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Transformation of land use change in Cilegon City 2017-2023 using passive sensor satellite imagery

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ABSTRACT

Transformation Land change that occurred in Cilegon City is a phenomenon that involves a significant transformation in urban land use over the last few years. Land is a natural resource that has an important function to meet various human needs. This change was caused by several factors, one of which was rapid population growth. This research involves analyzing satellite imagery from several different time periods to track the evolution of land use in Cilegon City. From the results of observations made, it is known that there is a reduction in green land in Cilegon City. Where in each period of the year there are changes in green land which is increasingly decreasing. This reduction was caused by several factors, namely the transfer of land function from greenland to housing and the occurrence of fires on the green land.

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Introduction

Cilegon City is one of the cities in Banten Province, located in the western part of Banten, Indonesia, precisely on the shores of the Sunda Strait. Cilegon City is known as the "Steel City" due to the presence of the Indonesian government-owned steel industry, Krakatau Steel. Cilegon City is located in the Greater Serang metropolitan area. Previously, Cilegon City was an administrative city that covered the entire Cilegon City area. Land use change is the increase of a land use from one type of use to another followed by a decrease in another type of land use from one time to the next, or a change in the function of a land in different periods of time (Arafat et al., 2021; Fauzi et al., 2018; Muafi & Shofwan, 2023; Mukti & Taryono, 2020).

Cilegon City, which is strategically located as an industrial and trade center, has experienced a significant transformation in land use. Over a period of 7 years, with industrial development, natural disasters, population growth, and corona cases. Land use change is a major concern in designing sustainable development policies (Putra & Adeswastoto, 2018). Basically, the increase in development in the Cilegon City area is followed by the demand for land in accordance with the needs to accommodate community activities, including land needs for settlements, trade and services (Fatichah, 2019; I. H. J. Ridwan & Achmad Sodik, 2023). This has led to an increase in built-up land, where the growth of built-up land at this time was initiated by the entry of large-scale industrial development investment in Cilegon City (Iqbal et al., 2021; Noor & Sulaeman, 2022). Cilegon City as a Regional Activity Center with

relatively high population growth has led to land use development and high demand for urban services for its people(MUHLISIN et al., 2021; Putri & Sulistyo, n.d.; R. Ridwan et al., 2019) .

Cilegon City, identifying land use change and its location distribution in the center of Cilegon City and analyzing the factors that influence the change. By using descriptive and spatial analysis, it can be seen that land use change in the center of Cilegon City is also influenced by territorial activities that intersect directly with urban activities in Cilegon City. These results are expected to be used as input in the planning, utilization and control of land use policies, so that all potential and problems of change can be anticipated as early as possible.

Passive sensor satellite imagery refers to a basic concept in satellite image processing that uses passive sensors to measure electromagnetic radiation emitted or reflected by objects on the Earth's surface. These passive sensors receive electromagnetic radiation from objects on the Earth's surface, including reflected sunlight, and then convert them into digital images that represent the characteristics of these objects. This process involves various stages, from signal reception by the sensor, signal processing to remove interference or noise, to image formation that can be used for various applications such as environmental monitoring, regional mapping, and monitoring changes in the earth's surface. Passive sensor satellite imagery also considers the basic physical principles underlying the measurement of electromagnetic radiation, such as the Lambert-Beer law that explains the relationship between the intensity of radiation received and the thickness and optical properties of the medium through which it passes. In addition, the use of various spectral bands by passive sensors to obtain information about objects on the Earth's surface, such as imagery in the visual, infrared and thermal bands, is an important part of this theory. With a solid understanding of these principles, the analysis of passive sensor satellite imagery can provide valuable insights in the understanding of the environment and geospatial processes on the Earth's surface (Sus et al., 2018; Tian et al., 2020; Yang et al., 2018).

This study aims to investigate and analyze the transformation of land use change that occurred in Cilegon City in the 2017-2023 time span using passive sensor satellite image data. By observing land use change patterns from a spatial perspective, this research aims to understand the dynamics of urban development, including urban growth, land use change, and its impact on the environment and local communities. Through the analysis of satellite image data, this research will explore in depth the land use change trends that may be influenced by social, economic and environmental factors, thus providing valuable insights for sustainable urban planning and natural resource management in Cilegon City. In addition, this study also aims to identify the factors that drive land use change transformation in Cilegon City during the 2017-2023 period. By analyzing satellite image data, this research will try to uncover the social, economic and environmental factors that influence land use change decisions by communities and interested parties. With a better understanding of these driving factors of transformation, it is hoped that this research can provide a more holistic view of the dynamics of urban change and assist in designing appropriate policies for the sustainable development of the city in the future.

Method

The method used in the research is the spatial analysis method using geographic information system techniques using the Arcgis application and supported by secondary data, data processing using secondary data, namely data from sentinel-2A images (Indraswari et al., 2018; Nirwansyah, 2017; Sa'adah et al., 2022). The method of analyzing land change using image maps involves several steps in processing satellite imagery, such as image selection, classification on maps, analysis of changes, indication of causal factors, and making maps of analysis results.

Results and Discussions

A. Land Use Change in Cilrgon City in 2017

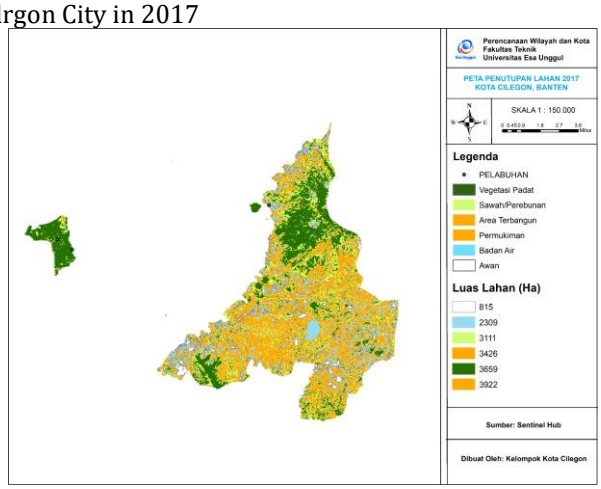

Figure 1. Cilegon City Land Use Map 2017

Based on the results of the Cilegon City image data in 2017, there are six classifications processed from raster data which are classified into vector data. Gaka is implemented to create a Land Use Map as shown in Figure 1. There are six classes of land use identified including, dense vegetation such as jungle, rice fields / plantations, built-up areas, settlements, water bodies, cloud shadows / road networks. The following is the land use by area (ha) in 2017.

Table 1. Land Use of Cilegon City in 2017

Land Use	Extent (Ha)
Dense Vegetation	3859
Rice Fields / Plantations	3111
Built-up Area	3426
Settlement	3659
Water Body	2309
Cloud Shadows	815

Judging from the results of the 2017 image map, it can be seen that the dominating land in Cilegon City is Dense Vegetation but the forests there look less green, besides that green land which should have rice fields in the image looks very lacking, only small areas of rice fields are visible on the image map. and which dominates continued by built-up areas and settlements.

B. Land Use Change in Cilegon City in 2019

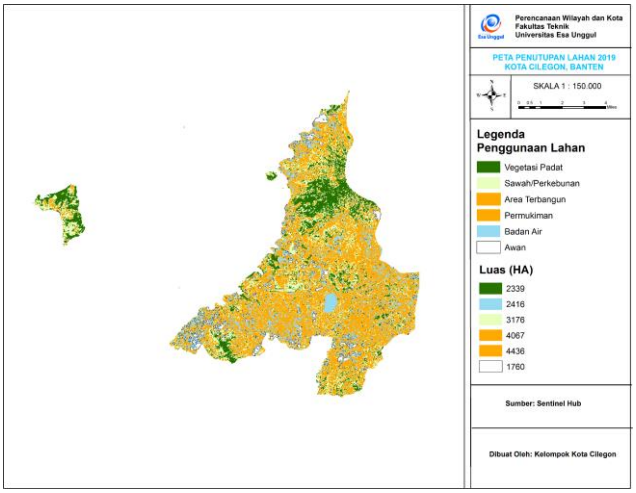

Figure 2. Cilegon City Land Use Map 2019

Based on the results of the Cilegon City image data in 2019, there are six classifications processed from raster data which are classified into vector data. Gaka is implemented to create a Land Use Map as shown in Figure 2. There are six classes of land use identified including, solid vegetation such as jungle, rice fields / plantations, built-up areas, settlements, water bodies, cloud shadows / road networks. The following is the land use by area (ha) in 2019.

Table 2. Land Use of Cilegon City in 2019

Land Use	Extent (Ha)
Dense Vegetation	2339
Rice Fields / Plantations	3176
Built-up Area	4067
Settlement	4436
Water Body	2416
Cloud Shadows	1760

Judging from the results of the 2019 image map, it can be seen that the appearance is worse than the previous year, 2017. Where in 2019 green land such as forests, rice fields, gardens, gardens, shrubs are far from sufficient. In this image, it can be seen that this green land / dense vegetation is greatly reduced from the previous year, this year when viewed from the image map the growth of settlements is greater which causes the reduction of green land in Cilegon City.

C. Land Use Change in Cilegon City in 2021

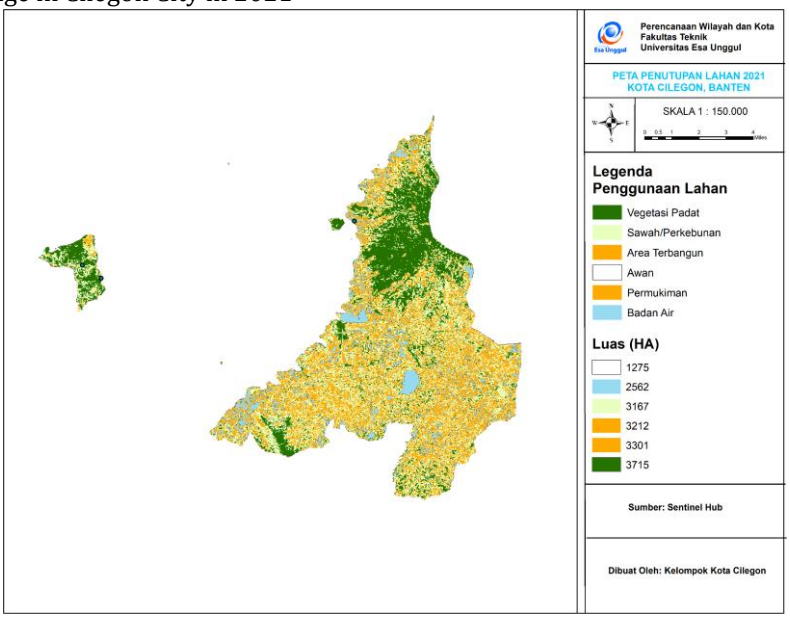

Figure 3. Cilegon City Land Use Map 2021

Based on the results of the Cilegon City image data in 2021, there are six classifications processed from raster data which are classified into vector data. Gaka is implemented to create a Land Use Map as shown in Figure 3. There are six classes of land use identified including, dense vegetation such as jungle, rice fields / plantations, built-up areas, settlements, water bodies, cloud shadows / road networks. The following is the land use by area (ha) in 2021.

Table 3. Land Use of Cilegon City in 2021

Land Use	Extent (Ha)
Dense Vegetation	3715
Rice Fields / Plantations	3167
Built-up Area	3212
Settlement	3301
Water Body	2562
Cloud Shadows	1275

D. Land Use Change in Cilegon City in 2023

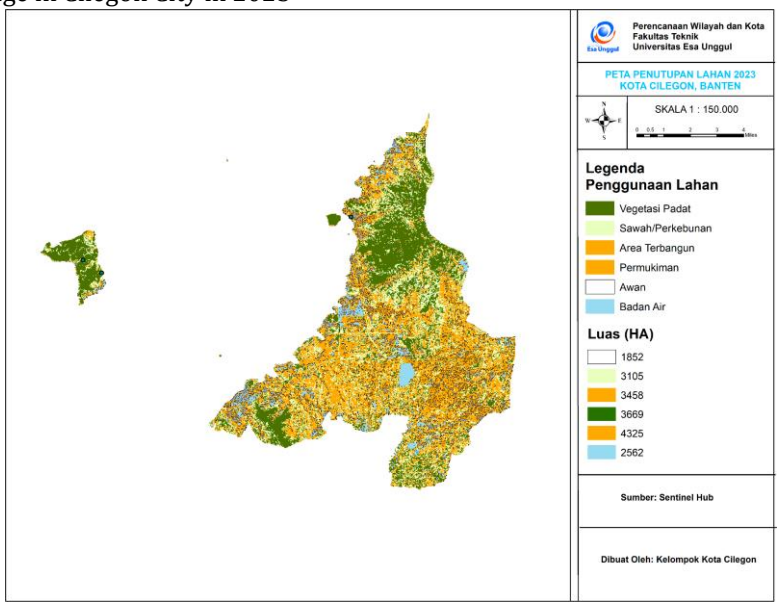

Figure 4 Cilegon City Land Use Map 2023

Based on the results of the Cilegon City image data in 2023, there are six classifications processed from raster data which are classified into vector data. Gaka is implemented to create a Land Use Map as shown in Figure 4. There are six classes of land use identified including, dense vegetation such as jungle, rice fields / plantations, built-up areas, settlements, water bodies, cloud shadows / road networks. The following is the land use by area (ha) in 2023

Table 4. Land Use of Cilegon City in 2023

Land Use	Extend (Ha)
Dense Vegetation	3669
Rice Fields / Plantations	3105
Built-up Area	3458
Settlement	4325
Water Body	2562
Cloud Shadows	1852

In the 2023 image of Cilegon City, it can be seen that the green area in Cilegon City is decreasing, but it can still be said to be quite green. the green area in the 2023 image is decreasing because there are several factors, namely, the volume of air pollution in urban areas began to increase dramatically so that green areas that previously could grow optimally, and now cannot grow optimally due to extreme weather factors. In addition, there are other weather factors, which at the end of 2023 has erratic weather so that it becomes an obstacle to the growth of green areas in Cilegon City. and as for the disaster factor that causes green areas in Cilegon City to decrease, this is due to land and forest fires in 2023 the fire burned +/- 1.5 hectares of grass vegetation.

From the data, facts, and results of the analysis carried out on the transformation of land change in Cilegon City, that on the 2019 image map, Cilegon City is the year with the lowest percentage of green areas, and the green area with the largest percentage is in 2021. from these data can occur due to extreme weather factors, and a pandemic that lasts long enough to cause the condition of green areas in Cilegon City to change up and down a lot.

Table 5. Land Use of Cilegon City in 2017-2023

Land Use	Extent (Ha)			
	2017	2019	2021	2023
Dense Vegetation	3859	2339	3715	3369
Rice Fields / Plantations	3111	3176	3167	3105
Built-up Area	3426	4067	3212	3458
Settlement	3659	4436	3301	4325
Water Body	2309	2416	2562	2462
Cloud Shadows	1830	1760	2237	1652
Total	18194	18194	18194	18194

Figure 5. Land use transformation curve

Conclusions

Land change in Cilegon City is a phenomenon that involves a significant transformation in urban land use over the past few years. Factors such as rapid population growth, industrial development, natural disasters, and COVID-19 cases have led to this change. Analysis of satellite images from several time periods shows a reduction in green land in Cilegon City, caused by land conversion from green land to housing, the occurrence of fires, and the impact of COVID-19. Agricultural land conversion is also occurring, with the area of agricultural land reduced due to residential and industrial development. In addition, there is a proposed change in the area of strategic land in Cilegon City. Thus, land use change in Cilegon City requires attention in designing sustainable development policies. Limitations in studying land change in Cilegon City may stem from data availability, particularly regarding the finer details of land use dynamics such as the specific drivers behind land conversion and the socio-economic factors influencing these changes. Additionally, while satellite imagery provides valuable insights, it may not capture certain nuances or changes on the ground accurately. Future research could focus on integrating multi-source data, including ground surveys and socio-economic indicators, to better understand the underlying causes of land change. Moreover, employing advanced analytical techniques such as machine learning algorithms could enhance the accuracy of land use classification and prediction models. Longitudinal studies tracking land change over extended periods would also offer insights into the temporal dynamics and trends. Collaborative efforts between researchers, local authorities, and stakeholders could facilitate data sharing and the development of comprehensive land use planning strategies aimed at promoting sustainable urban development in Cilegon City

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