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Regional Case Study

Vegetation Density Analysis in Padalarang Bandung Regency Using NDVI Method on Landsat 8 Satellite

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Abstract

Vegetation is an important component in an ecosystem. Padalarang Sub-District is a sub-district in West Bandung Regency with the smallest area but the most densely populated among other sub-districts in West Bandung, with a density of 3,478 people km². The purpose of this research is to analyze the level of vegetation density using the Normalized Difference Vegetation Index (NDVI) technique as a consideration, especially for the government regarding development program arrangements. The method used was Landsat 8 image interpretation with NDVI, and the results will be classified according to the classification of vegetation density used. As a result, the density of vegetation has decreased from 2013 to 2021, area of non-vegetation and sparse vegetation land indicates, increasing by 5.3% and 4.51%, respectively. In the classification of fairly dense, dense, and very dense vegetation, density decreased by 4.39%, 4.86%, and 0.55%, respectively, which has resulted in reduced green areas becoming built-up areas along with the development of the number and mobility of the population. It is necessary to increase the amount of vegetation and stipulate development regulations that take into account the existence of vegetation as a support for ecological functions.

Keywords: Vegetation density; NDVI; landsat 8 satellite; Padalarang Bandung

1. Introduction

Vegetation or plants are important in building an ecosystem (Ginting and Jadera, 2018). Vegetation can balance various elements in an ecosystem so that the sustainability of the ecosystem is maintained. Vegetation in ecological studies is a term that denotes the entire collection of plant communities. includes both the communal mix of its constituent flora and the land cover it forms. Vegetation is a living part composed of plants that occupy an ecosystem or in a narrower area, namely an ecological niche. Vegetation can also be interpreted as a part of life composed of plants living in an ecosystem. Vegetation is characterized by a richness of life forms, structure, periodicity, as well as specific floristic features. Among the examples are various types of forests, grasslands, gardens, and tundra (Andini et al., 2018). Vegetation or plants that are elements of a spatial arrangement have significant benefits. One of them is indirectly or directly improving air circulation in the atmosphere (Winarti and Rahmad, 2019). The existence of vegetation will decrease the percentage of carbon dioxide (CO_2) at noon in the atmosphere through the process of photosynthesis by plant tissues (Oktaviani et al., 2017). Therefore the existence of vegetation in an area plays a crucial role in cleaning and supplying clean air around it. In addition to the position of vegetation in regulating the balance of oxygen (O_2) and carbon dioxide (CO_2) in the atmosphere so that the quality of the air component is getting better, also the interaction of vegetation with other abiotic components can be used to improve the physical, chemical, and biological properties of the soil, including regulation of groundwater systems and so on (Ginting and Jadera, 2018).

Vegetation has a diversity of species and different characteristics. This vegetation variation affects the number of populations of each type of vegetation in each area, so the density of existing vegetation is also different (Hayu and Ridwana, 2019). Vegetation analysis is an analysis of plant ecology used to identify various types of vegetation in plant communities that grow and develop on a temporal and spatial scale. One of the functions of this analysis is as a medium for determining the proper development of vegetation to suit the conditions of the region or environment, so that the vegetation can develop properly. Proper vegetation is expected to improve air, water and soil quality in terms of quality and quantity. Meanwhile, according to (Ufiza et al., 2018), vegetation analysis is a method for determining the level of distribution of various species in an area through observation. The existence of vegetation in a room will positively impact the balance of the ecosystem on a larger scale. The application of vegetation development in narrow spaces must be carried out massively. The role of remote sensing is needed as a field of science that collects information on an object quickly and efficiently without conducting direct observation of the thing under study. In general, there is a link between remote sensing and image processing in mapping software to observe conditions or a phenomenon on earth (Lukiawan et al., 2019). If remote sensing and image processing in mapping software are utilized and used properly, they can assist in various analytical processes such as vegetation density, land use change, biodiversity distribution, and many more. Vegetation density is the amount of vegetation or plant that lives in a particular area (Wahrudin et al., 2019). The diversity of vegetation species affects the density of vegetation in a room.

Remote sensing is a tool that plays an essential and influential role in monitoring land cover. Through its capabilities, remote sensing can provide information related to various spatial variations on the earth's surface quickly, precisely, and straightforwardly (Gong et al., 2013; Hansen et al., 2000; Liu et al., 2003; Thenkabail et al., 2009). Remote sensing data is believed to be better than data from government agencies because the value obtained is the value seen and analyzed directly through satellite imagery. However, the government began to use this tool in decision making and policy making. In some cases, the provision of data information by the government to the public generally uses data obtained and processed on the basis of sights on satellite imagery. The benefits of remote sensing are numerous, starting from low costs, no need for a large number of survey personnel, can be completed by a staff quickly, and the data obtained is more accurate and reliable.

Usually, in remote sensing specifically for land cover classification, information is obtained from Landsat satellites (Gong et al., 2013; Gumma et al., 2011). Remote sensing techniques t have developed rapidly since Landsat 1 was launched in 1972 and continued to create until Landsat 7 was founded (et al., 2016). After the failure of Landsat 7 on the Scan Line Corrector in 2003, the latest generation of Landsat was launched, namely the new Landsat Data Continuity, namely Landsat 8, in 2013. With the latest Landsat, Landsat satellite mission's can be continued to observe the earth's surface (Lulla et al., 2013). The Landsat 8 satellite orbits near the sun-synchronous circle at an altitude of 705 km, inclination of 98.2º, a period of 99 minutes, and the return time (temporal resolution), and the time it crosses the equator is from 10.00 to 10.15 am (Sitanggang, 2010). Landsat 8 is supported by two sensors, the Operations Land Imager (OLI) sensor and the Thermal Infra- Red Sensor (TIRS). Remote sensing generates data that is an essential factor in the success of land cover classification (Jia et al., 2014). Landsat 8 can be used in processing vegetation change with the Normalized Difference Vegetation Index (NDVI) method. NDVI is a method often used to calculate the value of greenness or vegetation density through digital signal processing of brightness value data with several channels of satellite sensor data using satellite imagery (Philiani et al., 2016). The NDVI technique is a transformation of spectral sharpening images used in analyzing anything related to vegetation (Putra, 2011). NDVI is one of the vegetation indices that is currently often used. The vegetation index is a mathematical transformation involving various channels that produce new images representing vegetation descriptions (Danoedoro, 2012). Through NDVI, the slope is measured by the original value of the red band infrared bands in space through the values present in each image pixel (Philiani et al., 2016). In addition, NDVI also shows parameters related to vegetation, such as green leaf biomass. The area of green leaves is used to estimate the distribution of vegetation (Simarmata et al., 2021). NDVI is obtained from observations where different surfaces reflect different types of light waves (Andini et al., 2018).

Collaboration of geographic information systems (GIS) and remote sensing can help assess vegetation density using Landsat imagery obtained from satellite capture (Khairawan et al., 2020). The density of vegetation in an area can be determined using the NDVI (Normalized Difference Vegetation Index) method. The NDVI algorithm is obtained by calculating the ratio between the red band and the near-infrared and from satellite imagery, so that vegetation's "greenness" index can be determined (Luvi et al., 2021). The greater the NDVI value results or leads to a positive, the better the density of vegetation in the area. However, if the NDVI value decreases or is negative, the area's vegetation density level worsens (Khairawan et al., 2020).

Padalarang District is a sub-district in West Bandung Regency with the smallest area but the most densely populated among other sub-districts in West Bandung; its density reaches 3,529 people km^{-2}. Besides that, the Padalarang sub-district is the second fastest-growing sub-district in terms of population growth compared to other areas in the West Bandung (Statistik, 2021). A large number of residents, accompanied by an increase in settlement development, especially the development of the independent city of Baru Parahyangan City are several factors causing the shift of vegetation land into built-up land. Therefore, it is necessary to carry out a vegetation analysis using the NDVI technique as a consideration, especially for the government regarding development program regulations.

2. Methods

Research on changes in vegetation area used the NDVI technique in 2013 and 2021 was carried out using case studies in Padalarang District, West Bandung Regency, in November 2022 with coordinates 6°50'53.8"S 107°28'22.2"E and the area of Padalarang District namely 51.40 km^2. To the north, it is directly adjacent to Cikalongwetan District, then to the east, it is bordered by Cisarua District, Ngramprah District, and Cimahi City. While in the south, it is bordered by Batujajar District, and in the western part, it is bordered by Sanguling District and Cipatat District. The administrative map shp data for Padalarang District obtained from website https://tanahair.indonesia.go.id and the use of Landsat 8 satellite imagery was obtained through the website https://earthexplorer.usgs.gov in 2013 and 2021 as well as data in the form of journals or literature, documents, as well as various other sources of information acquisition by research studies. To presented the results of the analysis visually, ArcGIS 10.3 version was used. This research was included in the quantitative descriptive analysis using remote sensing techniques with interpreted images. The step of this research was to monitor the satellite imagery of Padalarang District between 2013 and 2021 using the near-infrared, red, and green or blue channels (bands). NDVI calculations use a raster calculator on ArcGIS 10.3 version and are classified using natural breaks. The NDVI calculation can be done with the following equation:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} \quad (1)$$

Description : NDVI = Normalized Difference Vegetation Index, NIR = Near infrared radiation from pixels, Red = Red light radiation from pixels.

Furthermore, the resulting data from NDVI processing is analyzed for each land cover area using reclassification and conversion to polygons in ArcGIS 10.3 version. Then, the data is tabulated into Microsoft Excel 2013 15.0 version to obtain the area-by-class results and will then be analyzed. The calculation results on NDVI have a different range of values, f; the NDVI classification results are presented in **Table 1**.

Table 1. Classification of normalized difference vegetation index (NDVI)

Class	NDVI	Description
1	-1 – 0.25	Not Vegetation
2	-0.25 – 0.35	Sparse Vegetation
3	0.35 - 0.45	Fairly Dense Vegetation
4	0.45 - 0.50	Dense Vegetation
5	0.50 - 1.00	Very Dense Vegetation

Table 2. Population density of Padalarang District in 2013 and 2021 (Statistik, 2021, 2013)

Year	Area (km^2)	Population (people)	Population Density (people km^{-2})
2013	51.40	163,732	3,185
2021	51.40	181,357	3,529

3. Result and Discussion

3.1 Padalarang District

Padalarang District is one of the sub-districts in West Bandung Regency. Based on data from the Central Bureau of Statistics for 2021 (Statistik, 2021), Padalarang District has an area of 51.40 km^2 consisting of 10 villages. The population of this sub-district is 181,357 people, with a population density of 3,529 people km^2, in full presented in Table 2. Based on land use, Padalarang District consists of forests, plantations, settlements, rice fields, shrubs, vacant land, dry fields, and bodies of water. Judging from the geographical conditions, most of the land in this region has a slope of 0-8%, which means it is still classified as a relatively flat slope. The characteristics of the land in Padalarang District are moderately fertile, and many rivers flow so that most of the land is used for agriculture. However, this topography tool creates the potential for land development into residential areas.

Padalarang District is increasingly showing the growth and development of its territory from year to year. This is because this area has a strategic location, so there is an arterial road connecting Bandung and Jakarta. Its strategic location has the potential to support the construction of settlements and other supporting infrastructure. In addition, Padalarang District, which is easy to reach, has adequate transportation facilities. The d area's development has increased life's mobility in Padalarang District. The existence of the New City of Parahyangan Padalarang, an elite residential area, shows objective evidence of the development of this area. Table 2 shows that increasing population growth within a fixed location will encourage the conversion of green land into built buildings that support life. This condition tends to have a negative impact because it results in the closure of green land so that the availability of green open space decreases (Hardianto et al., 2021; Hayu and Ridwana, 2019). The reduced green area will affect the density of vegetation in a low place. Appropriate handling and policy making is needed so that the vegetation elements remain balanced and in line with the development that is occurring in the West Bandung Regency in order to create the principle of sustainable development.

3.2. Analysis of Change in Vegetation Density

Studies using geographic information systems (GIS) and remote sensing have proven to be used to assess vegetation density using Landsat imagery obtained from satellite catches. The NDVI method makes it easier to assess vegetation density in an area used as a study object. Vegetation density can be seen from the size of the NDVI value, which is interpreted as the dense or thin vegetation in the area. Based on the data analysis that has been carried out, the results of the vegetation density or NDVI values in Padalarang District in 2013 and 2021. There have been changes in the state of vegetation density that have occurred within eight years. Changes that occur yearly are by the anthropogenic activities of the population and land use in the Padalarang sub-district. Comparison of the results of the distribution of vegetation density maps for 2013 and 2021 can be seen in **Figure 2**. The NDVI results map is classified into five classes, namely the first class in the range of –1 to 0.25, with red indicating that the area is in a non-vegetated condition. Then in the second class, which ranges from 0.25 to 0.35, the orange color indicates that the site is coarse vegetation. In the third class, the NDVI value, which runs from 0.35 to 0.45, is colored yellow, indicating that the area is in fairly dense vegetation. In the fourth class, the NDVI value ranges from 0.45 to 0.50, with a light green color indicating that the site is in lush greenery. In the fifth class, the NDVI values range from 0.50 to 1.00 with a dark green color, indicating that the area is in a very dense vegetation condition (Hansen et al., 2000; Luvi et al., 2021).

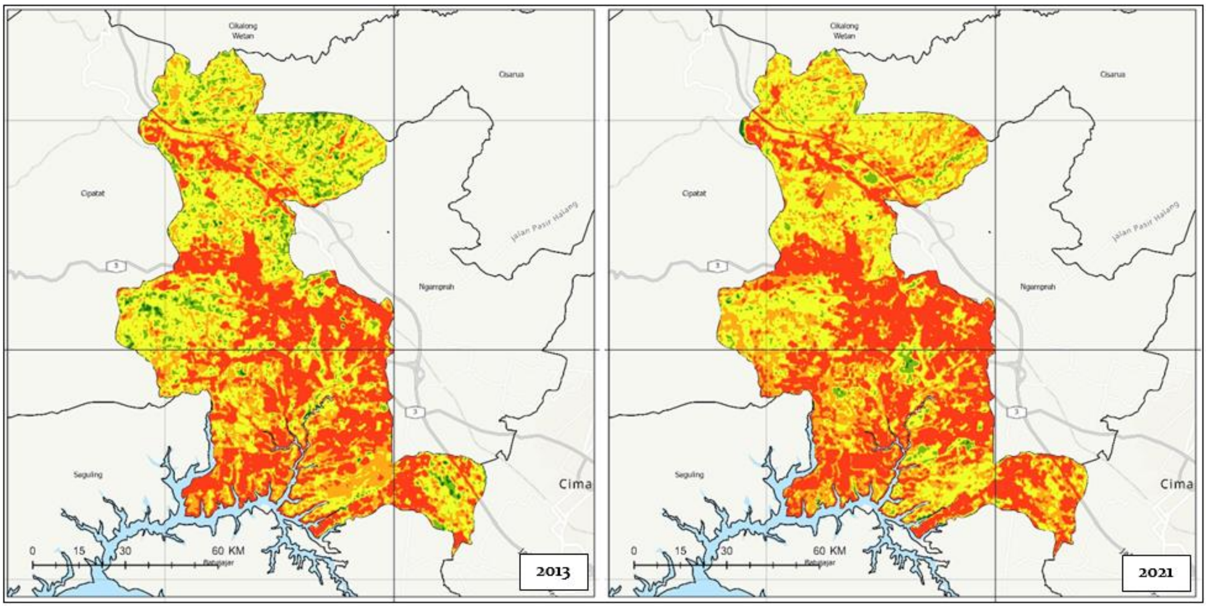

Figure 2. Normalized difference vegetation index (NDVI) map of Padalarang District in 2013 and 2021

Table 3. Vegetation density values of Padalarang District in 2013 and 2021

Class	Vegetation Density	2013		2021	
		Area (km²)	Percent (%)	Area (km²)	Percent (%)
1	Not Vegetation	154.28	29.88	181.61	35.18
2	Sparse Vegetation	132.66	25.7	155.94	30.21
3	Fairly Dense Vegetation	188.29	36.47	165.60	32.08
4	Dense Vegetation	37.46	7.26	12.38	2.4
5	Very Dense Vegetation	3.57	0.69	0.722	0.14

Changes in the condition of the existing vegetation density in Padalarang District within eight years are pretty significant when viewed from its area (**Table 3**). Very dense vegetation has decreased from 3.57 km² in 2013 to 0.722 km² in 2021, or a change of 0.55%. Then the area of lush vegetation decreased significantly, namely in 2013, 37.46 km² to 12.38 km² in 2021, or a change of 4.86%. Areas with reasonably dense vegetation density will also decrease from 188.29 km² in 2013 to 165.60 km² in 2021, or a decrease of 4.39%. Furthermore, for regions with sparse vegetation density, there will be an increase of 123.66 km² in 2021 to 155.95 km² in 2021 or an increase of 4.51%. Areas not vegetated have experienced significant growth, from 154.28 km² in 2013 to 181.61 km² in 2021, or as much as 5.3%. Based on the calculating the area of vegetation density values, it shows that there was an increase in size that occurred from 2013 to 2021 in the classification of the non-vegetated density of 27.33 km². In the category of sparse vegetation, density increased by 23.28 km². In the fairly reasonably dense and very thick vegetation, density decreased by 22.68 km², 25.07 km², and 2.85 km², respectively. Analysis of the results of vegetation density using the NDVI method carried out in Padalarang District, West Bandung Regency, found that in 2013 the sub-district area was dominated by quite dense vegetation classification, namely 36.47% of the entire region. Even so, non-vegetated land has spread to 29.88% of the site. This indicates that the transition from vegetated land to built-up areas is already underway. Based on the 2013-2018 Regional Medium Term

Development Plan (RPJMD) West Bandung Regency, massive industrial potential development is only found in a few sub-district locations. One is in Padalarang District as an industrial area and industrial center on a large to small scale. In West Bandung Regency, the type of small industry is dominated by woven and food centers. Meanwhile, the textile industry dominated the medium-large sector at 30.32% and various kinds of agro-industry.

Until 2021 the development of regional development is increasingly massive, and the percentage rate of population growth is increasing its mobility has resulted in a reduction in vegetated land in the Padalarang District area, especially the northern part. It can be seen from the total area of land that is not chilled, in 2021 increase to 35.18% of the entire room. An increase in non-vegetated land is always accompanied by a decrease in vegetated land, affecting the vegetation density in the region (Aditiya et al., 2021; Khairawan et al., 2020). Land that is less vegetated causes direct contact with sunlight on the surface of objects and the temperature on these objects and the environment increases. So if the temperature on the surface of the object increases due to direct contact with sunlight, it can be concluded that the lower the concentration of vegetation will have an impact on the phenomenon of increasing temperature and global warming in an area. (Timami et al., 2017).

3.3. Efforts to Increase The Vegetation Density

The reduced level of vegetation density in Padalarang District will affect the environmental and climatic conditions in the region. In an 8-year time interval, many significant changes in vegetation density have occurred. If this is not followed up immediately, over time, there will be the potential for even more substantial changes to occur (Aditiya et al., 2021). Recommendations that can be made as an effort to increase the presence of vegetation are to analyze and determine which areas are prioritized for green open space planning to improve vegetation density in residential areas, industries, highways, and public facilities areas. After obtaining a list of regions and their priorities, the government can establish regulations for planting greenery in the area and work with the local management. Likewise, rules showing built-up parts are to be carried out so that they still pay attention to vegetation as a form of ecological support for the area. Vegetation types must also be adapted to the region because each vegetation has different characteristics and land requirements. If there is a large enough land area, it should be directed to urban forest development. Besides that, planting vegetation (indoor and outdoor areas) is very useful for stabilizing regional temperatures and reducing the impact of carbon gases produced by industrial fumes and vehicle exhaust (Hayu and Ridwana, 2019; Ramadhani et al., 2022).

4. Conclusion

Based on the analysis that has been carried out in this study, the value of vegetation density in Padalarang District, West Bandung Regency, has decreased from 2013 to 2021. In 8 years, the area of non-vegetated land increased by 5.3% and the area of land with sparse vegetation increased by 4.51%. Furthermore, it decreased in each of the following classifications: fairly dense vegetation 4.39%, dense 4.86%, and very dense 0.55%, from 2013 to 2021. This means that the value of vegetation density in Padalarang District is decreased with increasing population and regional development. Therefore, it is necessary to grow vegetation in all areas starting from residential areas, industries, highways, to public facilities areas and stipulate government regulations so that builders continue to pay attention to vegetation as ecological support for the area.

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