ISSN 3032-1230
The Southeast Asian Journal of Advance Engineering and Technology *Original Research*
Vol. 2, No. 2, June 2025, pp.48-54

Land Use Dynamics Using Google Earth Engine
(Case Study: Padang City, West Sumatra Province)

Sinta Dewi Siregar[1], Fajrin[1], Ilham Armi[1], Dwi Marsiska Driptufany[1], Dwi Arini[1]
[1] Geodesy Engineering Study Program, Faculty of Engineering, Institut Teknologi Padang, Indonesia

Corresponding Author:

Fajrin
Geodesy Engineering Study Program, Institut Teknologi Padang, West Sumatra, Indonesia

E-mail: fajringeo@gmail.com

ABSTRACT

Land use change is a critical issue in rapidly developing cities, driven by population growth and urban expansion. This study analyzes land use dynamics in Padang City, West Sumatera, using Sentinel-2 imagery from 2020-2022, and 2024 processed on the Google Earth Engine platform. The Random Forest supervised classification method was applied to identify six major land use categories: water bodies, forest, open land, settlement, rice fields, and shrubs. The results show a consistent decline in forest and rice fields, while open land and settlement expanded significantly due to urbanization. Between 2020 and 2022, large areas of forest were converted into shrubs, and rice fields were transformed into residential zones. Although the rate of change slowed during 2022-2024, forest degradation and agricultural land conversion persisted. The overall classification accuracy exceeded 99%. Confirming the reliability of the approach. These finding demonstrate the effectiveness of Google Earth Engine for spatio-temporal monitoring and provide valuable insight for sustainable spatial planning in rapidly growing regions.

Keywords: Land Use, Google Earth Engine, Random Forest, Padang City, Remote Sensing

1. Introduction

Economic, social, and cultural developments in a city are inevitable. These conditions can create new growth locations for various activities, which may impact land use changes. In the city center, land use has significantly shifted from residential areas to commercial zones, while in the outskirts, agricultural land has been converted into residential and industrial areas. As a result of this phenomenon, people tend to prefer living in suburban areas while their workplaces remain in the city center. During the development process, land use often changes due to rapid population growth and increasing land demands. This frequently leads to conflicts of interest regarding land use and discrepancies between actual land use and its designated planning [1].

Padang City is the capital of West Sumatra Province. It has been rapidly developing due to the activities and services of its residents. Unconsciously, the population growth rate never stops and continues to increase. The population of West Sumatra has consistently grown from 2010 to 2021, according to data from the 2010/2020 population census and the intercensal survey (BPS, 2021:2022). The increasing population and urban development in the center of Padang City significantly impact land use changes [2]. These changes are primarily driven by high population growth. In 2020, land use increased rapidly, particularly for residential and industrial areas. By 2021, land use further expanded for residential areas, industrial zones, commercial enterprises, service areas, fields, vacant land, and urban land. Conversely, there was a decline in rice fields [3].

Land use changes have been occurring for a long time. The continuous increase in population directly impacts the growing demand for land. Land use changes in Padang City are suspected to be influenced by population growth, the proportion of people working in the non-agricultural sector, accessibility distance, and the number of incoming migrants. As the city's population grows, the demand for land increases. Since land cannot be expanded, land use changes tend to reduce the proportion of land previously used for agricultural purposes, converting it into non-agricultural uses. Land use change refers to any human intervention in a collection of natural and man-made resources to fulfill material or spiritual needs [4]. The purpose of land use change is to maximize land resources to achieve optimal benefits [5]. Random Forest is one of the most effective approaches for identifying land use using satellite imagery or other available data types. In this study, the Random Forest method is used to categorize land use. This method generates multiple decision trees, where the final classification is determined based on majority voting. Random Forest is highly effective in addressing overfitting issues, as the trees or classifications it produces are generated randomly, preventing them from being overly influenced by overfitting [6].

Advancements in remote sensing technology have transformed the need for massive, efficient, and fast data processing. Cloud computing-based systems integrate big data and the Internet of Things (IoT) to address challenges in the field of remote sensing. Google Earth Engine (GEE) is one of the latest technologies in remote sensing. For geospatial analysis and decision-making, GEE utilizes the latest multi-temporal imagery data to process large volumes of geospatial information [7]. By leveraging cloud computing technology, all activities in Google Earth Engine rely on the Internet for data storage, applications, and processing, enabling the rapid resolution of complex problems. The shift toward machine learning technology is driven by rapid technological advancements. Google Earth Engine is one of the platforms that has integrated machine learning concepts into the field of remote sensing.

2. Research method

This study examines land use dynamics using Google Earth Engine with a case study in Padang City, West Sumatra Province. This research is descriptive and quantitative. The descriptive aspect illustrates the land use map of Padang City using Google Earth Engine, while the quantitative aspect involves algorithmic calculations to measure land use dynamics in Padang City, West Sumatra Province, utilizing remote sensing data and supplementary data. This study employs supervised classification, conducted under analytical guidance. The research location is in Padang City, the largest city on the west coast of Sumatra Island and the capital of West Sumatra Province. Padang City is situated between 0°44’00” and 01°08’35” South Latitude and 100°05’05” and 100°34’09” East Longitude, covering an area of 694.22 km² with a coastline of 84 km. Extending from north to south, Padang City has a 68.126 km-long coastline and is characterized by the Barisan Mountains, with a hilly region (including rivers) spanning 486.209 km².

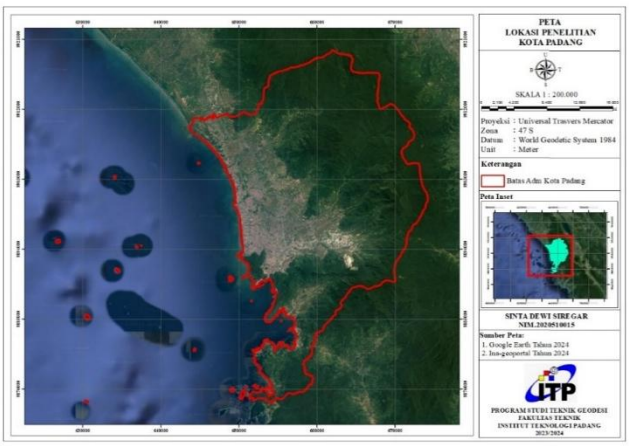

Figure 1. Research Location

The first Based on the research begins with data collection such as Table 1, which includes Sentinel 2A imagery from 2020, 2022, and 2024, as well as the administrative boundaries of Padang City in 2024. Once the data is collected, image interpretation is carried out, starting with Cloud Masking to remove cloud disturbances in the satellite imagery. Next, land use samples are collected for use in supervised classification using the Random Forest method. This is followed by training and testing of the samples to improve classification accuracy. The classified imagery is then visualized for further analysis. The next step is accuracy assessment, which determines whether the classification results meet the established standards. If the accuracy is insufficient, the classification process is refined and re-evaluated. Once the required accuracy is achieved, the study proceeds to geospatial analysis of land use changes (Overlay) to compare changes over the studied time periods. The outcome of this research is a land use change map of Padang City, which serves as the primary output before the study is concluded.

Table 1. Data

Data	Source
Administrative Boundary of Padang City (2024	Ina-Geoportal
Sentinel Imagery (2020, 2022, and 2024)	Google Earth Engine

Accuracy assessment is calculated using the producer's accuracy and user's accuracy formulas, followed by the overall accuracy calculation using the following formula:

$$\text{Overall Accuracy} = \frac{Number\ of\ Agreements}{Total\ Observations} \quad (1)$$

The number of agreements is the total number of elements in the main diagonal, and the total observations are the sum of all elements in the table. Then, use the Kappa Index formula to measure the level of agreement between the classification results and the reference data:

$$K = \frac{Po - Pe}{1 - Pe} \quad (2)$$

Where Po is Overall Accuracy (the number of correctly classified pixels divided by the total pixels) and Pe is probability of random agreement between the classification results and the reference data

3. Result and discussion

The land use maps for 2020, 2022, and 2024 illustrate changes across various land categories in Padang City. In 2020, forest areas dominated land use but gradually decreased in size until 2024. Conversely, there was an increase in open land and settlements, reflecting land conversion due to urbanization and development. Rice fields also experienced a decline, indicating a possible shift from agricultural land to built-up areas. Meanwhile, water bodies remained stable without significant changes. Overall, these land use dynamics suggest growing development pressure on green spaces and agricultural areas.

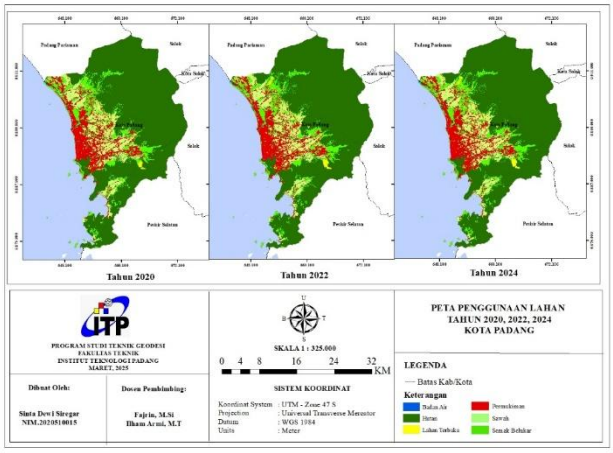

Figure 3. Land Use in 2020, 2022, and 2024

Over the past five years (2020-2022-2024), various land use changes have occurred in the study area. Significant land conversion has been observed in production forest areas and shrubs, which have been transformed into agricultural and residential land. Additionally, there has been a conversion of agricultural land into residential areas. The analysis of land use changes in the study area was conducted using Sentinel-2 imagery observations through Google Earth Engine, with further data analysis performed using ArcMap. A more detailed overview of the land use changes can be seen in Table 2. Table 3 presents the accuracy assessment results of land use classification for the years 2020, 2022, and 2024, including the number of classes, overall accuracy, and Kappa Index.

Table 2. Land Use Area in 2020, 2022, and 2024 (Ha).

Type of area	2020	2022	2024
Water bodies	463,493	463,493	463,493
Forest	45.973,087	45.722,286	45.715,363
Open land	174,422	324,257	329,700
Residential	8.244,893	8.302,948	8.305,402
Agricultural	6.915,029	6.774,390	6.770,283
Shrubs	7.651,244	7.834,795	7.837,927

Table 3. Accuracy Assessment

Years	Number of Classes	Overall Accuracy	Kappa Index
2020	7	99,06%	95,73%
2022	6	99,56%	97,72%
2024	7	99,72%	98,73%

Land Use Change Map 2020-2022

The Land Use Change Map 2020-2022 illustrates the dynamics of land conversion in Padang City. Significant changes include the transformation of forests into shrubs and open land, as well as the conversion of rice fields into residential areas. These changes are primarily concentrated in coastal areas and around the city center, reflecting the impact of urbanization and increasing development activities.

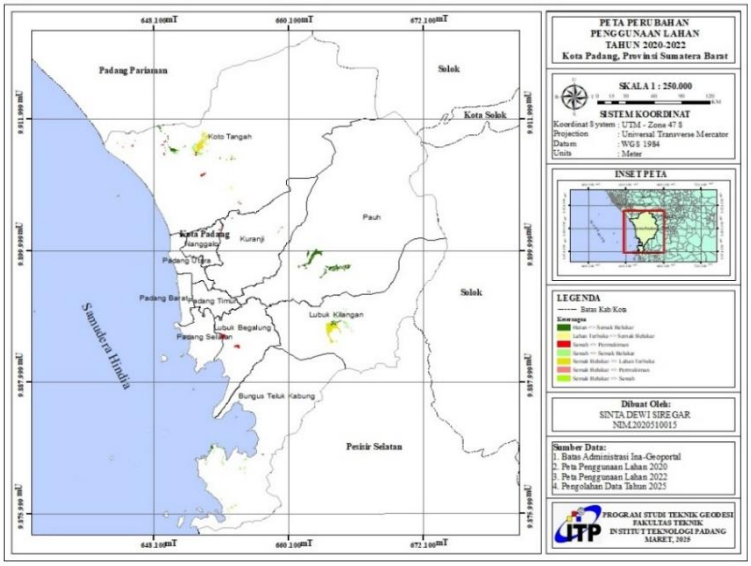

Figure 3. Land Use Change Map 2020-2022

Land use changes in Padang City from 2020 to 2022 show significant dynamics, particularly in the conversion of rice fields and forests. Many rice fields have been transformed into residential areas (55.453 hectares) and shrubs (91.614 hectares), reflecting development pressures and land-use changes. The conversion of forests into

shrubs, covering 197.006 hectares, indicates land degradation. Additionally, shrubs have undergone various transformations, such as becoming open land (154.583 hectares), residential areas (2.602 hectares), and rice fields (6.428 hectares), highlighting both natural dynamics and human intervention in land use planning.

Table 4. Land Use Changes in Padang City (2020-2022)

Land use changes	Area (Ha)
Forests into open land	197,006
Open land into shrubs	4,749
Rice fields into residential	55,453
Rice fields into shrubs	91,614
Shrubs into open land	154,583
Shrubs into residential	2,602
Shrubs into rice fields	6,428

Land Use Change Map 2022-2024

The Land Use Change Map 2022-2024 shows that land conversion is still occurring, although with lower intensity compared to the previous period. Forest degradation into shrubs and open land continues, albeit on a smaller scale. The conversion of rice fields into residential areas also persists, particularly in areas experiencing urban expansion. These changes reflect the ongoing urbanization trend in Padang.

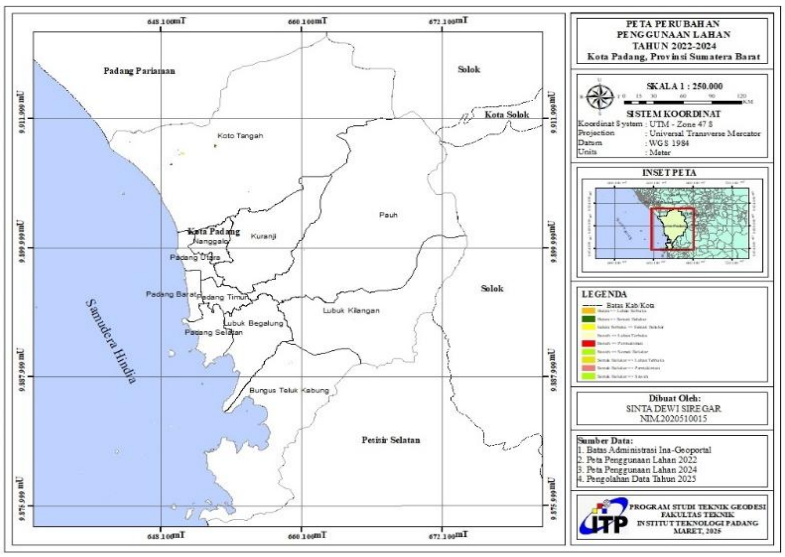

Figure 4. Land Use Change Map 2022-2024

Land use changes in Padang City from 2022 to 2024 occurred on a smaller scale compared to the previous period. The conversion of forests into shrubs, covering 5.854 hectares, indicates vegetation degradation. The transformation of rice fields into residential areas (1.938 hectares) and shrubs (1.423 hectares) continued, though at a lower rate than in the 2020-2022 period. Additionally, the conversion of shrubs into open land (3.605 hectares) and residential areas (0.516 hectares) reflect ongoing development dynamics in the region. Overall, land use changes during this period were more controlled compared to the previous phase.

Table 10. Land Use Changes in Padang City (2022-2024)

Land use changes	Area (Ha)
Forests into open land	1,069
Forests into shrubs	5,854
Open land into shrubs	0,083

Land use changes	Area (Ha)
Rice fields into open land	0,853
Rice fields into residential	1,938
Rice fields into shrubs	1,423
Shrubs into open land	3,605
Shrubs into residential	0,516
Shrubs into rice fields	0,107

Land Use Change Map 2020-2024

The Land Use Change Map 2020-2024 illustrates the dynamics of land use changes over the past four years in Padang City. The main transformation involves the expansion of residential areas replacing rice fields and shrubs, particularly in urban regions. Meanwhile, forests have experienced minor degradation, with some areas converted into open land. These changes reflect urban growth and increasing pressure on land resources.

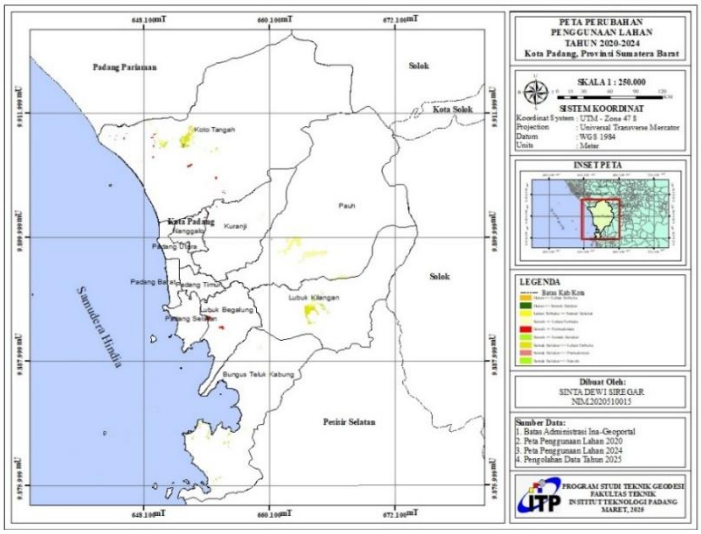

Figure 5. Land Use Change Map 2020-2024

During the 2020-2024 period, land use changes in Padang City were dominated by the conversion of forests into shrubs, covering an area of 256.655 hectares, indicating forest degradation. The conversion of rice fields into residential areas reached 57.391 hectares, reflecting rapid urban expansion. Additionally, the transformation of rice fields into shrubs (92.981 hectares) suggests that some agricultural land is no longer being utilized. Another significant change is the conversion of shrubs into open land (158.048 hectares), indicating land-clearing activities. Overall, these land use trends illustrate continuous urban development and ongoing land degradation.

Table 10. Land Use Changes in Padang City (2020-2024)

Land use changes	Area (Ha)
Forests into open land	1,069
Forests into shrubs	256,655
Open land into shrubs	4,749
Rice fields into open land	0,909
Rice fields into residential	57,391
Rice fields into shrubs	92,981
Shrubs into open land	158,048
Shrubs into residential	3,118
Shrubs into rice fields	6,535

4. Conclusion

This study revealed that land use in Padang City from 2020 to 2024 was characterized by a decline in forest and rice fields alongside an expansion of open land and settlements, primarily driven by urbanization and population growth. The analysis using Sentinel-2 imagery on Google Earth Engine with high Random Forest method proved in detecting these dynamics with high accuracy. The finding highlight the increasing development pressure on agriculture and green areas, underscoring the urgent need for sustainable spatial planning to balance urban growth and environmental conservation.

Bibliography

[1] Edy, H., Baiquni, M., & Triatmodjo, B. The impact of the South Cross Road (JJLS) development on land use changes in Gadingsari Village, Sanden District, Bantul Regency, Yogyakarta. *Jurnal Spasial*, 6(1), p. 1–11. 2019.

[2] Fardila, A. (2023). Analysis of land cover changes in Padang City using satellite imagery. [Journal Name], 10(x), xx–xx.

[3] Klein, T., Solms, H.-J., & Wegera, K.-P. *Flexionsmorphologie*. 25(1), p. 433–470. 2017

[4] Segarra, J., Buchaillot, M. L., Araus, J. L., & Kefauver, S. C. Remote sensing for precision agriculture: Sentinel-2 improved features and applications. *Agronomy*, 10(5), p. 1–18. 2020

[5] Sukoco, B., Fadly, R. Study on the utilization of Google Earth Engine technology for remote sensing. *Jurnal Penelitian Geografi*, 10(2), p. 79–88. 2022. https://doi.org/10.23960/jpg.v10.i2.24219

[6] Ulni, A. Z. P., Dasrizal, Zuriyani, E., Rezki, A., & Juita, E. Land use changes in Nanggalo District, Padang City. *Jurnal Multidisiplin Ilmu*, 2(3), p. 645–650. 2023.

[7] Zulfajri, D., Danoedoro, P., & Heru Murti, S. Land cover/use classification of Landsat-8 OLI data using the Random Forest method. *Jurnal Penginderaan Jauh Indonesia*, 3(1), p. 1–7. 2022.