting forest products for daily needs or working in the wood processing industry. Indonesia has forests based on the decision of the Minister of Forestry, namely an area of 133,528,579.71 ha, water reserves of 5,161,477.28 ha and a land area of 5,161,477 1228,367 102.43 ha. (Barbier-Victor, et al., 2014).

West Sumatra is located on the west coast of the central part of Sumatra Island and covers an area of around 42.2 thousand square kilometers. ("West Sumatra" Wikipedia, 2022) around 56.27% of the administrative area is a national forest area according to Minister of Forestry Decree no. 2022. 2020-2022. Sk.35/menhut-ii/2013 dated 15 January 2013. West Sumatra forests include forest areas for conservation, protection and production

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purposes. Level I West Sumatra no. 522-13-320-1996, dated 6-4-1996 forest area 488,000 ha (84.03%), current forest area reduced by 55,629 ha (11.03%). Forest. (West Sumatra Forestry Service, 2018)
The largest significant forest area in West Sumatra is located in Solok district, reaching 44,810 hectares out of a total of 214,580 hectares of significant land in other provinces. The land area of Solok Regency is quite large, namely 20,090 hectares inside the forest and 24,720 hectares outside the forest. (Gumawan Fauzi, et al., 2006) Changes in forest areas in the Gumanti Valley district are caused by the conversion of forest areas to afforestation, forest fires due to invasive human activities, and farmers trying to improve their agricultural processes in facing the limits of globalization. One way for residents of the Gumanti Valley sub-district to avoid this prohibition is to cultivate protected forest areas to increase their agricultural area. However, from another perspective, this method can prove to be dangerous. Disturbing the ecological environment. Processes related to the function of the forest itself. . The clearing of new land into forest areas due to land impacts occurs more frequently in cold air areas in the Gumanti Valley district compared to areas in the Guanti Valley district, Solok district. (Octinaldi, 2012) The status of forest resources and the potential of several sub-regions in Solok Regency is currently unknown. (RPJMD Solok Regency et al, 2021)
A method is needed to assess the balance of forest resources and forest potential in a wider area. One way to meet these needs is through the use of remote sensing technology. Remote sensing offers great potential for the development of methods for calculating the balance of forest resources and changes in the forest sector in terms of profitability, time and ease of measurement. The use of remote sensing in assessing forest reserve balances has expanded with increasing spatial accuracy, and is considered very effective in calculating forest reserve balances. (Danoedoro, 2012).

2. RESEARCH METHODS

2.1 Research site

This research was located in Lembah Gumanti sub-district, Solok district, West Sumatra provincelocated at coordinates 01.57'18 – 01.13'23 south latitude and 100.44'48 – 100.55'45 east longitude, with an area of 456.72 square kilometers.

2.2 Tools and materials

The type used in this research is quantitative research. The data used is secondary data, namely satellite images from Landsat 8 in 2017 and Landsat 9 in 2023 which were downloaded on EarthExplorer and administrative boundary maps downloaded on Inageoportal.

2.3 Data Processing Stage

2.3.1 Initial processing

At this stage, radiometric correction is carried out to improve the visual quality of the image while correcting pixel values that do not match the reflectance or spectral emission values of the actual object (Nilasari, 2017). As well as carrying out atmospheric corrections to reduce the influence of atmospheric disturbances on satellite image data, so that the reflectance values obtained are close to the actual reflectance values of objects on the earth's surface.
Next, cropping was carried out on the image using a polygon-shaped shapefile from the local government of Lembah Gumanti District, Solok Regency.

2.3.2 Processing

The maximum likelihood classification method is the most popular method for classifying remote sensing data. Maximum similarity classifiers quantitatively evaluate the variance and correlation of category spectral response patterns when classifying unknown pixels. The maximum likelihood method image classification process is carried out by creating a training sample or region of interest (ROI) on the image, then classifying it into seven classification classes: Primary Forest, Secondary Forest, Body of Water, Settlement, Field, Vacant Land, Shrub. and then run it using the maximum likelihood classification tools in ArcGis.

2.3.3 Creating a Land Use Change Matrix

From the land use results for 2017 and 2023, there are land use results for 2017 to 2023 which are processed using Microsoft Excel and then displayed in the form of tables and graphs.

2.3.4 Making Example Points

Purposive random sampling is a technique for determining and taking samples determined by researchers with certain considerations:

$$N = + \frac{Z^2 p q}{E^2}$$

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Where: N : Number of Samples
Z: The standard deviation value is 2
p : Expected accuracy is 85%
q : 100 – p
E : Error received

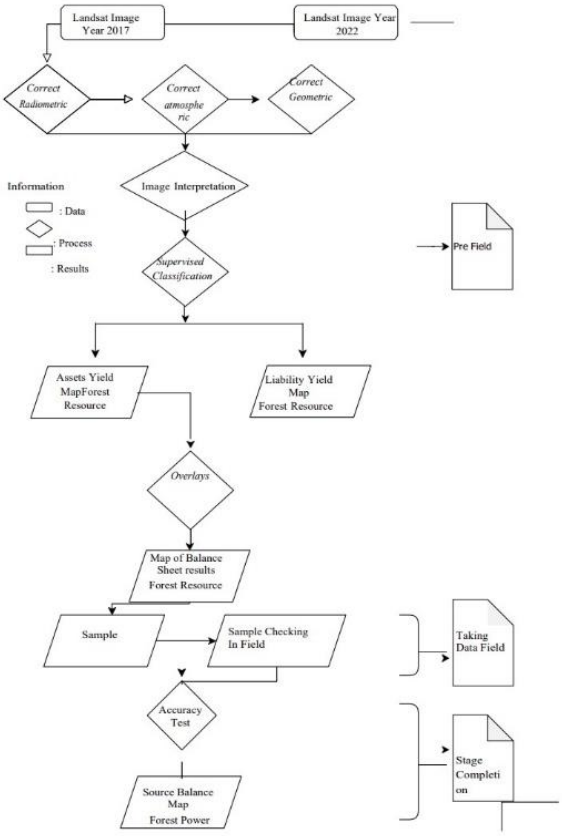
2.3.5 Field Survey / Field Inspection

Sampling using Google Earth Pro software is based on sample points that have been distributed to each land use class.

2.3.6 Accuracy Test

Accuracy tests are carried out to assess the accuracy of land use classification data from processing using Landsat imagery. Accuracy testing is a process that shows the truth of the research carried out. Accuracy testing classification uses the Kappa Accuracy calculation method which considers kappa accuracy, namely user value calculations, manufacturer accuracy calculations, overall accuracy calculations and kappa accuracy calculations.

2.3.7 Flow chart



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3. RESEARCH RESULTS AND DISCUSSION

3.1 Land Use Classification 2017

The two-year land use classification used is Landsat 8 OLI imagery for 2017.

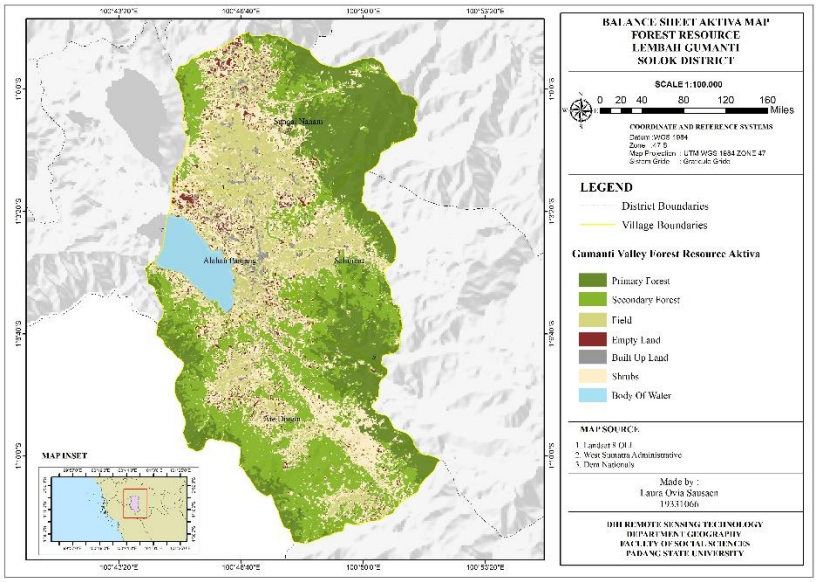

Figure 1. Land Use (Assets) in 2017

The land use that dominates the Lembah Gumanti sub-district in 2017 is in the Secondary Forest Area of 65,421 Ha or 23% of the Lembah Gumanti District, then in the Primary Forest Area of 52,254 Ha or 23%, and 50,794 Ha of 23% in the Shrub. Then the small area of built-up land is 4,482 ha and is 2%, the vacant land is 6,300 ha and is 3%. Meanwhile, the water body is 8,685 hectares or 4% of the Gumanti Valley District.

Table 1. Land Use Area 2017

Land Use	Number of Pixels	Area (Ha)	Area Percentage(%)
Built Up Land	577.00	5,193	2%
Body of Water	967.00	8,703	4%
Primary Forest	5,655.00	50,895	23%
Secondary Forest	5,857.00	52,713	23%
Shrubs	5,941.00	53,469	24%
Field	5,604.00	50,436	22%
Empty land	414.00	3,726	2%
Amount	25,015	225,135	100%

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3.2 Land Use Classification 2023

The two-year land use classification used is Landsat 9 OLI-2 imagery for 2023.

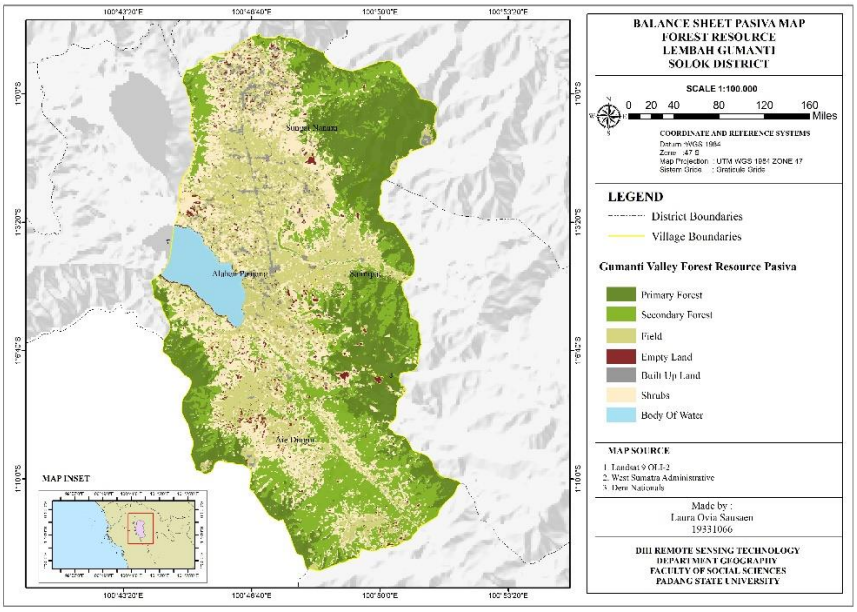

Figure 1. Land Use (Liabilities) in 2023

Land use in Lembah Gumanti District in 2023, the greatest area change will occur in the Shrubs, namely 53,469 Ha or 24%, Secondary Forest Area 52,713 Ha or 23%, Primary Forest 50,895 Ha or 23%, The smallest area is in Vacant land is 3,726 ha or 2%, built-up land is 5,193 ha, 2% and water bodies are 8,703 ha or 4% of the area in Lembah Gumanti District.

Table 2. Land Use Area 2023

Land Use	Number of Pixels	Area (Ha)	Area Percentage(%)
Built Up Land	577.00	5,193	2%
Body of Water	967.00	8,703	4%
Primary Forest	5,655.00	50,895	23%
Secondary Forest	5,857.00	52,713	23%
Shrubs	5,941.00	53,469	24%
Field	5,604.00	50,436	22%
Empty land	414.00	3,726	2%
Amount	25,015	225,135	100%

3.2.1 Land use changes from 2017 to 2023

Based on the results of data analysis on land cover and use in Lembah Gumanti District, changes in the area of forest resources in Lembah Gumanti District are in the form of primary forest -4%, secondary forest -38%, Shrubs 40%, Vacant Land 8%, Built-up Land 2 %, Fields +40%, Water Bodies 0%. Based on the data above, it is clear that the most significant changes in the area of forest resources occurred in shrubs at 40% and secondary forests at -38%. This shows that the increase in land conversion has an effect on changes in the area of forest resources. Changes in

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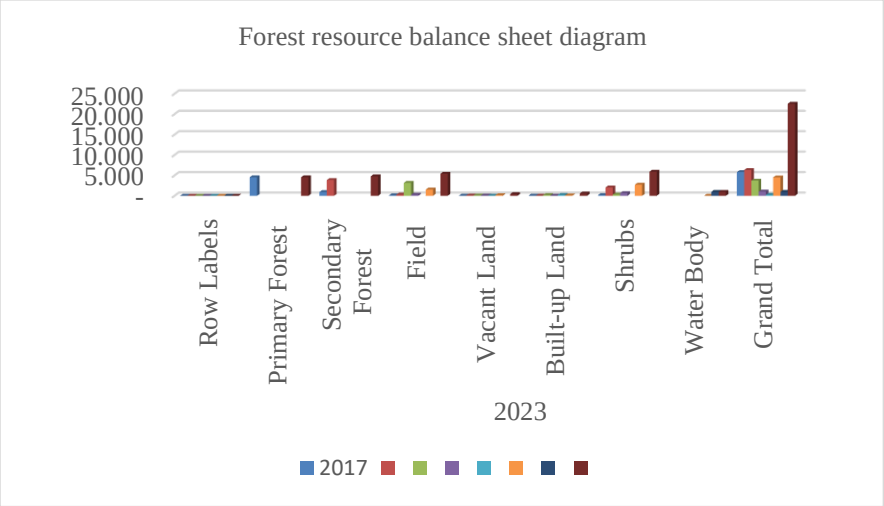
land cover and use in Lembah Gumanti District, if seen from 2017 (assets) and 2023 land cover and use (liabilities), it can be seen that the balance of forest resources in Lembah Gumanti District has experienced a deficit in primary and secondary forests but in fields and shrubs experiencing a surplus.

Table 3. Changes in land use from 2017 to 2023

Row Labels	Forest Primary	Forest Secondary	Field	Land Blank	Land Awakened	Bush Thicket	Body Water	Grand Total
Primary Forest	4,544.00	909.70	122.80	19.40	24.60	182.00		5,802.50
Secondary Forest		3,864.70	307.40	75.30	24.90	2,038.60		6,310.90
Field			3,156.70	75.00	189.50	297.40		3,718.60
Empty land			272.80	57.70	41.50	652.70		1,024.70
Built Up Land				20.80	205.80			226.60
Shrubs			1,534.60	159.60	90.70	2,713.00	5,10	4,503.00
Body of Water							957.80	957.80
Grand Total	4,544.00	4,774.40	5,394.30	407.80	577.00	5,883.70	962.90	22,544.10



Graph 1. Forest Resource Balance 2017-2023

3.3 Accuracy Test

In classification for accuracy testing using the Kappa Accuracy calculation method. Kappa accuracy can be used for the land cover mapping process by looking at the accepted accuracy value of 84% or 0.84 (Sausaen Laura Ovia, 2023). The following are the calculations that determine the sample points taken in this research. It is hoped that they can represent each classification class. The number of samples calculated can be determined. Determination of the sample size is determined using the following formula (McCoy, 2005):

$$\text{No} = \frac{2^2 \; x \; 85 \; x \; 15}{15^2} \quad \frac{4 \; x \; 1275}{225} = 23$$

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Table 4. Distribution of sample points based on land use class

Land Use	Sample Point
Primary Forest	6
Secondary Forest	6
Field	4
Empty land	1
Developed Land	1
Shrubs	4
Body of Water	1
Amount	23

Table 5. Level of truth of land use interpretation

Class Reference	Sample Data 1	2	3	4	5	6	7	Total Sample	Omission	MA %
1	5	1	0	0	0	0	0	6	1	83%
2	0	6	0	0	0	0	0	6	0	100%
3	0	0	4	0	0	0	0	4	0	100%
4	0	0	0	1	0	0	0	1	0	100%
5	0	0	0	0	1	0	0	1	0	100%
6	0	0	2	0	0	2	0	4	2	50%
7	0	0	0	0	0	0	1	1	0	100%
Total Sample	5	7	6	1	1	2	1			
Omission	0	1	2	0	0	0	0			
MA %	100%	85%	66%	100%	100%	100%	100%			
Overall Accuracy	86%									
Kappa	84%									

In terms of accuracy using the kappa accuracy method, the user accuracy of primary forests is 100%, secondary forests 85%, fields 66%, empty land 100%, built-up land 100%, shrubs 100%, water bodies 100%. In terms of overall accuracy, a value of 86% was obtained and in the calculation of kappa accuracy, a value of 84% was obtained.

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3.4 Forest Resource Balance Map Results

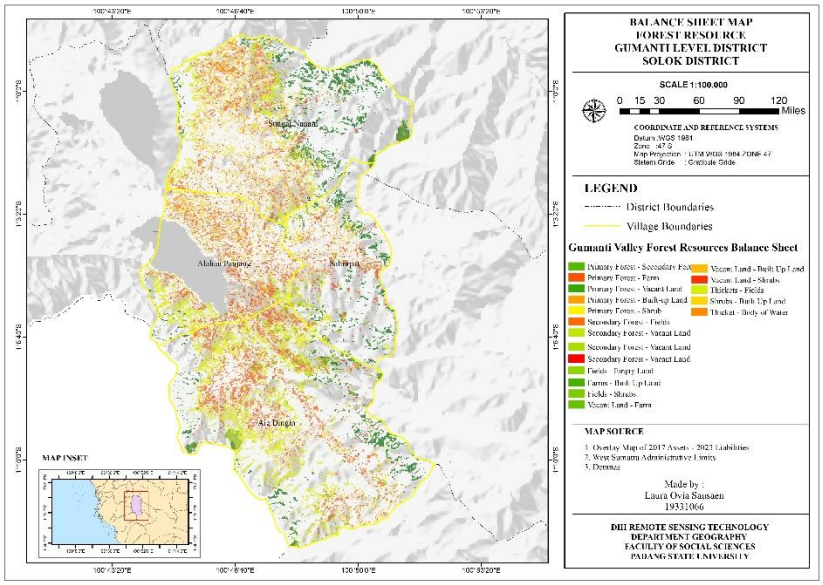

Figure 3. Gumanti Valley Forest Resources Balance Map

4 CONCLUSION

The balance of forest resources in the Gumantic valley district tends to experience a balance between surplus and deficit. The largest deficit occurred in secondary forests, namely 38%, the smallest deficit occurred in primary forests, 4%, and the largest surplus occurred in fields, namely 40%, then the smallest surplus occurred in water bodies, 0%..Changes in land cover and use in Lembah sub-district Gumanti, starting from 2017 to 2023, the most significant change in the addition of field areas and reduction in secondary forest areas, the accuracy of Landsat 8 OLI and 9 OLI-2 images in making forest resource balance maps is 86%, where the figure of 86% is feasible for used as a source in mapping forest resource balances.

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