Detection of potential green open space area using landsat 8 satellite imagery

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ARTICLE INFO	ABSTRACT
	Green city development policies have an essential role in improving the ecological functions of a municipality. According to Law 26/2007 on spatial planning, it contains provinsions for green open space which oblige the government to set aside 30% of the city as green open space. However, the main obstacle in providing green open space remains the limited availability of urban land. Therefore, efforts are needed to detect urban land that is available for use as green open space. The purpose of this study is to determine the initial description of the availability of green open space in Malang City. This study uses an integrated method of calculating the Normalized Difference Vegetation Index (NDVI) with land cover classification. NDVI analysis reveals the distribution value of vegetation density in Malang City. Based on NDVI analysis results, green open space requires medium and high density vegetation. In Malang City, only 2946.56 ha, or 26.60% of the city, meets these requirements. The availability of green open space in Malang City therefore does not meet minimum green open space requirements. This study's results suggest the need for additional policies aimed at providing green open space for Malang City.

Introduction

Green open space (GOS), as an urban landscape element, exhibits a city's social, cultural, economic, and ecological dimensions. Thus, urban GOS has a very strategic function to create an urban environment that promotes harmonious and sustainable interaction between human life and the natural environment (Respati Wikantiyoso et al. 2020). The Minister of Home Affairs Regulation No. 1 of 2007 concerns the preparation of urban GOS. According to this regulation, urban GOS planning ideally requires an area of green space equal to at least 30% of the city (R Wikantiyoso, Suhartono, and Sulaksono 2020). This 30% should be comprised of 20% public GOS and 10% private GOS in each region.

Providing and utilizing a city's open space to achieve a 30% balance is a complicated problem for local governments in urban development (Respati et al. 2020).

The main obstacle in providing green open space is the limited availability of urban land. Thus, efforts are needed to detect urban land that is available for use as green open space. Efforts to realize the conceptual provision of urban open space planning have produced regulatory requirements related to the provision of urban public spaces (Juwito, Wikantiyoso, and Tutuko 2019). Still, technical regulations cannot function as guidelines and directives for improving the quality of open urban areas (Pannell and Roberts 2009).

Vegetation is an important constituent of land use, and it exhibits diverse types (Ives et al. 2014). The collection of various vegetation types will produce different vegetation density levels, and these levels, in turn, impact land use in an area. Current efforts aim to use technology to assess the level of vegetation density in an area (Ives et al. 2014; Lausch et al. 2018; López et al. 2001). Vegetation has unique spectral characteristics that allow analysts to obtain an index representing the vegetation's condition using various methods. These technologies are remote sensing technology and geographic information systems (GIS).

The method of measuring vegetation using satellite imagery relies on the reflectance of landscape features (Mears and Brindley 2019). Vegetation index results from remote sensing data processing can note the presence and condition of vegetation in urban areas (Yunhao et al. 2006). The data utilization of remote sensing satellites for green open space mapping offers numerous advantages over the terrestrial method (López et al. 2001; Li, Fan, and Shen 2018; Kothencz et al. 2017; Mears and Brindley 2019). The method commonly used for GOS mapping employs satellite data for qualitative classification, or quantitative classification using a vegetation index. Meanwhile, green open space mapping research uses Normalize Difference Vegetation Index (NDVI) to measure plant growth and determine the vegetation coverage area (Mears and Brindley 2019; Mohamed, Worku, and Kindu 2019; Aguilera Benavente, Rodríguez Espinosa, and Gómez Delgado 2018). In NDVI calculations, the wavelength of visible red and near-infrared (NIR) light is used. The basic calculation is based on the pigment inside the leaves or chlorophyll highly absorbing light (0.4 – 0.7 um) during the photosynthesis process. Meanwhile, the leaves' cell structure is highly reflective of near-infrared light (0.7 – 1.1 um) (Sulma et al. 2017).

This research was conducted to analyze the vegetation density level of green open space in Malang using Landsat 8 satellite imagery data with the NDVI method. NDVI is the standard method for comparing the level of the greenness of vegetation in satellite image data. NDVI can be used as an indicator of biomass, relative greenness, and the status (in terms of health and density) of vegetation in an area (Lausch et al. 2018; Lai et al. 2019; Li, Fan, and Shen 2018). This study aimed to describe the potential availability of green open space in Malang using an integrated NDVI calculation method with Landsat 8 OLI data.
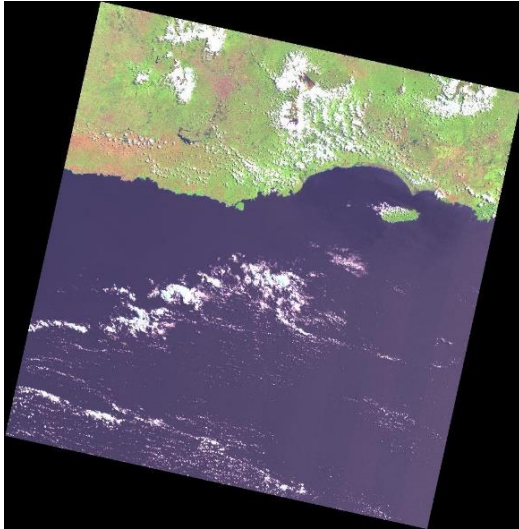
Table 1. Landsat 8 bands designation

Bands	Resolution (m)	Wavelength (μm)
Band 1 – Coastal aerosol	30	0.435 – 0.451
Band 2 – Blue	30	0.452 – 0.512
Band 3 – Green	30	0.533 – 0.590
Band 4 – Red	30	0.636 – 0.673
Band 5 – NIR	30	0.851 – 0.879
Band 6 – SWIR 1	30	1.566 – 1.651
Band 7 – SWIR 2	30	2.107 – 2.294
Band 8 - Panchromatic	15	0.503 – 0.676
Band 9 – Cirrus	30	1.363 – 1.384
Band 10 – TIRS 1	100	10.60 – 11.19
Band 11 – TIRS 2	100	11.50 – 12.51

Source: NASA Landsat 8 Bands

Landsat 8 launched on February 11, 2013. It was originally called the Landsat Data Continuity Mission (LDCM), and it carried two sensors: An On-board Operational Land Imagery (OLI) sensor and a Thermal Infrared Sensor (TIRS) with 11 channels. Among these channels, nine channels (bands 1-9) are on OLI, while two others (bands 10 and 11) are on TIRS. Table 1 shows the channel characteristics of Landsat 8 satellite imagery.

Method

Research on the potential availability of green open space in Malang uses satellite image data from Landsat 8 OLI Level 1TP sensor line 118, line 066. Figure 1 show the recording from September 17, 2020, which was obtained from the LAPAN Landsat Catalog. This research used the descriptive interpretation method with NDVI analysis of Landsat 8 OLI imagery.

Figure 1. Landsat 8 satellite imagery path/row 118/066
Source: LAPAN Landsat Catalog, 2020-09-17

The research began with preprocessing the Landsat 8 satellite image data by making geometric corrections and cropping the image to create a subset image. Landsat 8 image data was then used for further analysis (A. Purwanto 2015; Xu 2014). This research used the NDVI calculation method with land cover classification integration (Lausch et al. 2018; Li, Fan, and Shen 2018).

NDVI analysis produces the distribution value of vegetation density in Malang City. NDVI is sensitive to chlorophyll's photosynthetic activity, which enables researchers to use the NDVI value to classify vegetation (Zaitunah et al. 2018; A. D. Purwanto et al. 2014). The number and thickness of a plant's leaves will significantly affect the results of its reflection (Lufilah, Makalew, and Sulistyantara 2017). If NIR reflection is greater than red wavelength radiation, an area's vegetation is dense, and it may be classified as forest. If there is a small difference between the brightness of the reflected red and NIR wavelengths, the vegetation can be classified as grasslands or rice fields in terms of vegetative mass (Ridwan and Muharoroh 2017). NDVI values represent vegetation classification based on plant dominance (A. D. Purwanto et al. 2014; Zaitunah et al. 2018).

A faster and more accurate calculation of green open space's distribution and potential can be conducted using the NDVI analysis method. The method and use of the latest Landsat 8 data can identify changes, including additions and reductions (Feltynowski et al. 2018; Rafiee,

Salman Mahiny, and Khorasani 2009; A. D. Purwanto et al. 2014), of green open space potential in Malang City. This method is an efficient calculation and can form the basis for policy decisions on Green Open Space provision for the city in the future.
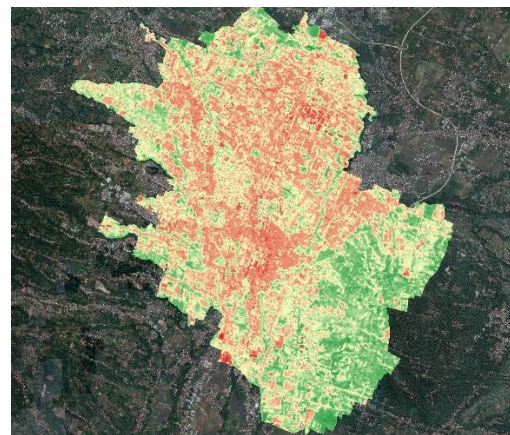
Normalized Difference Vegetation Index (NDVI)
Data analysis in this study used the NDVI method according to the following equation:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

NIR wavelengths show from band five and red from band four in Landsat 8 satellite imagery data. NDVI values range from -1 to 1. NDVI values below 0 represent the presence of clouds, ice, or snow, while values between 0 and 0.1 usually indicate empty land, and values above 0.1 indicate vegetation (Febrianti and Sofan 2014).

Result and discussion

Based on NDVI analysis, the distribution of vegetation density values in Malang City ranged from -0.0078 to 0.5169 (figure 2). The level of vegetation density based on the NDVI value can be used as the basis for classification according to plant dominance (A. D. Purwanto et al. 2014). Vegetation surfaces with an NDVI value around 0.1 indicate grasslands and shrubs. Meanwhile, values between 0.1 and 0.8 indicate tropical rain forests, and NDVI values close to +1 indicate vegetation cover.

Figure 2. Malang NDVI
Source: LAPAN Landsat Catalog, 2020-09-17

In this study, the vegetation threshold value is 0.1836. A value less than the threshold value is a non-vegetation area occupied by buildings or other types of land (figure 3). The color spectrum in figure 3 shows the distribution of non-vegetation areas in Malang City. The color spectrum's identification with an NDVI index between -0.0078 to 0.1835 classifies it as a non-vegetation area (see table 1).

Figure 3. Non-vegetation area

Table 2 shows the results of the NDVI classification for Malang City in 2020. The non-vegetation class falls in the range of 0.0078 to 0.1835 and covers 5185.71 ha, or 46.81% of the total area of the city. The moderate vegetation class, which mostly includes shrubs and tall grasses, falls in the range of 0.1836 to 0.2506. It covers 29.59% of the total vegetation area, or 3278.16 ha. Finally, dense vegetation classes, like mangrove forests, have medium to dense canopies and are considered city forests. They fall in the range of 0.5207 to 0.5169 and comprise 23.60% of the total vegetation area, or around 2614.95 ha.

Figure 4 shows the green color spectrum distribution. The distribution and value of NDVI indicate the potential area and area of Green Open Space area. Based on the NDVI calculation of the area of vegetation (Zaitunah et al. 2018) in Malang City (figure 4), the potential of green open space in Malang City is 26.60%, which falls short of the 30% required under the Minister of Home Affairs Regulation No. 1 of 2007.

Figure 4. Vegetation area

Table 2. NDVI value of Malang City

No	Classification	NDVI value	Area (ha)	%
1	Non-vegetation	-0.0078 – 0.1835	5185.71	46.81
2	Moderate vegetation	0.1836 – 0.2506	3278.16	29.59
3	Dense vegetation	0.5207 – 0.5169	2614.95	23.60
Total area			11078.82	100

Table 3 shows the results of the NDVI analysis of vegetation density in each district of Malang City, including districts with the lowest vegetation densities and the highest vegetation densities. The district with the highest vegetation density was the Kedungkandang district at 19.03%, while the district with the lowest vegetation density was the Klojen district at 2.00%.

Table 3. Vegetation area by district of Malang City

No	District	NDVI value	Area (ha)	%
1	Kedungkandang	0.25907 – 0.516138	2108.43	19.03
2	Klojen	0.17511 – 0.450339	221.31	2.00
3	Blimbing	0.211059 – 0.516935	467.82	4.22
4	Lowokwaru	0.217884 – 0.505209	732.87	5.52
5	Sukun	0.216061 – 0.480683	722.88	6.52

Conclusion

The NDVI value distribution method offers a faster and more accurate calculation of the distribution and potential of green open spaces.

The method and use of the latest Landsat 8 data can identify changes, including additions and subtractions, of potential green open space in Malang City. Because it is more efficient while remaining accurate, this method may be useful as the government works to implement future green open space policies.

The novelty of research with this method lies in implementing a control mechanism for urban green open space availability, which requires 30% of the city area. Controlling changes in urban green open space availability is significant for controlling urban green open space provision. The detection method for green open space potential is significant and should be integrated with Green Open Space Management Information System development to highlight the potential for integrated and sustainable control of urban green open space provisions.

This research opens the opportunity for further detailed research by calculating the potential of green open space in river corridors, high-voltage electricity connection corridors and railway corridors, with more comprehensive parameters.

Acknowledgment

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