e-ISSN 2621-8062
Elipsoida : Jurnal Geodesi dan Geomatika
Vol 08 No 02, (2025)

IDENTIFICATION OF GREEN OPEN SPACES USING THE NDVI AND SAVI METHODS IN THE CITY OF METRO

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(Received 07 May 2025, Accepted 26 November 2025, Published 04 December 2025)

ABSTRACT

The availability of green spaces in urban environments has begun to become a focus for local governments in Indonesia. Various initiatives have been undertaken to achieve efficient and quality urban development. Based on Spatial Planning Regulation No. 26 of 2007, every city is required to have 30% of its total city area as green open space, with the aim of creating a productive, safe, comfortable, and sustainable environment. At a minimum, 20% of the green open space must be public green space and 10% private green space. This study utilized two methods to measure vegetation density, namely NDVI and SAVI. Both indices are very important in vegetation analysis. Therefore, to overcome their respective weaknesses, the two indices were used together, with the hope that the resulting vegetation mapping in this study would be more accurate. This suggests that before NDVI and SAVI can be optimally utilized, green open space (GOS) needs to be contextualized as a clear research problem. Therefore, the urgency of using these two indices arises when green open space is understood not only as a spatial entity, but as an ecological and social phenomenon that has a direct impact on environmental quality. This effort serves as an important bridge to determine the relevance of NDVI and SAVI analysis in addressing the issue of green open space availability and quality. The comparison results show that the final green open space area is 77.97 hectares, while the Metro City Green Open Space map from BAPPEDA records an area of 110.82 hectares. There is a percentage difference of 0.70 or 70%. However, both maps show differences in the results of the green open space area from the research and BAPPEDA data. Metro City's green open space area is known to cover 110.82 hectares. The NDVI method is used to classify green open space, with the smallest value ranging from -0.16 to 0.25. Meanwhile, the SAVI method classifies green open space with the lowest value ranging from 0.36 to 0.52. However, this condition is not optimal because rice fields and land cover that are still categorized as green are also detected. After overlaying the vegetation density, land cover, and rice fields maps, rice fields and residential areas are no longer detected as green open space. As a result, Metro City's green open space in 2022 will be 77.97 hectares.

Keywords *: Green Open Space, NDVI, SAVI, Metro City.*

1. INTRODUCTION

Cities in Indonesia are currently undergoing a phase of significant growth (Rushayati et al., 2011). Local governments in Indonesia, especially in large cities, are paying special attention to the availability of green open spaces in urban areas. Many efforts are being made to achieve effective and high-value urban development. In accordance with Spatial Planning Regulation No. 26 of 2007, all cities are required to provide at least 30% of the total area of the city as green open space in order to create a productive, safe, comfortable, and sustainable urban environment. The criteria for these green open spaces include a minimum of 20% for public green open spaces and 10% for private green open spaces (Achsan, 2015).

The purpose of green open spaces in urban areas is to maintain the harmony and balance of the ecosystem, create harmony between the built environment and nature, and improve the quality of an attractive, comfortable, and healthy urban environment (Mukafi, 2013). To support the evaluation of green open space conditions in sustainable spatial planning, the NDVI and SAVI methods are applied. Vegetation indices such as NDVI and SAVI serve to map and analyze green open spaces (Hardianto et al., 2021). NDVI assesses vegetation density by utilizing the spectral reflection of red and near-infrared light taken from satellite image data. On the other hand, SAVI is designed to overcome the influence of soil, especially in areas with sparse vegetation. (Eka Rahma Wati et al., 2023).

1.1 Problem Statement

Based on the information provided, the following are the problems addressed in this study:

1. How can the NDVI and SAVI methods be applied to identify green open spaces?
2. How can the NDVI and SAVI methods be used to evaluate existing green open spaces?

1.2 Research Objectives

The objectives of this study are as follows:

1. Identify green open space areas using the NDVI and SAVI methods.
2. Analyze the comparison between the RTH map from Bappeda and the RTH map produced in this study

2. DATA DAN METHODS

The data collection stage, including Landsat 8 imagery data for 2022, rice field land use data for 2022, and green space maps for 2022, enabled vegetation and land use analysis with adequate spatial resolution. The data and research tools used in this study were as follows:

Table 1. Research Data Tables

No	Data	Data Type	Source
1.	Landsat 8 imagery from 2022	Vector	USGS
2.	Land Use of Metro City Rice Fields in 2022	Vector	BAPPEDA Metro City
3.	Metro City Green Space Map in 2022	Vector	BAPPEDA Metro City

2.1 Vegetation Density

One important element that shapes an area and provides many benefits is vegetation, which is ground cover consisting of plants. In general, vegetation density is measured as a percentage to determine the distribution of vegetation density. (Nafi'atul Istifadah, 2018).

2.2 Vegetation Index

An algorithm known as the "vegetation index" is used to determine vegetation density, including biomass, Leaf Area Index, chlorophyll content, and other factors, applied to specific images, usually multispectral images. The chlorophyll process of vegetation (0.4-0.7 μm) absorbs red light and reflects near-infrared light at the mesophyll layer (0.7-1.1 μm), causing leaves to show variations in brightness for the sensor (Nafi'atul Istifadah, 2018).

2.3 Normalized Difference Vegetation Index (NDVI)

Showing the degree of plant brightness and photosynthetic activity found in vegetation, NDVI is widely used in studies. Green leaf biomass is used for vegetation separation, which is a parameter of NDVI. Plant conditions and vegetation levels are assessed using the Normalized Difference Vegetation Index (NDVI). The approach applied to assess leaf brightness (chlorophyll content) is NDVI. The formula commonly used to determine NDVI values is: (Laurensz et al., 2019)

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

Where:
NIR (Near Infrared) : Near-infrared channel
RED : Red Channel Reflector

The NDVI index has a value range from -1 (areas with no vegetation) to +1 (very dense vegetation). After calculating the area of vegetation density, the area will be divided into five categories.

Table 2. NDVI Class Table

NDVI Range	Category
-1 s/d -0,03	Non-vegetated
-0,04 s/d 0,15	Very low greenery
0,15 s/d 0,25	Low greenery
0,26 s/d 0,35	Moderate greenery
0,36 s/d 1,00	High greenery

2.4 Soil Adjusted Vegetation Index (SAVI)

The Normalized Difference Vegetation Index (NDVI) was developed into the Soil Adjusted Vegetation Index (SAVI), which is adjusted for soil conditions. By using SAVI, we can minimize the impact of soil conditions on vegetation cover. Through the application of the L adjustment factor related to vegetation density, SAVI highlights the influence of soil pixels. The SAVI index ranges from -1 at the lowest point to 1 at the highest point. (Wardana dkk., 2024).

$$SAVI \frac{(NIR-Red)}{(NIR)+Red+L)} \times (1+L) \quad (2)$$

Where:
NIR : Near-infrared radiation from pixels
Red : Red light radiation from pixels
L : Background lighting (0.5)

Table 3. SAVI Class Table

SAVI Range	Category
-0,36 s/d -0,01	Non-vegetated
-0,01 s/d 0,10	Very low greenery
0,10 s/d 0,36	Low greenery
0,36 s/d 0,52	Moderate greenery
0,52 s/d 0,78	High greenery

2.5 Green Blue Index (IHBI)

The measurement of green open space (GOS) has evolved in line with the latest regulations, shifting from a focus on area and geometric distribution to encompassing the quality of green open space itself. This change is realized with the introduction of the Green-Blue Index (IHBI).

The IHBI is a holistic approach to assessing green open space by integrating green (vegetation) and blue (water) elements as essential components of the urban ecosystem and the provision of environmental services.

The IHBI is a holistic approach to assessing green open space by integrating green (vegetation) and blue (water) elements as essential components of the urban ecosystem and the provision of environmental services.

- Green Aspect: Refers to all vegetation cover (trees, shrubs, grass) that has an ecological function, such as CO2 absorption, shade, and improving air quality.
- Blue Aspect: Includes water bodies (rivers, lakes, reservoirs, or ponds) that support biodiversity, hydrological functions, and the aesthetics of the city environment.

NDVI	Category	Area (Ha)
-1 s/d -0,03	Non-vegetated	0,09
-0,04 s/d 0,15	Very low greenery	3021,48
-0,16 s/d 0,25	Low greenery	2194,11
0,26 s/d 0,35	Moderate greenery	1444,5
0,36 s/d 1,00	High greenery	657,72
	Total	**7317,9**

2.6. The Position of NDVI and SAVI in Geospatial Analysis of Green Open Space

NDVI and SAVI are important vegetation indices in geospatial analysis because they can quickly and objectively evaluate vegetation conditions from satellite imagery. NDVI is effective for measuring overall vegetation density, but is less accurate in areas with extensive open soil. SAVI addresses this shortcoming by correcting for soil cover, making it more suitable for urban areas with less dense vegetation. The use of these two indices is considered effective and relevant for identifying green open space (GTH) because it provides more accurate results in distinguishing vegetation that truly serves an ecological function from other cover such as soil or rice fields.

2.5 Land Cover

The physical characteristics of our Earth's surface and the need to visualize and understand the natural phenomena that occur on Earth are known as land use. The two main categories in land use classification include areas with vegetation and areas without vegetation. The grouping of vegetation areas is based on the concept of fixed physiognomic structures, including plant shape, cover type, plant height, and distribution patterns, which form the basis for the classification of vegetated areas. Meanwhile, areas without vegetation refer to factors such as surface cover, distribution or density patterns, and the height or depth of objects.

2.6 Determining the Number of Sample Points

The determination of the number of sampling points was carried out in proportion to the area being mapped. The method for determining the number of samples was based on Regulation No. 3 of 2014 of the Geospatial Information Agency (BIG) (Badan Informasi Geospasial, 2014) using the following formula:

$$A = TSM + \left(\frac{luas(ha)}{1500}\right)$$

Where :

A : Number of Sampling Points

TSM : Training Sample Minimum

2.7 Accuracy Test

To measure the extent of errors in sample point classification, accuracy testing was conducted. Subsequently, a visual analysis of the accuracy of the directed classification was performed. A confusion matrix was used to ensure that the mapping was performed correctly.

3. RESULTS AND DISCUSSION

3.1 NDVI Analysis

NDVI in Metro City obtained the lowest value of -0.416405 and the highest value of 0.575043. In the range of -1 to 1, these values are considered to meet the criteria. Next, NDVI classification was carried out on the classification table. To obtain the following area:

Tabel 4. NDVI classification classes

NDVI	Category	Area (Ha)
-1 s/d - 0,03	Non-vegetated	0,09
-0,04 s/d 0,15	Very low greenery	3021,48
-0,16 s/d 0,25	Low greenery	2194,11
0,26 s/d 0,35	Moderate greenery	1444,5
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	Total	**7317,9**

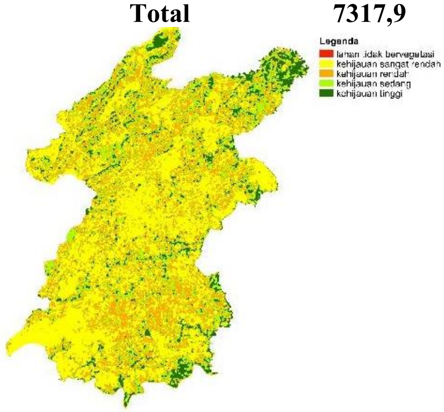

Figure 1. Metro City NDVI Map in 2022

3.2 SAVI Analysis

SAVI in Metro City obtained the lowest score of -0.272586 and the highest score of 0.506353. With a range between -1 and 1, these scores are considered to meet the criteria. Next, SAVI grouping will be carried out based on the following classification table. To produce the following area:

Table 5. SAVI classification classes

SAVI	Category	Area (Ha)
-0,36 s/d - 0,01	Non-vegetated	320,31
-0,01 s/d 0,10	Very low greenery	2357,1
0,10 s/d 0,36	Low greenery	4590,99
0,36 s/d 0,52	Moderate greenery	49,5
	Total	**7317,9**

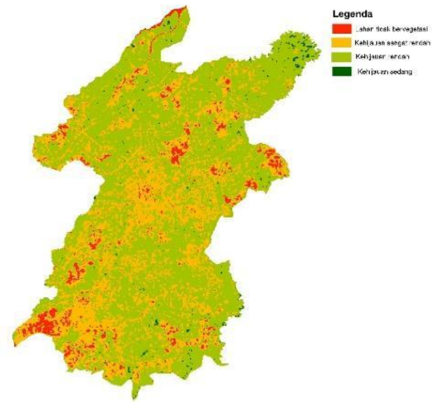

Figure 2. Metro City SAVI Map in 2022

3.3 Land Cover Analysis

Land cover in Metro City in 2022 was determined using Landsat 8 imagery and resulted in three classes because Landsat 8 only has a resolution of 30 meters, making it difficult to distinguish small objects.The land cover area in Metro City in 2022 is shown in Table 6.

Table 6. Land Cover Analysis

Class	Area (Ha)	%
Vegetation	4129,614	0,564317
Settlement	1412,754	0,193055
Open Land	1775,532	0,24269
Total	**7317,9**	**100%**

3.4 Overlay NDVI and SAVI

Based on the results of processing the NDVI and SAVI overlays, which were used to create a Vegetation Density map, referring to the classification in **Table 7**.

Vegetation Density was classified to determine green open spaces on the NDVI and SAVI overlays using low, medium, and high vegetation density. In accordance with the types of green open spaces in **Table 4** and **Table 5**.

Table 7. Overlay NDVI and SAVI

NDVI	SAVI	Area (Ha)	Percentage
Low greenery	Low greenery	2193,93	29,98%
Moderate greenery	Moderate greenery	1444,5	19,74%
High greenery	High greenery	608,22	8,31%
High greenery	Moderate greenery	49,5	0,68%
	Total	**4296,15**	**59%**

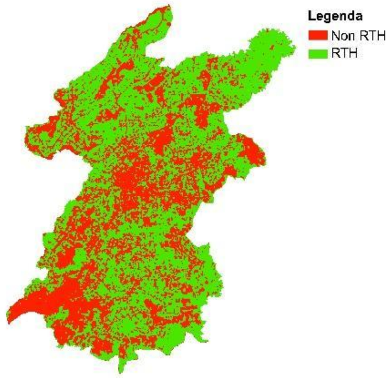

Figure 3. Vegetation Density Map

Vegetation density with low greenness covers an area of 2,193.93 ha or 29.98%, and vegetation density with medium and high greenness covers an area of 49.5 ha or 0.68%.

3.5 Analysis of Vegetation Density, Land Use, and Rice Field

The results of the Vegetation Density and rice field overlay can be seen in **Table 8**. Rice fields were selected for land use so that they would not be detected as green open space.

Table 8. Overlay of vegetation density, rice fields, and land cover

Penggunaan lahan sawah	Tutupan lahan	Keterangan	luas (Ha)
sawah	vegetasi	RTH	1464,162
-	vegetasi	RTH	1679,593
sawah	vegetasi	Non RTH	803,0496
-	vegetasi	Non RTH	110,2624
sawah	Permukiman	RTH	85,82958
-	Permukiman	RTH	411,843
sawah	permukiman	Non RTH	223,9096
-	permukiman	Non RTH	716,6144
sawah	lahan terbuka	RTH	142,4163
-	lahan terbuka	RTH	512,5919
sawah	lahan terbuka	Non RTH	563,5896
-	lahan terbuka	Non RTH	604,0396
		Total	7317,901

Based on **Table 8**. After the Vegetation Density Map was overlaid with rice field land use and land cover, which has the criteria for green space, namely:

Table 9. RTH classification

Vegetation Density Map	Use of Rice Fields	Land Cover	Area (Ha)
RTH	-	Vegetation	1680,80
RTH	-	Open land	513,80
		Total	2194,60

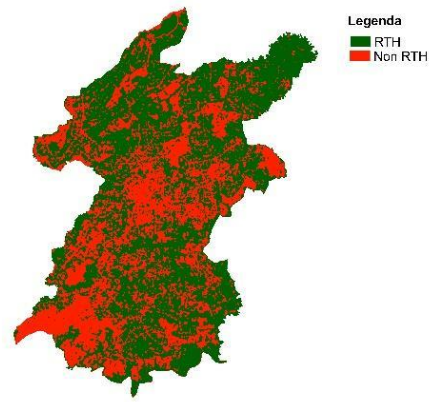

Figure 4. Metro City Green Open Space Map in 2022

3.6 Green Open Space Analysis

After rice fields and settlements were excluded from green space, codes were used for comparison results. This can be seen in **Table 10**.

Table 10. Comparison Code

NDVI+SAVI (RTH)	RTH Bappeda	Code	Total (Ha)
RTH	RTH	RR	77,96
Non RTH	RTH	NR	32,48
Non RTH	none	NN	1849,57
RTH	none	RN	2116,63

From the results in **Table 10**, it is clear that the green space with the code RR covers an area of 77.96842 ha. Next, the code RR in the table was compared with the Bappeda green space map. The results are shown in Table 11.

Table 11. Comparison Results

RTH Bappeda	RTH	Area of Difference (Ha)	Percentage Difference
110,8232	77,96842	0,703539	70%

Based on the comparison results in **Table 11**, the final green space area is 77.96842 hectares, while the green space map of Metro City obtained from the Metro City Development Planning Agency (BAPPEDA) is 110.8232 hectares. The difference is

0.703539 or 70%. There is a difference in the final green space area and the Bappeda green space area on both maps.

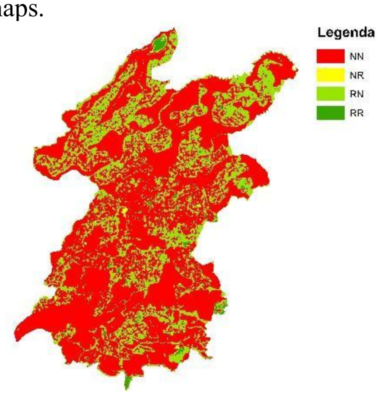

Figure 5. Metro City Green Space Comparison Map 2022

3.7 Identification of Recommended Green Open Space Areas

Based on **Table 12**. The RTH RN comparison code can be categorized in the RTH recommendations in Metro City.

Table 12. RTH recommendation area

No	Koordinat		Kerapatan Vegetasi	Tutupan Lahan	Sawah	luas (Ha)
	X (m)	Y (m)				
1.	533.273,99	9.433.062,16	RTH	Vegetasi 1	_	488,5197
2.	535.024,17	9.434.054,35	RTH	Vegetasi 2	_	733,7736
3.	534.910,40	9.435.129,12	RTH	Vegetasi 3	_	369,0589
4.	536.952,86	9.435.256,65	RTH	Vegetasi 4	_	20,96297
5.	534.469,42	9.436.599,73	RTH	Lahan Terbuka 1	–	405,2382
6.	534.465,10	9.432.387,29	RTH	Lahan Terbuka 2	–	93,90656
7.	532.548,06	9.434.198,10	RTH	Lahan Terbuka 3	–	4,988272
8.	534.124,05	9.433.498,27	RTH	Lahan Terbuka 4	–	0,18914
					Total	**2116,63734**

Table 12 shows that the area identified as green open space covers 2,116.637 hectares or 29%. Based on research conducted to achieve 30% green open space in accordance with Regulation No. 26 of 2007 concerning spatial planning, with the aim of providing recommendations for the city of Metro.

4. CONCLUSIONS AND SUGGESTIONS

The results of the RTH study show that the RTH based on NDVI and SAVI processing covers an area of 77.96842, while the RTH map obtained from the Metro City Bappeda Agency in 2022 covers an area of 110.8232. Therefore, the overall difference between the RTH research map and the Bappeda RTH map is 0.703539 or 70%. It can be concluded that the NDVI and SAVI methods are not accurate enough to be used in determining Green Open Space.

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