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| Research Article

Vegetation Index Analysis Using the NDVI (Normalized Difference Vegetation Index) Method from SPOT 7 Imagery in Simeulue Regency

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Abstract: Vegetation cover is a crucial component for ecosystem stability in island regions such as Simeulue Regency. This study aims to map vegetation density using NDVI analysis from SPOT 7 2022 satellite imagery in Simeulue Regency. Data processing was performed using ArcGIS 10.8 software, with the study area covering the districts of West Simeulue, Central Simeulue, and Teluk Dalam. NDVI classification refers to five categories based on Ministry of Forestry regulations. The analysis revealed that the High Vegetation class dominates the area, reaching 29,162.21 ha (69.67%), reflecting the still dense vegetation conditions. Non-Vegetation Areas are the second largest, covering 11,445.68 ha (27.34%), dominated by water bodies. Other vegetation classes have very small percentages, marking transition areas. Although green cover remains dominant, the presence of extensive non-vegetation land requires an integrated environmental management strategy to support sustainable development.

Keywords: Vegetation; NDVI; SPOT 7; Simeulue.

1. INTRODUCTION

Vegetation is an important component in maintaining the carbon balance and the hydrological cycle, so monitoring its condition is crucial to prevent environmental degradation (Morshed & Fattah, 2021). Remote sensing is an efficient and comprehensive approach to vegetation monitoring, providing accurate, continuous spatial data compared to conventional methods (Novando & Arif, 2023). One of the most effective methods is the Normalized Difference Vegetation Index (NDVI), which is useful for seeing the difference in chlorophyll spectral reflectance in the red and near infrared channels to measure plant density and health precisely (Trinufi & Rahayu, 2020). The use of high-resolution satellite imagery, such as SPOT 7, in Simeulue Regency is crucial because it can help produce more detailed mapping, thus supporting sustainable planning and management of the archipelago.

In the face of environmental change and the need for extensive and accurate vegetation data, remote sensing technology is a crucial instrument in ecological studies (Senf, 2022). Remote sensing helps to collect spatial and temporal information about vegetation at local to global scales (Zha, 2025). Modern satellites and sensors capture electromagnetic radiation reflected from the Earth's surface. These reflected radiation are then interpreted to generate data on the condition, health, and changes in vegetation cover (Ahmadi et al., 2023).

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Remote sensing data and field information help to understand vegetation conditions in response to various environmental changes and natural disturbances (Ahmadi et al., 2023).

The Normalized Difference Vegetation Index (NDVI) is a vegetation index used to assess vegetation using remote sensing data (Zapata et al., 2022). NDVI is calculated as the difference between near-infrared and red reflectance divided by their sum, expressed as [NDVI = (NIR − Red) / (NIR + Red)]. NDVI values range from −1 to 1, with higher positive values indicating denser, healthier vegetation. In contrast, values close to zero or negative represent non-vegetated features such as water, clouds, or bare soil (Zapata et al., 2022). However, NDVI has several limitations, including sensitivity to atmospheric effects and saturation in areas with very dense canopy cover. Despite these limitations, NDVI remains a reliable method for analyzing vegetation dynamics and environmental pressures (Boothroyd et al., 2021).

SPOT satellite imagery is widely recognized as a high-quality source of remote sensing data. SPOT 7, launched in 2014, provides high spatial resolution with 1.5 meters for the panchromatic band and 6 meters for multispectral bands (green, red, and near-infrared) (Phinzi et al., 2023). One of the main advantages of SPOT 7 is its rapid revisit capability of approximately one day, enabling near-daily data acquisition. This feature is particularly useful for monitoring rapid and dynamic environmental changes (Morin, 2020). Its high spatial resolution supports detailed vegetation mapping, accurate land-cover identification, and precise analysis of land-use changes (Derksen, 2019).

Simeulue Regency is an island located approximately 150 km off the western coast of Aceh, Indonesia, directly facing the Indian Ocean (Rasyid et al., 2023). The topography of Simeulue varies, with most areas lying at elevations between 0 and 300 meters above sea level, while some hilly regions reach up to 600 meters (Gadeng et al., 2019). These geographical conditions significantly influence settlement patterns and communities' adaptation to natural hazards, as natural vegetation plays an important role in mitigating tsunamis. Vegetation in Simeulue Regency exhibits characteristics typical of coastal and island ecosystems. Common vegetation formations include mangrove forests along the coastline, coconut trees, shrubs, and other plant species that dominate coastal areas (Gadeng et al., 2019). Continuous monitoring of vegetation cover and land use change in Simeulue is essential to support ecosystem conservation efforts and adaptive spatial planning.

This study is important considering the crucial role of vegetation in maintaining ecosystem balance and supporting community livelihoods in Simeulue Regency amid environmental changes. However, most vegetation monitoring studies in Indonesia's island regions are still dominated by medium-resolution satellite imagery such as Landsat (Kurniadin et al., 2022). The spatial resolution limitations of such data reduce the ability to capture detailed vegetation density needed for specific spatial planning purposes (Damsir et al., 2023). To date, studies specifically mapping vegetation conditions in Simeulue using high-resolution sensor technology remain very limited (Suriani et al., 2023).

Therefore, this study aims to analyze vegetation indices in Simeulue Regency using the NDVI method with SPOT 7 satellite imagery. The use of SPOT 7 imagery is expected to provide more accurate and effective information about vegetation cover than conventional methods. The results of this study are expected not only to enhance scientific understanding of Simeulue's ecological conditions but also to provide a spatial data foundation for environmental conservation policies and future environmental adaptation strategies.

2. RESEARCH METHODS

Research Location

This study was conducted in Simeulue Regency, one of the island regencies in Aceh Province, located on the western coast of Indonesia facing the Indian Ocean. Based on data from the Central Bureau of Badan Pusat Statistik Kabupaten Simeulue (2025) Statistics in 2024, Simeulue Regency had an administrative area of 1,838.10 km². It consists of ten sub-districts, namely Teupah Barat, Teupah Tengah, Teupah Selatan, Simeulue Timur, Simeulue Tengah, Simeulue Barat, Simeulue Cut, Teluk Dalam, Salang, and Alafan.

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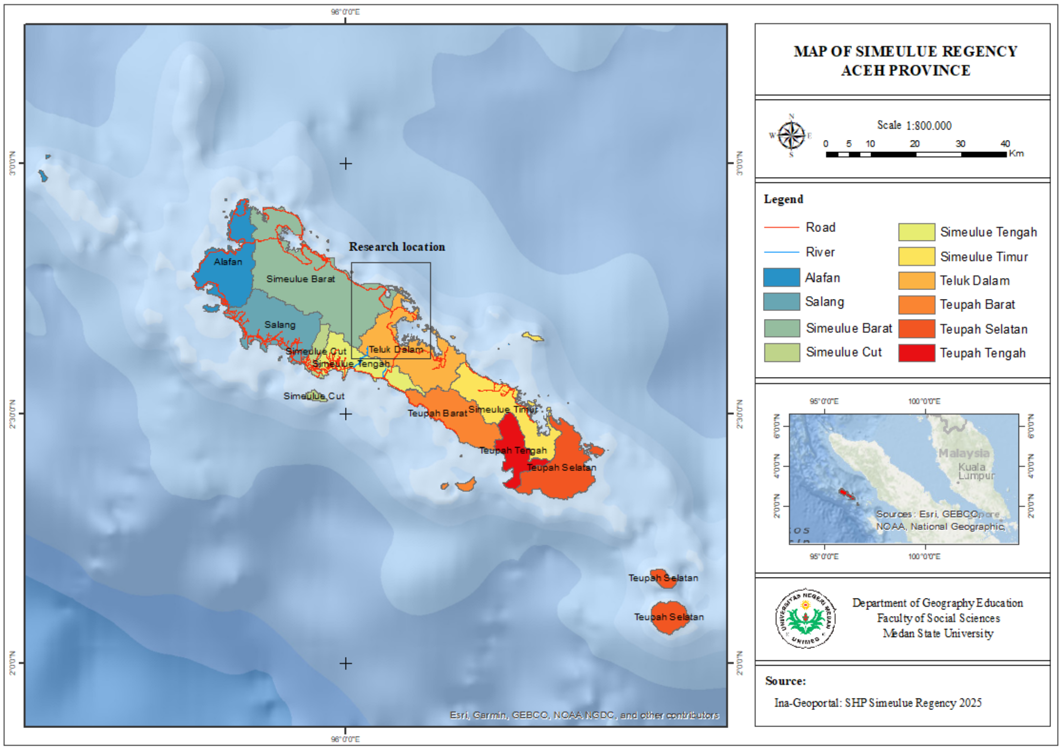

Figure 1. Map of the study area in Simeulue Regency (Source: Data Processing Results, 2025)

The study area focuses on three sub-districts: Simeulue Barat, Simeulue Tengah, and Teluk Dalam. These locations were selected to monitor vegetation cover in coastal areas vulnerable to land-use changes driven by human activities. Therefore, vegetation index analysis using SPOT 7 imagery and the NDVI method was conducted to evaluate vegetation density in the study area.

Population and Sample

The population in this study consists of all scenes from SPOT 7 imagery that captured the geographical area of Simeulue Regency on July 7, 2022. This population covers all ten sub-districts within Simeulue Regency. The sample used in this study is a single scene of SPOT 7 imagery from 2022, covering parts of the Simeulue Barat, Simeulue Tengah, and Teluk Dalam sub-districts. The use of a single scene is due to the limited availability of SPOT 7 imagery data covering the entire Simeulue Regency for the same period.

The primary material used in this study is SPOT 7 satellite imagery. This imagery has high spatial resolution (1.5 meters panchromatic and 6 meters multispectral), enabling detailed vegetation analysis. Additional materials include image processing software, namely ArcGIS 10.8, which is used for vegetation index calculation and spatial visualization.

The data collection technique in this study focuses on acquiring SPOT 7 satellite imagery. Data collection was conducted using remote sensing methods, where the SPOT 7 satellite captures reflected electromagnetic radiation from the Earth's surface. The raw data obtained from this imagery serve as the basis for vegetation analysis. The data analysis technique used in this study is the calculation of the Normalized Difference Vegetation Index (NDVI) from SPOT 7 satellite imagery using ArcGIS 10.8. The analysis was conducted through several stages as follows:

1. Image Processing: This stage includes image correction and cropping of the study area to ensure that the analyzed data corresponds to the research area and is of higher quality.
2. NDVI Calculation: Vegetation analysis was carried out by calculating NDVI values using the following formula:

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

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3. NDVI Classification: The NDVI values were classified into five vegetation density categories based on the Regulation of the Minister of Forestry of the Republic of Indonesia, Number P.12/Menhut-II/2012. This classification aims to represent the spatial distribution and condition of vegetation within the study area.

Table 1. NDVI Value Classification

Class	NDVI Value	Description
1	-1 – -0,03	Non-vegetation
2	-0,03 – 0,15	Very Low Vegetation
3	0,15 – 0,25	Low Vegetation
4	0,25 – 0,35	Moderate Vegetation
5	0,35 – 1	High Vegetation

(Source: Menteri Kehutanan Republik Indonesia, 2012)

4. Presentation of Analysis Results: The analysis results are presented as NDVI distribution maps, accompanied by analytical descriptions of vegetation density in the study area.

3. RESULTS AND DISCUSSION

Spatial Distribution of Vegetation Based on NDVI

Based on the NDVI analysis map, most of the study area, particularly in Teluk Dalam, Simeulue Tengah, and Simeulue Barat sub-districts, is dominated by the High Vegetation class, indicated by dark green on the map. This condition indicates that these areas have dense, relatively healthy vegetation cover. High NDVI values indicate that vegetation reflects more radiation in the near-infrared spectrum than in the red spectrum, indicating higher vegetation density (Dasrizal et al., 2019).

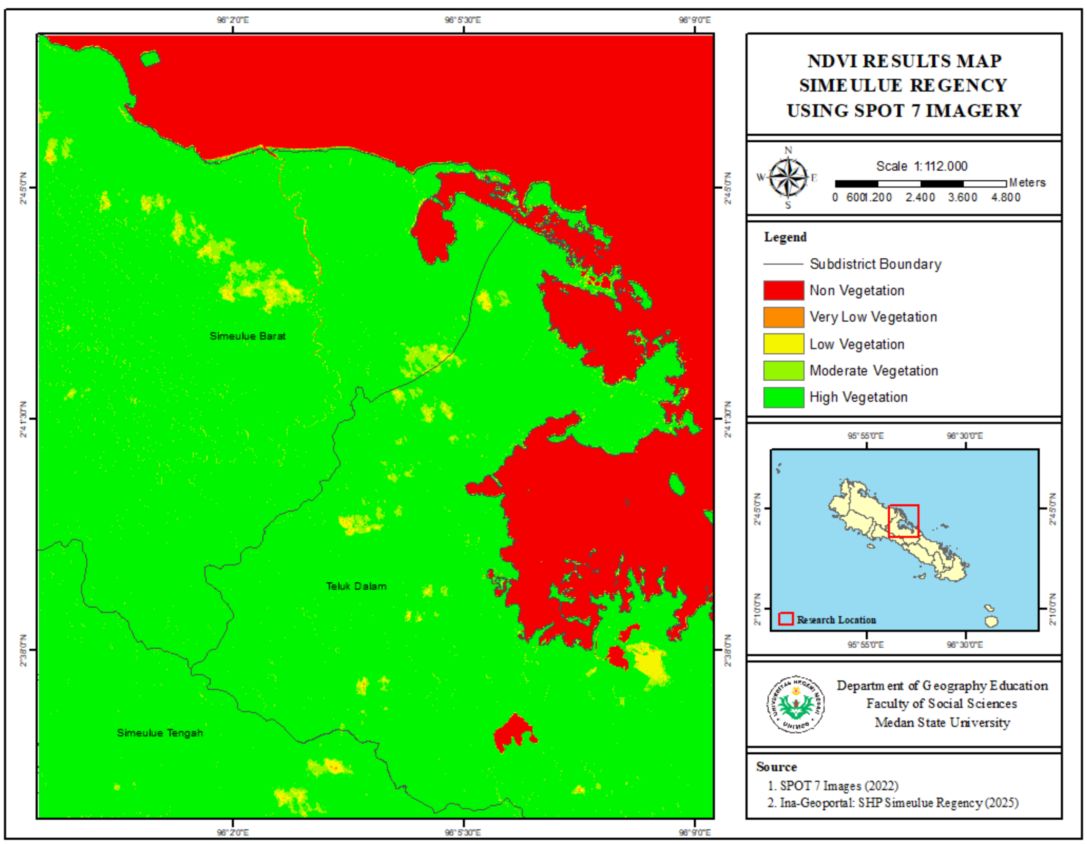

Figure 2. Vegetation Index (NDVI) Map of Simeulue Regency using SPOT 7
(Source: Data Processing Results, 2025)

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The dominance of high vegetation is influenced by ecological factors, such as the tropical climate with relatively high rainfall and soil conditions that support vegetation growth. Island regions like Simeulue also possess rich coastal ecosystems with natural vegetation such as mangroves, coconut trees, and various coastal plant species adapted to shoreline environments (Gadeng et al., 2019). These ecological factors contribute to the high vegetation density observed across most of the study area.

The geographical conditions of coastal areas also influence vegetation distribution patterns. Simeulue Regency is an island region that faces the Indian Ocean, with a topography dominated by lowlands and hills. These geographical characteristics support the growth of various types of coastal vegetation that play important roles in maintaining ecosystem stability, such as protecting coastal areas from erosion and reducing the impact of ocean waves (Gadeng et al., 2019).

The NDVI map also shows relatively large Non-Vegetation areas, represented in red. These areas include settlements, open land, and water bodies that lack active vegetation cover. This condition indicates that both human activities and coastal geographical factors influence vegetation distribution patterns in the study area. The presence of non-vegetation areas reflects anthropogenic influences, such as settlements, open land, and economic activities in coastal regions, which can lead to changes in land cover and reduced vegetation density in certain areas (Trishiani et al., 2022; Zaitunah et al., 2019).

In addition, there are areas with moderate to low vegetation density. Moderate Vegetation (light green) and Low Vegetation (yellow) appear as transitional zones between non-vegetation and high-vegetation areas. Very Low Vegetation (orange) is also identified in several locations, indicating areas with minimal vegetation cover. According to Julianto et al., (2022) these, vegetation changes are characterized by dense vegetation shifting into moderate or low vegetation classes, indicating ongoing land-cover dynamics.

Area and Percentage of Vegetation Classes

The classification of NDVI values in this study is based on five classes referring to the Regulation of the Minister of Forestry of the Republic of Indonesia Number: P.12/Menhut-II/2012 concerning the Second Amendment to Minister of Forestry Regulation Number P.32/Menhut-II/2009 on Procedures for Preparing Technical Plans for Forest and Land Rehabilitation in Watershed Areas (Rtk RHL-DAS). This classification interprets vegetation density levels based on reflectance values in the red and near-infrared bands of SPOT 7 satellite imagery, where higher NDVI values indicate denser, healthier vegetation (Dasrizal et al., 2019).

Table 2. Area and Percentage of NDVI in Simeulue Regency

No.	Class	Area (ha)	Percentage
1.	Non-vegetation	11.445,68	27,34 %
2.	Very Low Vegetation	121,28	0,29 %
3.	Low Vegetation	317,86	0,76 %
4.	Moderate Vegetation	812,85	1,94 %
5.	High Vegetation	29.162,21	69,67 %
	Total	41.859,88	100 %

(Source: Data Processing, 2025)

Based on the results of the NDVI classification analysis, the High Vegetation class dominates the study area, covering 29,162.21 ha or approximately 69.67% of the total area. This distribution pattern is also evident in the NDVI map, which shows a dominance of dark green across most parts of Teluk Dalam, Simeulue Tengah, and Simeulue Barat sub-districts. This condition indicates that the majority of the study area still has relatively dense vegetation cover. This dominance is closely related to the geographical characteristics of Simeulue Regency, an island region that still retains natural vegetation and experiences relatively limited development compared to urban regions.

Meanwhile, the Non-Vegetation class ranks second, covering 11,445.68 ha or 27.34% of the total area. On the NDVI map, this class is generally distributed along coastal areas and water bodies. The presence of non-vegetation areas is associated with the geographical characteristics of coastal regions, including extensive water bodies, coastlines, and coastal settlements (Gadeng et al., 2019).

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The Very Low Vegetation, Low Vegetation, and Moderate Vegetation classes have relatively small proportions. Very Low Vegetation covers 121.28 ha (0.29%), Low Vegetation 317.86 ha (0.76%), and Moderate Vegetation 812.85 ha (1.94%). The presence of these lower-density vegetation classes may be attributed to land use changes that have caused vegetation disturbance. The transition from dense to lower-density vegetation reflects land-cover dynamics influenced by both human activities and environmental factors (Denih et al., 2024).

The findings of this study indicate that the High Vegetation class dominates the study area, suggesting that most areas still maintain relatively dense vegetation cover. This result is consistent with the study, Zaitunah et al., (2019) which found that coastal areas with well-preserved natural vegetation tend to exhibit high NDVI values, although they are still subject to change due to human activities. Similarly, Denih et al., (2024) showed that high NDVI values are associated with dense vegetation and relatively good environmental conditions. These consistent findings demonstrate that the NDVI method effectively represents vegetation density across diverse regional characteristics. Monitoring vegetation cover using high-resolution satellite imagery, such as SPOT 7, is therefore essential for understanding land-cover dynamics and supporting sustainable environmental management, particularly in island regions such as Simeulue Regency.

4. CONCLUSION

This study aimed to analyze vegetation density using the NDVI method derived from SPOT 7 satellite imagery in Simeulue Regency. The results show that the High Vegetation class dominates the study area, covering 29,162.21 ha (69.67%), indicating that most of the region still has relatively dense vegetation cover. The Non-Vegetation class ranks second, covering 11,445.68 ha (27.34%), primarily water bodies. Other vegetation classes have relatively small proportions and represent transitional areas influenced by land use changes. These findings demonstrate that the NDVI method is effective for identifying vegetation density conditions and distribution, and it can support environmental monitoring and management in island regions.

Based on these findings, it is recommended that local governments implement sustainable coastal management strategies, in which remaining high-vegetation areas should be preserved as natural buffer zones to support disaster mitigation in the Simeulue Island region. Strict control over the expansion of open land or settlements in transition zones should also be optimally integrated into spatial planning policies. Future research should conduct time-series land-use change mapping to detect spatial dynamics and anticipate future declines in green cover more accurately and at an earlier stage.

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