Vegetation density analysis using normalized difference vegetation index in East Jakarta, Indonesia

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Abstract. East Jakarta, which is included in the DKI Jakarta Province, continues to grow in population. As a result, the demand for settlement land increases. The presence of plants is critical for environmental equilibrium. The purpose of this study was to determine the vegetation density and its variations in East Jakarta year 2020. The method used the Normalized Difference Vegetation Index (NDVI) analysis and classification. In 2020, the highest NDVI value in East Jakarta was 0.1–0.2, covering 7,952.64 ha (43.07\% of the entire area, while the lowest value was >0.6, covering 0.06 ha of the total area. The highest vegetation density class in East Jakarta was low dense class, accounting for 7,951.26 ha (43.06\%) of the whole area, while the lowest density class was under high dense class accounted for 1,116.41 ha (6.04\%) of the total area. In terms of green open space, there were a city park, a cemetery, a green lane on a road, and a river bank. The municipal park was classified as dense, while the rest were classified as medium dense. The presence of trees within the green space has aided in the area’s vegetation density. It also refers to the role of open green space in enhancing the community’s life and environment’s quality. The importance of educating and guiding the surrounding community about the benefits of vegetation or green open space, then replanting less vegetated land, as well as an integrated land use planning and implementation. The first section in your paper

1. Introduction
Special Capital Region of Jakarta (DKI) Jakarta is the capital city of Indonesia and serves as a focal point for the surrounding districts. This enhances many people's desire to live in a large city like DKI Jakarta. Naturally, population expansion entails an increase in housing requirements. As a result, vegetated land is converted to built-up land.
Rapid urbanization in Asian developing countries has led to large urban agglomerations called “megacities” [1]. Concentration of industry in metropolitan regions in the future will result in densely packed communities, amenities, and infrastructure, while population increase converts vegetative land to built-up land. This is consistent with [2] assertion that the city serves as the focal point for a variety of community activities. Urban places are equally important as a place of residence for the community. Mentioned by [3] that Jakarta, Indonesia’s primate city and the world's second largest urban agglomeration, is undergoing a deep transformation.

Building expansion results in the loss of vegetated areas such as open spaces, agricultural land, and urban woodlands. Changes in the area's land usage may potentially affect the ecological equilibrium. All of this is a result of the economics and growth of the DKI Jakarta Province advancing year after year. This is consistent with [4] that land availability is a significant constraint on development in DKI Jakarta, as development provides more economic benefits than vegetation.

The rapid social and economic development of urban populations has altered the commercial and industrial uses of land. The transition from closed to open land cover, and subsequent changes in land use, occur as the demands for basic human necessities continue to grow. This is consistent with [5] that land use change is the process of transitioning from one land use to another, whether permanent or temporary.

Land use changes occur as a result of the desire to accommodate the demands of an expanding population. In line with that, [6] stated that improving one's quality of life will eventually result in difficult-to-control changes in land use, causing the condition of natural resources to deteriorate and surface water flow to become rapid. More population can result in increased development, particularly in the housing sector. This will undoubtedly lower the amount of greenery that already exists in DKI Jakarta to meet the housing needs of residents.

With the development of a place, particularly in metropolitan areas, land resources will undoubtedly be required, converting previously vegetated land into built-up land to boost the economic value of individuals and groups, despite the fact that land is a finite resource. This is consistent with [7] assertion that the phenomena of land scarcity will continue to expand as a result of economic development and population growth. This is understandable, given the critical nature of land. Numerous critical facets of life and development are inextricably linked to land issues, whether directly or indirectly.

Facilities and infrastructure development operations will eventually result in changes to the function of the land and to the quality of the environment. The primary influence on land use in urban areas is the growth of social and economic factors; this is consistent with [8] assertion that changes occur as a result of the need to meet the needs of an increasing population and are associated with increasing demands for quality of life. better.

Because population growth continues to expand and humans essentially require a place to live for their needs, the surrounding area will be used as a place to dwell, reducing and eventually eliminating the vegetated land cover. Additionally, [9] stated that settlements will continue to be a cause of conflict throughout human history. Settlements will continue to expand in lockstep with population growth.

Due to limited acreage, vegetated land is converted to residential land to suit the population's primary needs, resulting in changes in land use and environmental deterioration. This is consistent with [10] assertion that the demand for houses continues to grow faster than available land. Due to the scarcity of residential land in metropolitan areas, it stimulates land use changes and environmental deterioration.

It is critical to have information regarding changes in vegetation density in order to understand the current state of DKI Jakarta Province, particularly East Jakarta. The Normalized Difference Vegetation Index (NDVI) analysis reveals the distribution of and changes in vegetation density. This data is necessary for environmentally conscious urban development. As a result, it is required to perform study on the dynamics of vegetation cover in East Jakarta. The purpose of this research is to analyze the distribution of vegetation density in East Jakarta City. This research is beneficial because
it provides information about the distribution and changes in vegetation density that can be used to assist associated parties in East Jakarta City's land use planning.

The DKI Jakarta area is comprised of 110 islands scattered around the Thousand Islands. The division of the DKI Jakarta Province is defined by Governor's Decree No. 1986/200 dated July 27, 2000. It comprises of the Municipalities of Central Jakarta, North Jakarta, West Jakarta, South Jakarta, East Jakarta, and the Thousand Islands Administrative District. Each municipality or district is subdivided into numerous sub-districts, and each sub-district is further subdivided into multiple sub-districts, as shown in the following table:

Jakarta, or more precisely, the Special Capital Region of Jakarta (DKI), is Indonesia's capital, the country's largest metropolis, and one of the world's most populated urban agglomerations. Jakarta is transforming into a metropolis with rapid social and economic development. Jakarta serves as the economic, commercial, banking, and trade industry's hub, as well as the political, social, cultural, and creative nexus. Additionally, Jakarta serves as a hub for a variety of international activities. The dominance of Jakarta's expansion is demonstrated quite plainly by the city's development as a magnet for the surrounding area [11].

DKI Jakarta Province continues to grow in population each year. Because humans require a place to dwell in order to exist, communities will continue to grow in size in lockstep with population growth. As a result, closed land is turned into settlements to suit the primary needs of each resident.

East Jakarta Administrative City covers an area of 187.75 kilometers square, or 28.37 percent of the entire area of DKI Jakarta Province. This area is primarily comprised of lowlands. East Jakarta City is an Administrative City with the largest size of any Administrative City in DKI Jakarta and a significant amount of vegetation area, which is consistent with [12] remark that greenery is primarily found in South and East Jakarta.

Vegetation is a collection of plant species that acts as a natural barrier between the environment and humans, protecting them from harsh microclimates, pollution, and erosion. The comfort of a city's citizens is inextricably linked to the presence of greenery as a form of sustainable green infrastructure. Optimizing the management of urban parks as multipurpose green areas has the potential to significantly improve environmental quality [13].

Green open space has a number of benefits for humans and the surrounding environment, including the reduction of air pollution and the improvement of environmental quality. Through the planning, provision, and management of green open space, urban areas are expected to become more comfortable, beautiful, and sustainable. This is consistent with [14] that the existence of a green system is inextricably linked to the unique potential of each city region, in terms of directing the area's balance as an ecological, sociocultural, and economic function.

GIS and remote sensing techniques were employed to identify urban expansion [1]. Remote sensing is a technique for identifying objects on the earth's surface without physically touching them. Remote sensing is mostly used to acquire data about environmental natural resources. The observer transmits information about the thing via electromagnetic energy. Thus, remote sensing is essentially a synthesis of wavelength information that must first be coded in order to be completely comprehended [15].

Landsat satellite imagery is a natural resource satellite image that records in seven spectral band and has a spatial resolution of 30 x 30 meters (except for the thermal infrared unit). Each channel of Landsat satellite imagery is sensitive to spectral responses, which results in pixels with varied spectral responses reflecting values with varying spectral responses [16].

The vegetation index is calculated as the ratio of the red band (R) to the near-infrared band (NIR) reflections in the electromagnetic wave spectrum. The NDVI formula is the most often used method for computing the vegetation index value, which may be used to determine the primary production of vegetation. The vegetation index is a highly useful metric for easily identifying vegetated areas when multispectral remote sensing data is employed [17].

Normalized Distinction the Vegetation Index is a method for determining the amount of vegetation on a surface based on the reflection of light waves produced by plants, as each surface reflects light
waves differently. This is consistent with [18] that vegetation or plants that are actively photosynthesizing will absorb the majority of the red wavelengths of sunlight and reflect or reflect the higher near infrared wavelengths. Meanwhile, vegetation that is less healthy or is no longer photosynthetic active reflects more red wavelengths and less near infrared wavelengths.

The vegetation index is a mathematical mixture of the red and near-infrared (NIR) bands that is used to determine the presence and quality of vegetation. Vegetation that is actively photosynthesizing will absorb the majority of the sun's red waves and reflect the higher near infrared waves. Vegetation that is dead or stressed (unhealthy) reflects more red light and less near infrared light. The vegetation index is a measure of vegetation's greenness that is calculated via digital signal processing of brightness value data from various satellite sensor channels. On non-vegetated terrain, including lakes, residential areas, unoccupied land, construction zones, and regions with damaged vegetation [19].

2. Methods
The research was conducted from December 2020 to April 2021. The research was conducted in East Jakarta. It is one of the cities in DKI Jakarta. The location can be seen in Figure 1.

![Figure 1. Research Location Map](image)

Data gathering and analysis were part of the study. GPS, camera compass, and stationery are all examples of field data collection instruments. Excel, ArcMap 10.3, and ERDAS Imagine 8.5 were utilized as applications. Table 4 contains the data required for this investigation. Primary data were collected during the course of this research; primary data are those obtained through direct observation at the research location (ground check); field surveys are conducted to ascertain the truth about a vegetation density in the field; and secondary data are those obtained from government agencies. In this research, purposive sampling was used to gather the coordinates of field observation locations and GPS. The types of land cover encountered in the field are documented; this is useful for confirming the accuracy of the data on vegetation density generated by image processing using NDVI transformation. The data collection approach is determined by determining the primary and secondary data that are required for the study.

2.1. Data analysis
The Normalized Difference Vegetation Index (NDVI) is a formula that calculates the NDVI value obtained by computing the Near Infrared with Red reflected by plants. The NDVI value might be between -1 and +1. Values near zero indicate arid places with scarce or no vegetation; higher positive values imply more live plants; higher negative values often indicate the presence of free-standing
water, clouds, or snow. The NDVI value is calculated as a measure of green vegetation by comparing Near Infrared and Red data using the following formula:

$$\text{NDVI} = \frac{\text{IR} - \text{R}}{\text{IR} + \text{R}}$$

NDVI stands for Normalized Difference Vegetation Index, NIR stands for Landsat 8 band 5 and Landsat 5 band 4, and red stands for Landsat 8 band 4 and Landsat 5 band 3.

2.2. Analyses of Vegetation Density
Classification of NDVI was used in the analysis. Classification of NDVI values begins with obtaining the highest and lowest values, which are then classified into five classes. Classification is based on field data and NDVI-related studies. Some references did NDVI classification into vegetation density class including by [17], [20] and [21].

Field data offers information about the land cover classes found in the research location. To identify the distribution of values within each land cover class, an NDVI study will be performed.

3. Results and Discussion

3.1. Distribution of Normalized Difference Vegetation Index (NDVI) in East Jakarta City Kota
The distribution of Normalized Difference Vegetation Index (NDVI) values in East Jakarta City in 2020 can be seen in Table 1.

| No | NDVI   | Area (Ha) | Area (%)   |
|----|--------|-----------|------------|
| 1  | <0     | 74.40     | 0.40       |
| 2  | 0–0.1  | 4,626.64  | 25.05      |
| 3  | 0.1–0.2| 7,952.87  | 43.07      |
| 4  | 0.2–0.3| 2,883.12  | 15.61      |
| 5  | 0.3–0.4| 1,813.54  | 9.82       |
| 6  | 0.4–0.5| 1,017.18  | 5.50       |
| 7  | 0.5–0.6| 94.91     | 0.51       |
| 8  | > 0.6  | 0.06      | 0.00       |
|    |        | 18,462.72 | 100        |

As shown in Table 8, the biggest NDVI value in East Jakarta in 2020 was 0.1–0.2, covering 7,952.64 ha (43.07 percent) of the whole area, while the smallest was >0.6, covering 0.06 ha (0.00 percent) of the total area, and the total area of East Jakarta City is 18,462.72 ha. Figure 1 illustrates the distribution of NDVI values in East Jakarta City in 2020. Map of the distribution can be seen in Figure 2.
3.2. Distribution of Vegetation Density Classes in East Jakarta

Based on classification of the NDVI values, there are 5 vegetation density classes. Those classes can be seen in Table 2. The table also shows the percentage of area within each class.
Table 2. Vegetation Density Class in East Jakarta in 2020

| No | Class       | Area (Ha) | Area (%) |
|----|-------------|-----------|----------|
| 1  | Non Vegetation | 4,702.94  | 25.47    |
| 2  | Low dense   | 7,951.26  | 43.06    |
| 3  | Medium dense | 2,882.96  | 15.61    |
| 4  | Dense       | 1,809.15  | 9.79     |
| 5  | High dense  | 1,116.41  | 6.04     |
|    |             | 18,462.72 | 100      |

According to Table 2, the highest density class in East Jakarta in 2020 was low dense class, accounting for 7,951.26 ha (43.06 percent) of the whole area, while the smallest was high dense, accounting for 1,116.41 ha (6.04 percent) of the entire area.

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Figure 4. Vegetation density map of East Jakarta year 2020

The spatial distribution of vegetation density in East Jakarta City in 2020 can be seen in Figure 4. Figure 5 shows the percentage of area within each vegetation density class.
The vegetation density class is divided into five categories based on the results of field checks. NDVI 0.1 represents a non-vegetation density class, 0.1-0.2 represents a low dense class, 0.2-0.3 represents a medium dense class, 0.3-0.4 represents a dense class, and >0.4 represents a high dense class. Non-vegetation density class, which includes bodies of water or reservoirs, tall buildings or structures, and areas with little or no vegetation. The sparse vegetation density class includes locations with low density, such as roads, buildings, communities, and bodies of water. The medium density class includes highways, mixed land, rice fields, buildings, grass, and settlements, all of which feature vegetation in the form of trees. In the dense class, there is a high concentration of vegetation in the form of rice fields, mixed land, grasslands, and forests. While the vegetation is high dense, the degree of vegetation in metropolitan areas is extremely high in the form of trees, grass, and rice fields.

Field checks conducted in East Jakarta offer a summary of the vegetation cover in each density class. The following explanation illustrates the distinctions between the density classes.

**Non vegetation**
The Perum Perumnas area is comprised of various high-rise buildings along Jalan Mayor General DI Panjaitan Jatinegara, the Cipinang Indah mall on Jalan Raya Kalimalang, water bodies such as the Haji Dogol Reservoir in Pondok Bambu, the Cililitan Wholesale Center on Jalan Mayjend Sutoyo, and the Kramat Jati Market on Jalan Raya Bogor. Figure 6 illustrates the area classified as non vegetation.
3.2.1. **Low dense class**

Low dense class found in residential areas, such as Jalan Mandal Cililitan, Jalan Industri Kecamatan Makassar, Jalan Cawang Baru Utara Jatinegara, Kalimalang Toll Road, Cipinang Cempedak Jatinegara residential areas, Jalan Pahlawan Revolution Duren Sawit, Jalan Raya Kalimalang Pondok Bambu, Jalan Pahlawan Kartika Eka Paski Cipinang Melayu, Jalan Kapin Raya Pondok Kelapa, Jalan Raya Pondok Gede, Makassar District, Jalan Pusdiklat Depnaker, and Jalan Pinang Ranti. Areas belonging to the rare vegetation density class can be seen in Figure 7.

![Figure 7. Low dense Class](image)

3.2.2. **Medium dense class**

Medium dense class are found in mixed land areas such as Jalan Kapin Raya Duren Sawit, Picnic Park in Cipinang Melayu, Dogo Field on Jalan Duku Kebon Pala, grass on Jalan Jaani Nasir Cawang, Jalan Haji Bakri Pondok Bambu, Jalan Kangguru Halim Perdana Kusumah. Vegetated residential areas such as trees on Jalan Madawi Halim Perdana Kusumah, Jalan Usaha Cawang and Jalan Inspection Kalimalang Channel. Areas belonging to the medium vegetation density class can be seen in Figure 8.

![Figure 8. Medium dense class](image)

3.2.3. **Dense class**

Dense class are found in rice fields such as near Jalan Anggrek Raya Jatinegara, Jalan Gebang Mutiara Cakung Timur, and Jalan Irrigation in Ujung Menteng. The tree area is located on Jalan Trikora Halim Perdana Kusumah, Ciracas District, Jakarta Cikampek Toll Road, Halim Perdana Kusumah, Makassar District. In the grass and mixed land area, it is located on Jalan Kakaskasen III Cawang, Kramat Jati District, Jalan Kebon Nanas Cipinang Besar, Jatinegara District, Jalan Raya Kalimalang, Pondok Bambu, Duren Sawit District, Jalan Overtime, Makassar District. The area belonging to the dense vegetation density class can be seen in Figure 18.
3.2.4. **High dense class**

High dense vegetation class were found in tree areas such as in the Halim Perdana Kusumah Golf Course area, the Cilangkap Military Complex area, Radar Street in Kalisari, Kaimana JH Baru Street, East Jakarta City, Pramuka Street, Matraman District, Ciliwung River area, Pasar Rebo District. The area belonging to the high dense class can be seen in Figure 10.

Comparison of visualization between NDVI images with Google Earth image and photos of ground check can be seen in Figure 11-15. Each figure representing each vegetation class.

**Figure 9.** Dense class

**Figure 10.** High dense class

**Figure 11.** Visualization of Non vegetation class in; (a) NDVI; (b) Google Earth; (c) field.
Figure 12. Visualization of low dense class in; (a) NDVI; (b) Google Earth; (c) field.

Figure 13. Visualization of medium dense class in; (a) NDVI; (b) Google Earth; (c) field.

Figure 14. Visualization of dense class in; (a) NDVI; (b) Google Earth; (c) field.

Figure 15. Visualization of high dense class in; (a) NDVI; (b) Google Earth; (c) field.
The NDVI image visualization demonstrates that the lighter the resulting hue, the denser the vegetation, and the darker the resulting hue, the lower the vegetation density. A higher vegetation density results in a higher NDVI value, while a lower vegetation density results in a lower NDVI value. The map and field visualizations indicate that the building area is a non-vegetation class with a low NDVI ratio, whereas the tree area is a very dense vegetation class with a high NDVI ratio, which is consistent with the statement made by [20] that the higher the NDVI value, the greater the vegetation density.

3.2.5. Green Open Space in East Jakarta

Urbanization is accelerating in Indonesia, particularly in East Jakarta, resulting in changes in the area of vegetation density, including the extent of green open space. Mentioned by [22] that air pollution has become a growing concern, especially in urban cities with rapidly developing economies, increasing infrastructure and vehicular population, and reduced green spaces.

Development has an effect on the surrounding environment as a result of growing socioeconomic needs as a result of population expansion. According to field checks, the green open space area falls between the medium and dense vegetation density classes.

According to Law No. 26 of 2007 on spatial planning, green open space is an elongated area, road, or group with a more open use as a location to grow plants, either naturally or artificially. The applicable minimum standard for green open space is 30%, with 20% in the form of public green open space and 10% in the form of private green open space. The following description details the various forms of green open space encountered.

3.2.6. City Park

A city park is an open space that serves social and aesthetic purposes as a venue for recreational, educational, and other city-level activities. Urban parks are designed to benefit the population of a city or a portion of a city. Figure 16 depicts City Park.

![Figure 16. City Park](image)

The names of the parks in East Jakarta City are Intirub Triangle Park, Ria Rio Reservoir Park, Orchid Garden, Palm Park, Menteng Utama Park, Mahogany Park. The types of vegetation in the park, which is located in East Jakarta City, are banyan (*Ficus benjamina*), mahogany (*Swietenia mahagoni*), glodokan (*Polyalthia longifolia*), pine (*Pinus merkusii*), cape (*Mimusops elengi*), pulai (*Alstonia scholaris*), mango (*Mangifera indica*), tamarind (*Tamarindus indica*), krei umbrella (*Filicium decipiens*), norfolk cypress (*Araucaria heterophylla*), and saga (*Adenanthera pavonina*) which spread around the location, city parks are included in the dense vegetation density class.

**Cemetery**

The cemetery serves an ecological purpose by acting as a water catchment area, a habitat for many species of vegetation, and a social function in the local community by serving as a place of rest and a source of revenue. Figure 33 depicts the cemetery.
The names of the public cemeteries in East Jakarta are Utan Kayu TPU, Pondok Kelapa TPU, Bambu Apus TPU, Cipinang Asem TPU, Prumpung TPU, Kebun Nanas TPU, Pondok Ranggon TPU, and Cijantung TPU. The types of vegetation that exist in the TPU located in East Jakarta City are krei payung (*Filicium decipiens*), mahogany (*Swietenia mahagoni*), flamboyant (*Delonix regia*), frangipani (*Plumeria*), sugar palm (*Arenga pinnata*), mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), petai china (*Leucaena leucocephala*), cape (*Mimusops elengi*), melinjo (*Gnetum gnemon*), areca nut (*Areca catechu*), cacao (*Theobroma cacao*), and overgrown with spreading medium grass and ornamental plants intentionally planted by residents, the burial area is included in the medium vegetation density class.

### 3.2.7. River Bank

As a water catchment and reservoir, Green Open Space in the shape of a river border area serves an ecological purpose. Additionally, the river border region provides water and nutrients, serves as a home for vegetation and animals, and serves as a filter for pollutants and hazardous substances. Figure 18 depicts the river's boundaries.

Ciliwung, Kalimalang, Sunter, and Cakung rivers are rivers located in East Jakarta City. The vegetation along the river border are banana (*Musa paradisiaca*), fig tree (*Ficus racemosa*), bamboo (*Bambusoideae*), sengon (*Paraserianthes falcataria*), glodokan (*Polyalthia longifolia*), mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), coconut (*Cocos nucifera*) and soursop (*Annona muricata*), and water guava (*Syzygium aqueum*), which spread along the river border area. The river border area is included in the medium vegetation density class.

### 3.2.8. Green Lane

The road green lane is the space on the left and right sides of the road where plants are planted to act as road shade, reducing air pollution levels by absorbing vehicle dust and fumes, absorbing
precipitation, and guiding traffic lanes, among other functions. The green lane that runs through East Jakarta City is still in good condition. The road's green lane can be seen in Figure 19.

![Figure 19. Green lane](image)

On the green lane, there are trees planted. Those trees include mahogany (*Swietenia mahagoni*), umbrella tree (*Filocium decipiens*), banyan (*Ficus benjamina*), trembesi (*Samanea saman*), glodokan (*Polyalthia longifolia*), frangipani (*Plumeria*), and ketapang (*Terminalia catappa*). The green lane area were under medium dense class.

Jakarta is Indonesia's economic capital and the key target for urbanization. This condition promotes urban growth, notably in Jakarta's peri-urban areas. Each year, the city of East Jakarta grows in population, resulting in a loss of vegetation due to the transfer of function from closed area to built-up land. This is consistent with [5] who state that land use change is the process of transitioning from one land use to another. other permanent or temporary land; this is a result of the community's rapid social and economic development, which results in changes in the function of land for commercial and industrial purposes, such as the transition from closed to open land cover.

The Governor's Regulation on Plant Management in the Jakarta Archipelago was enacted on December 26, 2018 in order to improve environmental quality. By utilizing land effectively and according to sound spatial planning principles, we can improve both our quality of life and the quality of the environment. Recommendation new approaches by [1] to mega-urban governance in developing countries to avoid the inefficiency of scarce resources, including industrial estates and new town governance with reliable data systems and collaborative approaches.

4. Conclusion

In 2020, East Jakarta's highest NDVI value was 0.1–0.2, covering 7,952.64 ha (43.07 percent) of the total area, while its lowest value was >0.6, covering 0.06 ha. East Jakarta's highest vegetation density class was low dense, covering 7,951.26 ha (43.06 percent) of the total area, while the lowest density class was under high dense, covering 1,116.41 ha (6.04 percent). There was a city park, a cemetery, a green lane on a road, and a river bank in terms of green open space. The municipal park was under dense class, while the remainder were under medium dense class. Trees within the green space have aided in increasing the area's vegetation density. Additionally, it refers to the role of open green space in improving the quality of life and environment in a community. The critical nature of educating and guiding the surrounding community about the benefits of vegetation or green open space, then replanting less vegetated land, as well as the importance of integrated land use planning and implementation.

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