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ASSESSING VEGETATION DENSITY TO DETERMINE GREEN OPEN SPACE (RTH) IN BOGOR REGENCY

Pendugaan Kerapatan Vegetasi untuk Menentukan Ruang Terbuka Hijau (RTH) Kabupaten Bogor

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ABSTRACT

Green Open Space (RTH) is part of the open spaces of an urban area filled with plants and vegetation to support ecological, socio-cultural, and architectural benefits. An approach that can be done to determine green open space is by analyzing the density of vegetation. The minimum distribution of vegetation in an urban area should be 30% of the total area. This vegetation distribution can be calculated using Landsat 8 imagery. This research was conducted to determine Green Open Space in Bogor Regency by using Landsat 8 imagery. This study clearly showed that some areas in Bogor Regency are still having lack of vegetation, bring a need to develop green open spaces in the areas.

Keywords: Landsat 8 imagery, Bogor Regency, Green Open Space, Vegetation

ABSTRAK

Ruang Terbuka Hijau (RTH) merupakan bagian dari ruang-ruang terbuka (open space) suatu wilayah perkotaan yang diisi oleh tumbuhan, tanaman, dan vegetasi untuk mendukung manfaat ekologis, sosial budaya, dan arsitektur. Salah satu pendekatam yang dapat dilakukan untuk menentukan RTH adalah dengan menganalisis kerapatan vegetasi. Persebaran minimal vegetasi pada suatu wilayah kota adalah 30% dari total luas wilayah tersebut. Sebaran vegetasi ini dapat dihitung dengan pemanfaatan Citra Landsat 8. Penelitian ini dilakukan untuk menentukan Ruang Terbuka Hijau di Kabupeten Bogor dengan menggunakan Citra Landsat 8. Penelitian ini menunjukkan bahwa masih banyak wilayah yang masih kekurangan vegetasi sehingga sangat diperlukan untuk membangun Ruang Terbuka Hijau di wilayah-wilayah ini.

Kata kunci: Citra Landsat 8, Kabupaten Bogor, Ruang Terbuka Hijau, Vegetasi

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INTRODUCTION

Bogor Regency is a district that plays a strategic role in the broader regional context. It serves as a peri-urban area of DKI Jakarta, acting as a buffer zone both in terms of economic activities and environmental functions. Consequently, there has been an increase in development in the Bogor Regency as a result of its role in supporting economic activities. Sustainable development without accompanying greening activities will impact the presence of Green Open Space (RTH).

Green Open Space is of crucial importance to the ecosystem of a region. It is a part of open spaces filled with plants, flora (endemic and non-endemic), and vegetation to support ecological, socio-cultural, and architectural benefits that provide economic and welfare advantages to the community. These spaces can serve as the lungs of the city, areas for water absorption, reduction and filtration of air pollutants, noise reduction in the city, improvement of microclimate, erosion control, recreational areas, and habitats for other wildlife. Green Open Space also influences the ecological balance in the region.

Vegetation refers to all plants within an area that function as land cover. The plants can be natural or cultivated, homogeneous or heterogeneous. The distribution of vegetation in an area can be influenced by topographic conditions. As a constituent of land, vegetation encompasses various types. The collection of diverse vegetation types results in different levels of vegetation density in each land use area. Vegetation density is one aspect that influences the characteristics of vegetation in an image. Vegetation density is typically expressed as a percentage to determine the level of vegetation density. To understand the relationship between vegetation density and its spectral reflection through digital analysis, a vegetation index is established.

The vegetation index is an algorithm applied to an image (usually a multispectral image) to highlight aspects of vegetation density or other related aspects such as biomass, Leaf Area Index (LAI), chlorophyll concentration, and so on. The level of vegetation density can be examined through the utilization of currently studied and developed technologies. Vegetation possesses spectral uniqueness, enabling analysis through various techniques to obtain representative indices of vegetation. These technologies include remote sensing and geographic information systems (GIS).

Practically, the vegetation index involves a mathematical transformation that involves multiple channels and produces a new image that better represents vegetation phenomena. This study aims to analyze the level of vegetation density in determining Green Open Space (RTH) in Bogor Regency using Landsat 8 satellite imagery and the Normalized Difference Vegetation Index (NDVI) method. The Normalized Difference Vegetation Index is the difference or subtraction between the near-infrared reflectance channel and the visible channel, normalized by the sum of the two reflectance values. According to Andini *et al.* (2018),

NDVI is an index of vegetation greenness or vegetation photosynthetic activity and one of the most commonly used vegetation indices. NDVI can be utilized as a parameter to detect the extent of vegetation greenness, both for monitoring purposes and estimation of vegetation health/density in a specific area. NDVI is extensively used in sectors such as agriculture, forestry, plantations, and the environment (Huang *et al.* 2021). Therefore, this technology can also be used to determine vegetation values based on the light reflection provided by the plants in a specific area.

RESEARCH METHODOLOGY

Location and Time

This research was carried out at the Silviculture Department, Faculty of Forestry, IPB University, spanning from February to June 2023.

Tools and Materials

The primary tools and materials employed in this research were Landsat 8 imagery of Bogor Regency, sourced from the United States Geological Survey (USGS) via the website https://earthexplorer.usgs.gov/. The Landsat 8 imagery served as a fundamental dataset for analyzing the study area. The data obtained underwent processing using the QGIS 3.26.3 software, a Geographic Information System (GIS) tool, leveraging the Normalized Difference Vegetation Index (NDVI) technique.

Data Collection

The primary dataset for this research was derived from Landsat 8 imagery of Bogor Regency, accessed through the United States Geological Survey (USGS) website (https://earthexplorer.usgs.gov/). Landsat 8 imagery is widely recognized for its comprehensive coverage and reliable information, making it a suitable choice for the study.

Procedure

The acquired Landsat 8 data underwent a systematic preprocessing procedure to extract meaningful information. The following steps were followed:

1. Importing Raster Files: The initial step involved the importation of raster files corresponding to Band 4 (Red) and Band 5 (Near-Infrared).
2. Raster Calculations: Utilizing the Raster toolbar and selecting the Raster Calculator, raster calculations were performed to derive meaningful insights.
3. NDVI Calculation: The NDVI (Normalized Difference Vegetation Index) for Landsat 8 imagery was computed using the formula: NDVI = (NIR (Band 5) – RED (Band 4)) / (NIR (Band 5) + RED (Band 4)).
4. Repetition for Subsequent Files: The established procedures were replicated for subsequent Landsat files until the desired image outcomes were achieved.
5. Merging Raster Files: The two raster files were merged, and adjustments to the transparency of the resulting image were made.

6. Administrative Boundary Application: The administrative boundary of Bogor Regency was applied and clipped to the raster file.
7. Image Coloring and Labeling: Utilizing single-band pseudocolor, the image was color-enhanced. Labels were adjusted to categorize areas into non-vegetated, low vegetation, medium vegetation, and high vegetation.
8. Vegetation Index Reclassification: The NDVI dataset was reclassified based on vegetation index values, facilitating a more nuanced analysis.
9. Raster Layer Analysis: The GRASS plugin of the processing toolbox in QGIS was employed for in-depth analysis of the reclassified raster layer.
10. Saving the File: The processed file, now rich with information, was saved for future reference and analysis.

Data Analysis

The resulting visualization provided a detailed depiction of vegetation density across different indices. This comprehensive dataset is invaluable for further ecological and land-use analyses in Bogor Regency.

RESEARCH RESULT

Utilization of Landsat 8 Images for Vegetation Index Analysis in Bogor Regency

One of the satellites commonly used for remote sensing is Landsat, which has now reached the generation of Landsat 8. Landsat 8 satellite is a continuation of the Landsat mission, which first became an Earth observer in 1972 (Landsat 1). The Landsat 8 satellite has an Onboard Operational Land Imager (OLI) sensor and a Thermal Infrared Sensor (TIRS) with a total of 11 channels. Among these channels, 9 channels (bands 1-9) are located in OLI, while the other 2 (bands 10 and 11) are in TIRS (Yudha 2018). The analysis of vegetation index in Bogor Regency was conducted using Landsat 8 satellite image data and the Normalized Difference Vegetation Index (NDVI) method. NDVI is a measurement of vegetation level obtained from the calculation of Near Infrared and Red reflectance by plants. The NDVI value is obtained by comparing the Near Infrared and Red data using the following formula:

$$\text{NDVI} = \frac{(\text{NIR (Band 5)} - \text{RED (Band 4)})}{(\text{NIR (Band 5)} + \text{RED (Band 4)})}$$

Note: NIR = Near Infrared channel reflectance value, RED = Red channel reflectance value

NDVI analysis is an analysis that can be used to obtain a value representing the density distribution of vegetation in Bogor Regency. NDVI has a value range from -1.0 to 1.0. Clouds, water, and non-vegetation objects have NDVI values less than zero. Values representing vegetation are in the range of 0.1 to 0.7. If the index value is higher than this range, it means that the vegetation cover is healthier. NDVI is highly sensitive to photosynthesis activity by chlorophyll, so NDVI values can be used to classify vegetation. The higher the leaf count, the more significant the impact on the results obtained, which are in the form of reflectance. If there is more reflection of Near Infrared wavelength radiation than RED, then the plant type in that area can be classified as forest. If there is a very small difference between the brightness of RED and NIR wavelengths reflected, then the vegetation may be sparse or thin, such as grassland or paddy fields. Based on this, the NDVI value is used to classify vegetation based on plant dominance (Purwanto 2015).

Analysis of Vegetation Density in Bogor Regency Using NDVI

The results of the study using NDVI in Figure 1 and Table 1 indicate that the relationship between vegetation index and plant percentage in Bogor Regency is quite high, reaching a value of 0.608722. The distribution of vegetation density values in Bogor Regency area obtained through NDVI analysis ranges from -0.17657 to 0.608722. The density of vegetation based on the NDVI value can be used as the basis for classification according to plant dominance. In Bogor Regency area, vegetation is divided into four classes for vegetation index analysis and mapping, namely high vegetation, moderate vegetation, low vegetation, and non-vegetated areas. This is because the range of vegetation index values from non-vegetated to dense vegetation is not too far. These four vegetation classes are represented using different colors. Blue indicates the classification of high vegetation index,

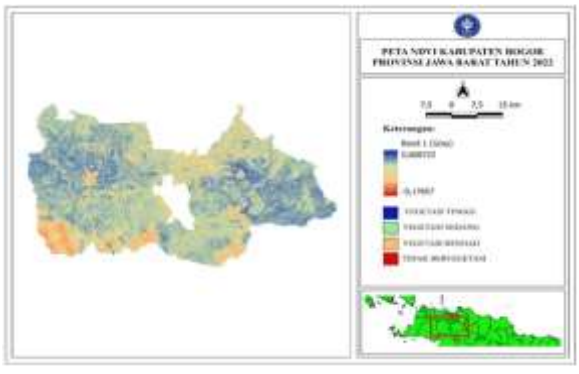

Figure 1 NDVI Map of Bogor Regency in 2022

Table 1 Classification of vegetation index in Bogor Regency (2022)

NDVI Value	Area (ha)	Percentage (%)	Density Classification
-0,17 - 0,0818	3	0,001	No vegetation
0,0818 - 0,3448	13.763	4,601	Low Density
0,3448 - 0,6078	117.782	39,376	Moderate density
0,6078 - 1	167.572	56,022	High density
Total	**299.120**	**100**	

green indicates moderate vegetation, orange indicates low vegetation, and red indicates non-vegetated areas.

Based on the map in Figure 2, it can be observed that the administrative area of Bogor Regency is dominated by blue color, indicating that Bogor Regency still has a high vegetation index value and has a positive impact on the environment. Several factors that affect the NDVI value include the solar angle, which affects the reflectance of red
and infrared light, atmospheric effects, and cloud conditions. Some researchers have reported that soil moisture decreases reflectance and increases NDVI values. To obtain a value for vegetation distribution or percentage, an equation is used based on the relationship between the vegetation index value NDVI and vegetation percentage. According to Lufilah *et al.* (2017), a vegetation surface with an NDVI value range of 0.1 indicates grassland and shrubs, a value greater than 0.1 to 0.8 indicates tropical rainforest, and an NDVI value approaching +1 indicates vegetation cover.

Classification of Vegetation Density in Determining Green Open Space in Bogor Regency

Table 1 shows the classification of vegetation density in Bogor Regency. The lowest classification or non-vegetated areas mostly consist of rocks or empty land, with a value range of -0.17 to 0.0818 covering 0.001% of the total area, equivalent to 3 hectares. The low vegetation class, consisting of grass/crop/shrubs, falls within the value range of 0.0818 to 0.3448, covering 4.601% of the total area, equivalent to 13,763 hectares. The moderate vegetation class, represented by bushes/shrubs, ranges from 0.3448 to 0.6087, covering 39.376% of the total area, equivalent to 117,782 hectares. The high vegetation class, mainly composed of trees/forests, falls within the value range of 0.6087 to 1, covering 56.022% of the total area, equivalent to 167,572 hectares. Based on this data, the existing condition of RTH is relatively larger in providing the oxygen needs to be distributed evenly across the region and the population of Bogor Regency. RTH filled with vegetation as the main component plays a role in enhancing the carrying capacity and ecological quality of the environment.

The distribution of vegetation in Bogor Regency area as a whole has reached the minimum limit for urban areas, which is 30%. However, this distribution is not yet evenly spread across each area. Areas with vegetation distribution below the minimum value are caused by the presence of many buildings such as residential areas, offices, universities, and rocky areas. The data obtained can be used as a reference by Bogor Regency Local Government to determine the need for RTH in areas with low vegetation distribution, in order to fulfill the minimum requirements within each area and bring a positive impact on the environment. Based on Table 1, the high and moderate vegetation categories have already met the minimum vegetation requirements in a certain area, with percentages of 56.022% and 39.376% of the total area of Bogor Regency, respectively. This indicates that the presence of RTH in Bogor Regency is ecologically sufficient. However, it is still possible to develop another RTH in areas with low vegetation and non-vegetated areas to improve the environmental conditions. The development of RTH in these areas with minimal vegetation is necessary to absorb the high carbon emissions resulting from construction activities and heavy traffic in Bogor Regency.

Vegetation can alter the surrounding environmental conditions by influencing air quality. It can lower air temperature, reduce activities that contribute to air and environmental pollution, and mitigate the impact of energy caused by buildings. Vegetation can be utilized as an alternative to minimize the daily temperature amplitude and reduce solar radiation for the surrounding environment. Moreover, the presence of vegetation can also provide moisture through vegetation transpiration and help control heat in densely trafficked areas. The decrease in temperature due to the presence of vegetation or trees can also reduce ozone levels in the air.

Vegetation contributes as noise control by dampening or absorbing sound waves through leaves, branches, and various layers of plants. Among the many trees capable of reducing noise pollution are trees with dense canopies or thick foliage, as their leaves can absorb up to 95% of noise. This is particularly important to consider because in land use planning or residential areas, green open spaces, and educational environments, noise levels have already exceeded environmental quality standards. Vegetation in heavily trafficked areas can also absorb water into the soil, helping to control surface water flow and prevent flooding, while enhancing the aesthetics and comfort of an area or environment.

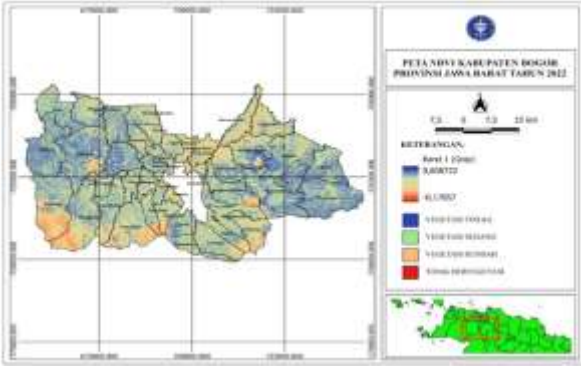

Figure 2 Map of Subdistricts in Bogor Regency in 2022 with NDVI

CONCLUSIONS AND RECOMMENDATIONS

This study shows that the distribution of vegetation density in Bogor Regency in 2022 is predominantly represented by the color blue, indicating high vegetation density. In general, the distribution of vegetation in Bogor Regency has reached the minimum requirement of 30% of the total area. However, this distribution is not evenly distributed across each sub-district. Based on the analysis of the NDVI map, some areas in Bogor Regency are still represented by the color orange, indicating low vegetation density. Revegetation activities can be considered as an alternative to address the low vegetation density in these areas. Information provide in this study can also serve as a reference for the local government in

implementing Green Open Spaces (RTH) to improve the vegetation density index in Bogor Regency. Findings of this study can be used as a consideration in determining the allocation of RTH in the administrative areas of Bogor Regency.

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