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LAND COVER CHANGE ANALYSIS IN TERONG TAWAH USING GOOGLE EARTH ENGINE

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ABSTRACT

This study analyzes land cover changes in Terong Tawah Village, West Lombok using Google Earth Engine (GEE) as the main platform. Landsat 8 satellite imagery data for 2015, 2018, 2022, and 2023 was used to classify five types of land cover: forests, settlements, fields, vacant land, and roads. The methods applied include data preprocessing, classification using the Random Forest algorithm, and spatial change analysis. The results show significant trends, such as an increase in settlement area and a decrease in vegetation. Validation of classification accuracy results in an overall accuracy value of above 93% per year. This study demonstrates the effectiveness and accuracy of GEE in analyzing land cover changes and provides important insights into development dynamics in Terong Tawah Village.

Keywords: *Land Cover Change, Google Earth Engine, Random Forest*

1. INTRODUCTION

Land cover refers to the physical materials present on the Earth's surface (Noviati et al., 2024). It reflects the interaction between natural and social processes occurring on the Earth's surface. Furthermore, land cover provides essential information useful for modeling and understanding natural phenomena on Earth Jia et al [9]. Land cover data can be utilized to study climate change or demonstrate how human activities impact changes on a global scale Jia et al [9].Accurate land cover information is a critical aspect of improving the effectiveness of hydrological, atmospheric, and ecosystem models Jung et al [10].Land cover information is often used as a primary resource for geoscience research and global change analysis Jia et al [9].

Remote sensing is one technology that can be used to analyze land cover changes It has been widely utilized to provide diverse spatial information about the Earth's surface quickly, precisely, accurately, extensively, and efficiently, including in land cover classification applications Gong et al [6]. Conventional methods, such as pixel-based classification, remain commonly applied in processing geospatial data through remote sensing technology. However, these methods often involve lengthy processing times and require high-performance computers, which can significantly delay image processing, particularly when analyzing large areas.

In early December 2010, Google introduced an advanced cloud-based computing technology called Google Earth Engine (GEE). This technology allows users to access and analyze large volumes of geospatial data efficiently GEE is a service designed for geospatial data processing and analysis using Google's repository and cloud-based system. It supports JavaScript and Python programming languages for implementing various algorithms that facilitate geospatial data analysis Fikri et al [5]. GEE offers algorithms specifically designed to process georeferenced satellite imagery stored in the cloud. These algorithms enable efficient utilization of satellite data for various geospatial analyses, making it easier for users to access and manage data available on the platform. The platform also provides an extensive catalog of geospatial data, including imagery from the Landsat, Sentinel-1, Sentinel-2, and MODIS-

Terra Aqua series, along with other datasets stored on the GEE server.

Terong Tawah is a village in the Labu Api subdistrict of West Lombok Regency, located at the border between West Lombok and the city of Mataram. Its location has made it a development hub and a transit area for incoming migrants Febrianti et al [4]. The village has experienced population growth over the last decade, with an annual growth rate of 0.63%. In 2016, the population was recorded at 6,525 residents BPS [3]. As the population grows each year, so does the demand for land for residential purposes and other activities, such as road narrowing, which makes the area prone to traffic congestion. Various studies have explored the use of GEE for land cover classification, employing both supervised and unsupervised methods. For instance, studied land cover in Africa, classifying it into built-up areas, open land, water, and vegetation. Similarly, conducted land cover observations using Landsat satellite imagery, covering areas ranging from small scales to global scales over a 12-year observation period. This study aims to analyze land cover changes in 2015, 2018, 2022, and 2023 using the cloud-based geospatial data processing platform Google Earth Engine (GEE). The case study focuses on Desa Terong Tawah, West Lombok, utilizing Landsat 8 OLI imagery for each study year.

2. RESEARCH METHOD

This study applies a quantitative approach based on spatial analysis to analyze the dynamics of land cover change in Terong Tawah Village in 2015, 2018, 2022, and 2023. Google Earth Engine (GEE) was used as the primary platform for processing and analyzing satellite imagery data. The methodological steps implemented are as follows:

1. Data and Data Sources
   This study used Landsat 8 satellite imagery data for land cover analysis:
   - Observation Years: 2015, 2018, 2022, and 2023.
   - Spatial Resolution: 30 meters.
   - Data Source: Imagery accessed through the Google Earth Engine repository.
   - Other supporting data: Terong Tawah Village administrative boundaries
2. Data Preprocessing
   Preprocessing was performed to improve data quality:
   - Cloud and Shadow Masking: Using GEE's built-in function to remove clouds and shadows.
   - Area of Interest (AOI): Cropping the imagery within Terong Tawah Village based on administrative boundaries.
   - Compositing: Creating a composite image based on median pixel values to reduce seasonal effects.
3. Land Cover Classification
   The directional classification method used to identify and group land cover types is as follows:
   - Land Cover Classes: Open Land, Rice Fields, Residential Areas, Highways, and Vegetation.
   - Training Data: Sample data was taken based on visual interpretation of the imagery for each class.
   - Classification Algorithm: Using the Random Forest algorithm, which has high accuracy for spatial data.
4. Land Cover Change Analysis
   Land cover change analysis was conducted using:
   - Overlay Analysis: Comparing classification results from 2015, 2018, 2022, and 2023 to identify changes between land cover categories.
   - Trend Change: Quantitative changes every 30 meters were analyzed for each class.
5. Validation of Classification Results
   Validation is performed to ensure classification accuracy:
   - Confusion Matrix: This is an analytical tool used to analyze the performance of a classification model in machine learning. This matrix provides a detailed overview of how the model's predictions compare to the actual data.

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Table 1 Confusion Matrix

Kelas Referensi	**Dikelasan ke Kelas** (Data Klasifikasi di Peta)			**Jumlah** Piksel	**Akurasi**
	A	B	C		
A	X_{11}	X_{12}	X_{13}	$X_1 +$	$\frac{X_{11}}{X_1 +}$
B	X_{21}	X_{22}	X_{23}	$X_2 +$	$\frac{X_{22}}{X_2 +}$
C	X_{31}	X_{32}	X_{33}	$X_3 +$	$\frac{X_{33}}{X_3 +}$
Total Piksel	$X +_1$	$X +_2$	$X +_3$	$\boldsymbol{N}$	
Akurasi Pengguna	$\frac{X_{11}}{X +_1}$	$\frac{X_{22}}{X +_2}$	$\frac{X_{33}}{X +_3}$		

- Kappa Coefficient:
  The kappa coefficient is used to measure the degree of agreement between classification results and reference data that did not occur by chance.
  Overall Accuracy.

$$((\sum_{i=1} X_{ii})/N) \times 100\%$$

Kappa Accuracy:

$$[(N \sum_{i=1} X_{ii} - \sum_{i=1} X_1 + X_{+1})/(N^2 - \sum_{i=1} X_1 + X_{+1})] \times 100\%$$

Description:
- N : Number of pixels in the sample
- X_1 : Number of pixels in row i
- X_{+1} : Number of pixels in column i
- X_{ii} : Diagonal value of the contingency matrix in row i and column i

- Kappa Coefficient:
  The kappa coefficient is used to measure the degree of agreement between classification results and reference data that did not occur by chance.
  The kappa value is interpreted as follows:
  - <0.20: *Poor Agreement*
  - 0.21–0.40: *Fair Agreement*
  - 0.41–0.60: *Moderate Agreement*
  - 0.61–0.80: *Substantial Agreement*
  - >0.81: *Almost Perfect Agreement*

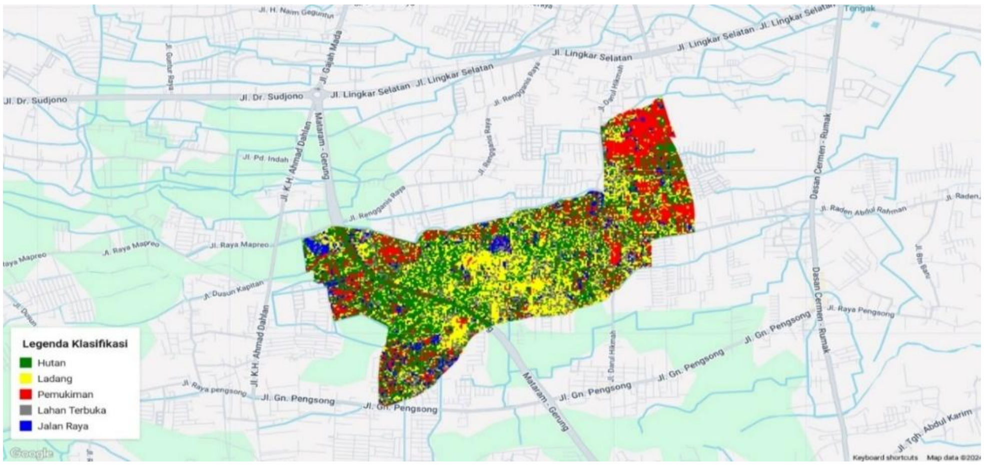
  Kappa calculations are carried out based on the error matrix generated from data validation.

6. Analysis Process Using Google Earth Engine (GEE)
   - Programming Language Used: JavaScript was used to write analysis scripts in the GEE platform.
   - Algorithm Function: GEE's built-in algorithms were applied for masking, classification, and change analysis.
   - Visualization: Classification and change results were displayed as thematic maps in the GEE platform.
   - Data Export: Analysis data was exported to GeoTIFF format for further analysis.

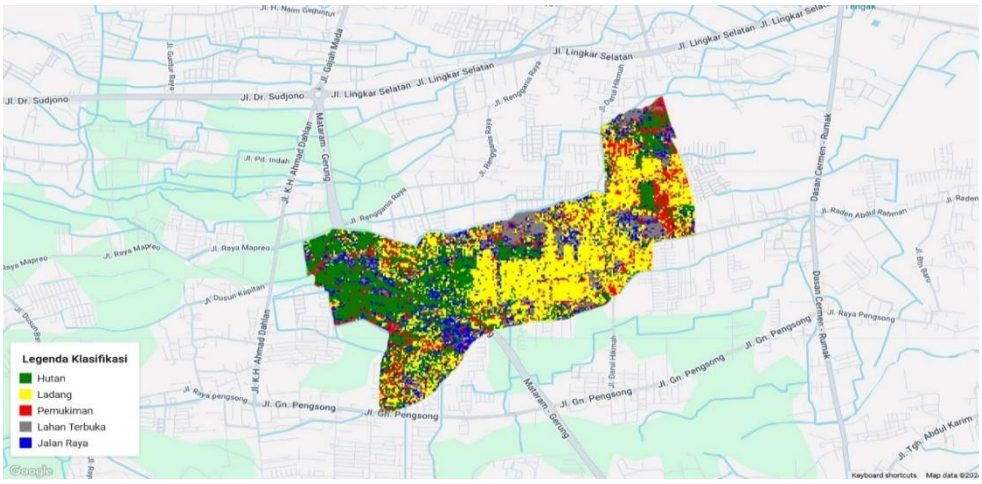
7. Data Analysis Procedure
   - Classified maps for each year (2015, 2018, 2022, and 2023) were created to show land cover distribution.
   - Land cover changes were analyzed in the context of development in Terong Tawah Village, such as the expansion of built-up land and the reduction of vegetation.

3. RESULTS AND DISCUSSION

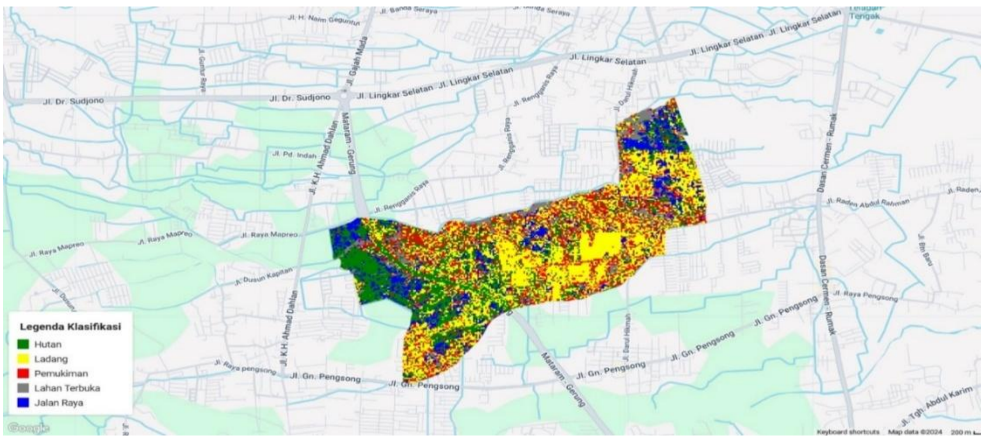
Based on the research conducted, the results of land cover classification in 2015, 2018, 2022, and 2023 were obtained in the image below.



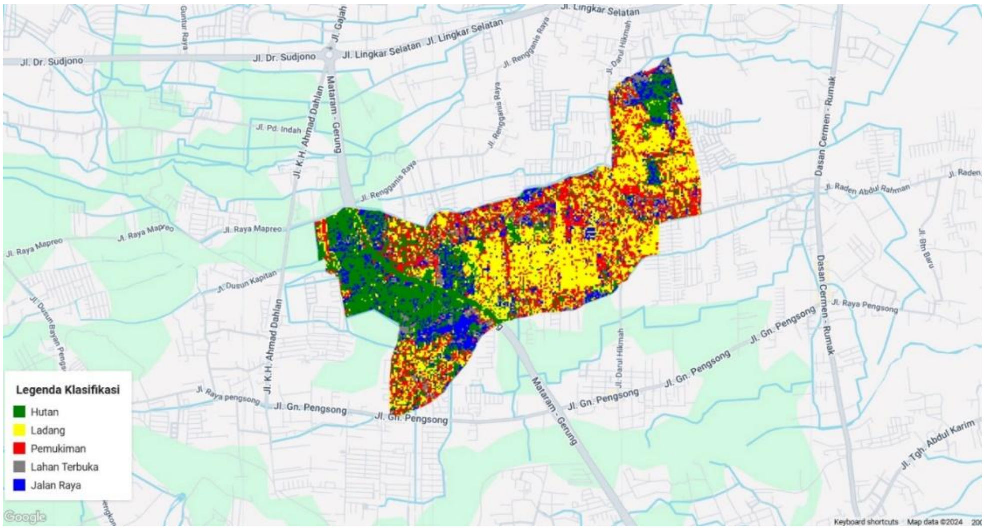
Picture 1 Land Cover Classification 2015



Picture 2 Land Cover Classification 2018



Picture 3 Land Cover Classification 2022



Picture 4 Land Cover Classification 2023

We can calculate the land cover classification area in Terong Tawah Village directly through the GEE platform, where we have five classes of land classified. The annual area classifications show year-to-year differences/changes in Terong Tawah Village. The following table shows the land cover changes in Terong Tawah Village.

Table 2 Area $(Km)^2$ Land Cover Area.

No.	Class	2015	2018	2022	2023
0	Forest	0.8691	0.6541	0.7134	0.6417
1	Settlements	0.6874	0.8015	0.8555	0.8787
2	Fields	0.3153	0.2863	0.2292	0.4039
3	Open Land	0.1627	0.1589	0.1574	0.1341
4	Highways	0.0987	0.1875	0.1547	0.1431

Based on Table 4, which shows the land cover class suitability index in 2015, 2018, 2022, and 2023, it can be interpreted as follows:

1. **Changes in the Forest class:** In the forest class, there was a decrease in the suitability index from 0.8691 in 2015 to 0.6417 in 2023. This decrease could be due to the conversion of forests to other land areas, such as residential areas or open spaces, which often occurs along with increased development and land needs in the area.
2. **Changes in the Settlement class:** The settlement class showed an increasing trend in suitability, from 0.6874 in 2015 to 0.8787 in 2023. This increase reflects the rapid development of residential development, leading to the expansion of residential areas with increased population density and housing facilities.
3. **Changes in the Field Class:** The field class experienced a significant decrease from 0.3153 in 2015 to 0.2292 in 2022, and a slight increase to 0.4039 in 2023. This decrease is likely due to the conversion of field land to residential or open land, while the slight increase in 2023 could be due to the return of some land to agricultural or field use.
4. **Changes in the Open Land Class:** The open land class showed a very low value (0.1627 in 2015) and continued to decline in subsequent years, reaching 0.1341 in 2023. This indicates that open land is decreasing and is being converted into other classes such as built-up land or high vegetation.
5. **Changes in Highway class:** The highway class shows a very small increase from 0.0987 in 2015 to 0.1431 in 2023. Although there is an increase, this change is relatively small compared to other

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classes, which may reflect more limited infrastructure development or more focused on certain areas only.

Accuracy Test Results

The results of the 2015, 2018, 2022, and 2023 land cover classifications show that five land cover classes remain within the classification. Accuracy testing was conducted using 25 samples from each land cover class. The results of the Confusion Matrix calculation performed on GEE showed the following Overall Accuracy values:

Table 3 Land Cover Confusion Matrix 2015

Class	1	2	3	4	5	Total
0	635	8	9	3	11	666
1	35	626	10	12	1	684
2	12	5	635	7	7	666
3	18	20	11	626	9	684
4	9	7	22	`10	636	684
Total	709	666	687	658	664	
Overall Accuracy			0.9332			

Table 4 Land Cover Confusion Matrix 2018

Class	1	2	3	4	5	Total
0	621	17	12	1	15	666
1	12	645	17	5	5	694
2	8	32	621	7	7	675
3	9	14	14	641	6	684
4	10	23	13	16	622	684
Total	660	731	677	670	655	
Overall Accuracy			0.9281			

Table 5 Land Cover Confusion Matrix 2022

Class	1	2	3	4	5	Total
0	636	9	5	4	12	666
1	6	655	9	5	9	694
2	11	22	611	15	7	666
3	4	9	22	641	8	684
4	27	24	17	21	595	684
Total	684	719	664	686	631	
Overall Accuracy			0.9273			

Table 6 Land Cover Confusion Matrix 2023

Class	1	2	3	4	5	Total
0	628	8	13	6	11	666
1	10	648	14	4	8	684
2	5	23	629	5	4	666
3	4	5	24	641	10	684
4	15	14	11	8	636	684
Total	662	698	691	664	669	
Overall Accuracy			0.9403			

Based on the calculation of the confusion matrix in tables 3 to 6, it is obtained that the classification of

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land cover in 2015, 2018, 2022, and 2023 with the Machine Learning algorithm using GEE can provide very good accuracy with values above 93.3%, 92.8%, 92.7% and 94.0% for overall accuracy and kappa accuracy values, respectively.

4. CONCLUSION AND SUGGESTIONS

This study was conducted to analyze land cover changes in Terong Tawah village to observe the causes of congestion in the area by utilizing land cover changes from 2010 to 2024 using Landsat 8 satellite imagery and the Classification and Regression Tree (CART) algorithm. Based on the results of the discussion on the land cover area of Terong Tawah Village from 2015-2023, information was obtained that in the area there had been significant changes, both in residential areas, open areas, road rice fields, and vegetation areas there must be changes every year, where the area of residential areas is increasingly expanding and the area of the highway is getting smaller. The CART method applied with a machine learning algorithm through GEE produces a high level of accuracy, with overall accuracy and kappa accuracy values exceeding 90% for each year. The area of land cover in Terong Tawah Village can be calculated using GEE based on six land cover classes that have been classified, with the results showing variations in the area of each class from year to year. The use of GEE enables efficient and accurate land cover change analysis and supports comprehensive change monitoring. Thus, this study significantly contributes to understanding the dynamics of land cover change in Terong Tawah Village and confirms GEE's potential as an efficient and reliable platform for geospatial analysis.

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