Vegetation distribution analysis of green open space in Binjai Timur, North Sumatera Province using normalized difference vegetation index

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Abstract. As the city grows, more and more vegetated land is converted to non-vegetated land. This also occurred at Binjai, a city in the North Sumatera Province, Indonesia. The aim of this study was to examine the urban vegetation cover and its changes between 2015 and 2019. The research was carried out in Binjai Timur, which is one of Binjai's sub-districts. The distribution of vegetation density was measured using the Normalized Difference Vegetation Index (NDVI) value classification. The decrease in the dense class to 10.08 percent was the most significant change in vegetation density class between 2015 and 2019. This was followed by an 8.87 percent increase in the high-density class. This indicates that there is an area with vegetation density increased from lower density to high density. The district has green open spaces in the form of a neighborhood park, cemetery, sub-district park, greenbelt along the road and river, and house yards, according to the field check. These green open spaces were located in low and medium-density areas. The findings suggest that planting trees in those locations and arrangement of vegetation within parks could improve its quality and function. For good quality of urban environments, it is optimizing the use of house yards as vegetated land and boosting green open space quality is required.

1. Introduction
The city is the central area of various socio-economic activities of the community. The development of the city affects the land use within the area. The increase of population has become one major issue in studying the change of land use. Changes in land use in the city have resulted in the loss of vegetative areas the area changes from open to built-up. For instance, certain agricultural lands or wooded areas have been converted into buildings and settlements. Binjai Timur is one of Binjai City's sub-districts in North Sumatra. The city has grown as a result of population growth and development efforts. Binjai Timur has a population of 61293 people, with a population density of 2824 inhabitants/km\textsuperscript{2}, according to [1]. Increased population and urbanization have resulted in land conversion and loss of green areas. The presence of vegetation improves the environmental quality in metropolitan environments [2].

Green open space plays a critical role in the environment. The role of green open space in producing oxygen and absorbing carbon dioxide. It helps to maintain the ecosystem's balance and viability [3].
Green open space is defined in Law No. 26 of 2007 on Spatial Planning and Ministerial Regulation No. 05/PRT/M/2008 on Guidelines for the Provision and Use of Green Open Space in Urban Areas. Green open space is an elongated area, road, or cluster with a more open use, where plants thrive, both naturally and via intentional planting. At least 30 percent of the city area is required by Law No. 26 of 2007, notably the obligation for the provision and use of green open space [4].

Urban green open space is a section of the open space in an urban region that has been planted with plants to give ecological, social, cultural, economic, and aesthetic benefits. Municipal parks, natural parks, recreational parks, residential parks, office, and commercial building parks, and city woods are all included in this space [3]. The existence of a green system will be closely related to the specific location in each city, and should also be considered and the role of functions and benefits both from its position as part of open space, as well as its position in the spatial plan [5].

Green open space is necessary to improve the ecological, aesthetic, and sociologic characteristics of metropolitan environments [6]. Urban green spaces are crucial for a city's ecological sustainability and have the potential to develop healthy social interactions that benefit residents' health and well-being. Additionally, urban green spaces have been linked to increased physical activity and social engagement [7].

Urban green open space can assist in mitigating the development and environmental impact of a variety of human activities in the urban environment. The need for an area of green space is a must for every city. The area of the space has been determined by the government. As there is a regulation for each city to have at least 30 percent of the total area as green space, with 20 percent being public and 10 percent being private, it is necessary to distribute green space evenly throughout each region to create a wonderful city ambiance [8].

Remote sensing and Geographic Information Systems are critical technologies for acquiring and collecting information about an object without direct physical contact with the object. The primary purpose of remote sensing is to collect data on the environment's resources. As mentioned by [9], remote sensing data is critical for geographic information provision. This technique generates a range of images, which are then processed and analyzed to yield relevant data. Satellite imagery interpretation is a type of remote sensing technology that aims to evaluate and identify an object.

Remote sensing is essentially information about wavelength synthesis that must be decoded in order to be properly comprehended [10]. Landsat satellite imagery is a natural resource imaging satellite that is sensitive to an object's spectral response over a particular wavelength range [11].

The Normalized Difference Vegetation Index (NDVI) is an analysis that quantifies a plant's degree of greenness by combining red and NIR (near-infrared) wavelengths. It is used to determine the existence and quality of vegetation [12]. The NDVI method is the most often used method for calculating vegetation index values that can be used to determine primary vegetation productivity. The vegetation index is one of the most significant indices since it enables the rapid identification of vegetated areas [13].

A city's knowledge of the area and condition of green open space is critical. The study was conducted to determine the availability of green open space in the Binjai Timur sub-district. The study's aims were to look at the distribution, vegetation density, and change, as well as identify green open space places in Binjai Timur. Through change analysis and fieldwork, the study could provide information on the state of green open space in Binjai city. The information could contribute to city spatial planning and environmental quality enhancement.

2. Research methodology
Between November 2020 and March 2021, this research was undertaken in Binjai Timur Sub-district, Binjai City, North Sumatra. The data analysis was carried out at the Forest Management Laboratory, Faculty of Forestry, University of Sumatera Utara. The study's location is depicted in figure 1.
Binjai Timur is situated between 3° 31' 40" and 3° 40' 2" north latitude and 98° 27' 3" and 98° 32' 32" east longitude. It is situated 30 meters above sea level. The area/total area is approximately 21.70 km². Binjai Timur has located with the following boundaries in the north: Binjai Utara sub-district and Deli Serdang Regency in the East: Deli Serdang Regency in the West: Binjai Utara sub-district and Deli Serdang Regency [1].

The data gathering approach involved determining the primary and secondary data that were required for the analysis. Primary data was collected by direct observation at the research site (ground checking) through purposive sampling (sampling determined by researchers based on specific criteria), while secondary data was collected from relevant government agencies.

Data used in the study include satellite images, maps, field data, and other supportive data. GPS (Global Positioning System), cameras, and stationery were used as tools in the ground check. Excel, ArcGis 10.3, Google Earth, and ERDAS Imagine 8.5 were used software to analyze the data. Data from different sources and ground check data are listed in Table 1 as the materials used in this investigation.

### Table 1. Primary and secondary data types are required in research.

| No. | Data name                        | Data type  | Source                        | Year    |
|-----|----------------------------------|------------|-------------------------------|---------|
| 1   | Field data (ground check)        | Primary    | GPS and digital cameras       | 2020-2021|
| 2   | Image of Landsat 7 path/row 129/57 | Secondary | www.glovis.usgs.gov           | 2015    |
| 3   | Image of Landsat 8 OLI path/row 129/57 | Secondary | www.earthexplorer.usgs.gov    | 2019    |
| 4   | Google Earth imagery             | Secondary  | Google Earth                  | 2020    |
| 5   | Binjai City Administration       | Secondary  | Geospatial Information Agency (BIG) | 2020 |
| 6   | Map BPS Data Binjai City         | Secondary  | https://binjaikota.bps.go.id  | 2020    |

NDVI analysis was performed on Landsat images of different years of 2015 and 2019. Image band merging, radiometric correction, and image cropping were the steps in image preparation and processing. A field survey was carried out to have a direct understanding of the land cover in the field. GPS was used to record the coordinates of field observation locations as well as the condition of the field points, as well as providing documentation in support of data truth obtained. The closer the NDVI number approaches +1, the more closely it correlates with vegetation cover and vigor [14]. The NDVI...
number ranges from -1 to +1 and has a variable presentation depending on the land use. The NDVI value of clouds, water, and non-vegetation objects is less than zero. The NDVI value indicates the density, and vice versa for a smaller value. The following formula was used equation 1:

\[
NDVI = \frac{IR - R}{IR + R}
\]  

(1)

where:
IR = reflectance value of the infrared band
R = reflectance value of the red band

Vegetation density was analyzed using the classification of value distribution within the study area. There are five vegetation density classes, namely Non-Vegetation, Low Dense, Medium Dense, Dense, and High Dense. The classification was based on the information on the land cover during ground check and references as mentioned by [15] and [16]. There was also some basic information in NDVI analysis that was used as guidelines in classifying the related to the NDVI values in certain land covers or objects. For instance, cloud, water, and non-vegetation objects have NDVI values less than zero. Vegetation is presented by the value from 0.1. If those areas with NDVI values are below 0.11, then the area is already out of the vegetation group [17]. For areas that have an NDVI value above 0.45, it can be concluded the area is an area of vegetation with a high level of greenery.

Analysis of green open space was conducted based on a vegetation density map and field data (ground check). The threshold value for each vegetation class was determined by conducting field checks and using Google Earth. The field check gives information on what types of plants/plants are included in the class. The change analysis was conducted by overlaying vegetation density maps of 2015 and 2019. By this analysis, the change of each vegetation density class was observed.

3. Results and discussion

3.1. Normalized difference vegetation index (NDVI) in Binjai Timur

The NDVI value distribution of Binjai Timur in 2015 can be seen in figure 2. In 2015, the largest area of NDVI values was in the range of 0.3-0.4 with 1249.50 hectares or 52.73% of the area, and the smallest value of NDVI was in the range of below 0.1 that represented 0.09 hectares of the area of the location. Figure 3 shows the distribution map of the NDVI values in Binjai Timur in 2015, where most of the areas had high NDVI values.

![Figure 2. Distribution of NDVI values in Binjai Timur in 2015 (x: NDVI values, y: percentage of area).]
In 2019, the largest area of NDVI values was in the range of 0.3 – 0.4 representing 1010.82 hectares or 42.66% of the location area, and the smallest NDVI value was in the range of <0.1, which represented 0.09 hectares. The distribution of NDVI value in Binjai Timur in 2019 can be seen in figure 4. Figure 5 shows the distribution of the NDVI values map in Binjai Timur in 2019, where most of the area had high NDVI values.

Figure 3. NDVI values distribution map in Binjai Timur in 2015.

Figure 4. Distribution of NDVI value in Binjai Timur in 2019 (x: NDVI values, y: percentage of area).

Figure 5. NDVI values distribution map in Binjai Timur year 2019.
3.2. Vegetation density class in Binjai Timur

Density classes were defined using the NDVI value obtained from image processing. These classes include nil, which is devoid of vegetation, seldom, medium, dense, and highly dense. The low NDVI value is greatly influenced by the density of vegetation, land cover, and type of vegetation because the denser the vegetation, the more radiation is reflected by the leaves, and if the vegetation detected is a tree, and the NDVI value will be higher than if it is shrubs or grass [13].

NDVI <0.1 or negative in the field was in the form of non-vegetation, including buildings, while NDVI value 0.1-0.2 in the field was found as settlements and buildings, also trees along the road. Medium vegetation density class with a value of NDVI 0.2-0.3 represented by settlements with a yard with a lot of vegetation, mixed gardens, grass, rice fields, dryland farming, sub-district parks, and roadsides overgrown with trees. The dense class with a value of NDVI 0.3-0.4 was in the form of mixed gardens, oil palm plantations, trees, residential houses with a lot of vegetation, dryland farming, shrubs, and rice fields. The high dense class with NDVI >0.4 in the field consists of land that is heavily overgrown with trees accompanied by shrubs, land planted with oil palm, and land that is not utilized so that grass grows, as well as mixed gardens owned by the community planted with various plants.

According to [18], high vegetation index value gives an idea that in the area observed; there is vegetation with a high level of greenness. On the contrary, the low vegetation index value indicates that the land has a low level of vegetation. As mentioned by [19], NDVI values and vegetation density have a positive relationship, where at high vegetation density, it will have high NDVI values, and low vegetation density will have low NDVI values. The classification of values can give information on the existence and dominance of plants in the field.

Vegetation density within the area of Binjai Timur in 2015 and 2019 can be seen in figures 6 and 7, respectively. In both years, the area showed less of a low, dense cover compared to a higher density cover. There was an increase in areas within medium dense and high dense classes. In the visual comparison of figures 6 and 7, there was a decrease of dense cover within four years.

![Figure 6. Vegetation density map in Binjai Timur year 2015.](image)
From the ground check results, the class of non-vegetation density with a value of <0.1 is in the form of buildings. Visualization of non-vegetation classes can be seen in figure 8.

The low, dense vegetation with an NDVI value of 0.1-0.2 had many residential areas, buildings, roadsides, and trees. Visualization of the low dense class can be seen in figure 9.

Medium vegetation density class with NDVI value of 0.2-0.3 was in the form of community settlements that have a yard of houses with a lot of vegetation, mixed gardens, grass, rice fields, dryland farming, roadside, and district garden overgrown with trees. The visualization of the medium dense class is available in figure 10.
Figure 10. Medium dense class visualization in NDVI image (a), Google Earth (b), in the field (c).

The dense class with the NDVI value of 0.3-0.4 was found as mixed gardens, oil palm plantations, trees, residential houses with a lot of vegetation, dryland farming, shrubs, and rice fields. A visual comparison of the medium dense class can be seen in figure 11.

Figure 11. Dense class visualization in NDVI image (a), Google Earth (b), in the field (c).

The vegetation density class very close to NDVI value of >0.4 consisted of land that was overgrown with trees, land planted with oil palm plantations, and land that is not utilized so that growing grasses and shrubs, as well as mixed gardens owned by the community planted with various plants. A visual comparison of the high dense class can be seen in figure 12.

Figure 12. High dense class visualization in NDVI image (a), Google Earth (b), in the field (c).

3.3. Changes in vegetation density in Binjai Timur between 2015 and 2019
The vegetation density changes were analyzed using NDVI on the map for 2015 and 2019. Changes in vegetation density from 2015 and 2019 can be seen from the difference in the number of areas in 2015 and 2019 (table 2).
Changes in vegetation density based on density class of vegetation in Binjai Timur sub-district between 2015 and 2019 showed that the areas of the non-vegetation, low dense, and dense classes were reduced over the last four years: non-vegetation reduced by 7.14 hectares (0.30 percent), low dense has reduced by 90.82 hectares (3.83 percent), and dense has reduced by 238.74 hectares (10.08 percent) (table 2). Medium and high dense classes were the ones that had an increase or addition. The dense class was dominated by palm oil and dryland farming, whereas the high dense class was dominated by dry land agricultural, oil palm plantations, and mixed gardens, according to a ground check. Binjai Timur has a plantation and agricultural area with oil palm plantations covering a substantial portion of the land. Agriculture accounts for the majority of land use. Binjai Timur still has dense vegetation in significant regions, according to NDVI data from 2015 and 2019.

| No. | Vegetation Density | 2015  | 2019  | Change |
|-----|--------------------|-------|-------|--------|
|     |                    | Area  | Area  | Area   | Area   |
|     |                    | (Ha)  | (%)   | (Ha)   | (%)    |
| 1   | Non Vegetation     | 9.00  | 0.38  | 1.86   | 0.08   | 7.14   | *0.30|
| 2   | Low dense          | 290.56| 12.26 | 199.74 | 8.43   | 90.82  | *3.83|
| 3   | Medium dense       | 675.42| 28.50 | 801.86 | 33.84  | 126.44 | 5.34 |
| 4   | Dense              | 1249.53| 52.73 | 1010.78| 42.66  | 238.74 | *10.08|
| 5   | High dense         | 145.13| 6.12  | 355.39 | 15.00  | 210.27 | 8.87 |
|     | Total              | 2369.64| 100.00| 2369.64| 100.00 |

Description (*): Experiencing decrease meant

Changes in vegetation density occur as a result of human activity. Changes in vegetation density occur as a result of changes in land utilization and use as many acres of land have been converted, with the most densely populated land being used for settlements, industry, and other purposes, resulting in less land available for vegetation, which can lead to lower water catchment areas. This is in line with the statement made by [20], which states that changes in vegetation density can result in erosion, flooding, and sedimentation.

3.4. Analysis of green open space in Binjai Timur
A public green open space zone includes a city park, public cemetery, tourist area, recreation park, city forest, sports field, and road green line, while a private green open space zone includes gardens, yards, public or private buildings planted with plants and is owned by a specific institution or individual. In Binjai Timur, green open space includes neighbor parks, cemeteries, district parks, green lanes, river borders, and yards. The map of green open space distribution can be seen in figure 13. A map of the distribution of green open space in Binjai Timur can be seen in figure 14. Figures 15 to 19 show the description of green open space found in Binjai Timur.
Figure 13. Map of green open space class distribution in Binjai Timur (red: private green space, yellow: public green space).

Figure 14. Map of green open space type distribution in Binjai Timur.
District Park
Green open space in a sub-district can be provided in the form of a park that is shown to serve the residents of a sub-district. The District Park in Binjai Timur can be seen in figure 15. The existence of the park is currently in good condition, but there is one park, namely Taman Megawati, which has been overgrown with grass and shrubs. It needs more attention to refuction the park as it was. Vegetation found in the park of Binjai Timur are mango (*Mangifera indica*), oil palm (*Elaeis guineensis* Jacq.), bamboo (*Gigantochloa apus*), fir udang (*Casuarina equisetifolia*), mahoni (*Swietenia mahagoni*), ketapang (*Terminalia catappa*), pinang (*Areca catechu*), yellow kamboja (*Plumeria acuminata*), trembesi (*Samania saman*) and other plants are arranged to look attractive, in both parks the sub district belongs to medium dense.

![Figure 15. District park in Binjai Timur.](image)

Cemetery
Cemetery, besides having the main function as a burial place, also has an ecological function as a water catchment area, a place of growth of various types of vegetation, microclimate, and social functions in the surrounding community such as rest areas, and as a source of income. The cemetery can be seen in figure 16.

![Figure 16. Cemetery.](image)

The vegetation in this cemetery are flamboyan (*Delonix regia*), pine (*Pinus merkusii*), saga (*Adenanthera pavonina*), mahoni (*Swietenia mahagoni*), cemara udang (*Casuarina equisetifolia*), akasia (*Acacia mangium*), kamboja kuning (*Plumeria acuminata*), kakao (*Theobroma cacao*), pinang (*Areca catechu*), kapuk (*Ceiba pentandra*), oil palm (*Elaeis guineensis* Jacq.) and mango (*Mangifera indica*). Overgrown grass vegetation and the presence of other plants are deliberately planted by the community on tombstones. Cemeteries were in the medium-dense class.
Green lane
The green lane is the left and right side of the road that is used as placement of plants that function as road shade, lowering the level of air pollution by absorbing residual combustion and dust, providing protection from the sun, absorption of rainwater, steering of traffic lanes and others. The green lanes of the road in Binjai Timur along the roadway today are still very neatly arranged. The green path of the road can be seen in figure 17.

Figure 17. Green lane.

The vegetation on the green path of the road is angsana (*Pterocarpus indicus*), mahoni (*Swietenia mahagoni*), kiara payung (*Filicium decipiens*), glodokan tiang (*Polyalthia longifolia*) which easily grows without the need for special care lined up with a certain distance along the way and has a wide title. The green path was in the medium density class.

Riverbank
The boundary is part of the land along the right-hand side of the river which has important benefits for maintaining the sustainability of the river's function and is set at a certain distance parallel to the edge of the river bank. Vegetation in the river can be seen in figure 18.

Figure 18. Vegetation along the river.

The vegetation along the riverbank is oil palm (*Elaeis guineensis Jacq*), bamboo (*Gigantochloa apus*), ara (*Ficus racemosa*) and other plants that are spread along the river border. Plants that dominate along the river border are oil palm. Thus, the river banks are at the risk of soil erosion because the vegetation that grows around the riverbank is not appropriate for the area. Vegetation diversity is influenced by human activity along the river boundary. Residents living around the stream use the land as agricultural land, which makes natural trees difficult to find. The upstream part of the river is generally overgrown by undergrowth such as grass and shrubs. Vegetation on the river border was in the medium class.
Private green space
Private green space is a green open space belonging to certain individuals who use it for limited circles in a yard of houses or buildings owned by the public or privately planted plants. The examples can be seen in figure 19.

Figure 19. Home yard.

The yard is a land outside the building, which serves to be various activities so that the house can also be used for green open space, in addition to cooling, the community can also make use of fruit when vegetation is planted by residents. In Binjai Timur, each house has a yard dominated by Multi-Purpose Tree Species, namely rambutan (Nephelium lappaceum), kakao (Theobroma cacao), mango (Mangifera indica), jambu air (Syzygium aqueum), and other plants. The vegetation in the yard of the house was in a medium class.

Green open space is an important component of a city's ecosystem. Green open spaces have functions both ecologically, socially, aesthetically, culturally, and economically that affect the quality of human life [21]. The city needs vegetation because plants have a diverse role in the life of organisms apart from the value of beauty. According to [22], green space has a role in the protection of ecosystems, means of creating cleanliness, health, and improvement of the microclimate that can affect the level of environmental comfort. The level of comfort of the environment is based on the temperature and humidity of the environment that can be improved by the presence of vegetation.

Based on field data, green open space is spread over a class of low dense and medium vegetation density. Some dense vegetation existed in the medium class. In the class of low density is a neighboring community park. The medium vegetation density is in a cemetery, a house, a green lane road, along the river, and district park. The low density is rarely dominated by grass and other plants. The medium dense class consisted of trees, grass, and shrubs.

The existence of green open space in spatial planning is very important considering spatial planning. Regulation of the Minister of Public Works No. 5/PRT/M/2008 concerning Guidelines for the Provision and Utilization of Green Open Space in Urban Areas (Kementerian Pekerjaan Umum, 2008) explained that big houses must have at least three protective trees, a medium house must have at least two protective trees, dan small house must have at least one protective trees. If there was no yard available, then it can be formed as a roof garden. The need for community and government cooperation to be able to plant trees along the river border and the yard of the house, so that the function of green open space in Binjai Timur sub-district can be run optimally.

Parks and other green spaces are critical components of an urban environment that is sustainable, healthful, and socially equitable. Urban planning and management of green spaces benefit from statistics on green space use and value, but such data are frequently sparse and laborious to obtain [23]. GIS and remote sensing have the ability to provide such data. This study gives information on vegetation distribution in urban areas and its relation with green open space areas.
4. Conclusion
The largest change in vegetation density class in Binjai Timur from 2015 to 2019 was a decrease in the area of the dense class by 10.08%. Binjai Timur has green space in the form of neighbor parks, cemeteries, subdistrict parks, green lanes, river borders, and yards. The green space areas were in low dense and medium dense classes. There is a need to replant trees in the area within the low dense class, especially in the area along the road and river. The government should encourage people to plant trees and other vegetation in their houses, yard and buildings. The green open space could support the quality of life of people by giving a good quality environment and preventing microclimatic problems.

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