CLASSIFICATION OF SENTINEL-2A SATELLITE IMAGE FOR TERNATE CITY LAND COVER USING RANDOM FOREST CLASSIFICATION IN SAGA GIS SOFTWARE

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Abstract— *Rapid population growth and increased human activities have caused significant changes in land cover in this region. These changes can impact the environment, including a decline in environmental quality. This study aims to classify land cover in Ternate City using Sentinel-2A satellite imagery with the Random Forest method in SAGA GIS 9.6 software. The classification results show that out of a total area of 10,163.41 hectares, built-up land accounts for 2,242.60 hectares (22.07%), while forests dominate with an area of 5,854.76 hectares (57.61%). This research highlights the impact of urbanization and population growth on land cover changes, as well as the importance of managing and protecting natural resources to maintain ecosystem balance. By utilizing remote sensing technology and machine learning algorithms, this study is expected to contribute significantly to understanding land cover dynamics and supporting decision-making in spatial* planning and environmental conservation in tropical regions.

Keywords— *Ternate, land cover, Random Forest, Sentinel-2A*

Abstrak— Pertumbuhan penduduk yang pesat dan meningkatnya aktivitas manusia telah menyebabkan perubahan signifikan pada tutupan lahan di wilayah ini. Perubahan ini dapat berdampak pada lingkungan, termasuk penurunan kualitas lingkungan. Penelitian ini bertujuan untuk mengklasifikasi tutupan lahan di Kota Ternate menggunakan citra satelit Sentinel-2A dengan metode Random Forest pada perangkat lunak SAGA GIS 9.6. Hasil klasifikasi menunjukkan bahwa dari total luas wilayah sebesar 10.163,41 hektare, lahan terbangun mencakup 2.242,60 hektare (22,07%), sedangkan hutan mendominasi dengan luas 5.854,76 hektare (57,61%). Penelitian ini menyoroti dampak urbanisasi dan pertumbuhan penduduk terhadap perubahan tutupan lahan, serta pentingnya pengelolaan dan perlindungan sumber daya alam untuk menjaga keseimbangan ekosistem. Dengan memanfaatkan teknologi penginderaan jauh dan algoritma pembelajaran mesin, penelitian ini diharapkan dapat berkontribusi secara signifikan dalam memahami dinamika tutupan lahan serta mendukung pengambilan keputusan dalam perencanaan tata ruang dan konservasi lingkungan di wilayah tropis.

Kata Kunci— Ternate, tutupan lahan, Random Forest, Sentinel-2A

I. INTRODUCTION

Ternate City, located in North Maluku Province, Indonesia, is an area rich in biodiversity and abundant natural resource potential [1]. However, rapid population growth and increasing human activities have caused significant changes in land cover in this region [2]. These changes can impact the environment, including soil quality degradation, habitat loss, and alterations in water flow patterns [3]. Therefore, monitoring and managing land cover is crucial to maintaining ecosystem balance and ensuring the sustainability of natural resources in Ternate City. In recent years, remote sensing technology has advanced significantly and become a highly valuable tool for monitoring land cover changes [4]. Satellite imagery, particularly from the Sentinel-2 mission launched by the European Space Agency (ESA), offers high spatial resolution and good image acquisition frequency. Sentinel-2A, with its capability to capture multispectral data, enables more in-depth analysis of land cover characteristics and changes over time [5]. The use of satellite imagery provides advantages in terms of efficiency and extensive area coverage, which are challenging to achieve using traditional field survey methods.

Land cover classification using satellite imagery requires the selection of an appropriate algorithm to produce accurate maps. One of the most widely used algorithms in image classification is Random Forest (RF) [6]. This algorithm is a machine learning method based on an ensemble of decision trees, known for its ability to handle complex and heterogeneous data [7]. Random Forest also has the advantage of reducing the risk of overfitting, thereby providing more stable and accurate classification results [8]. Therefore, applying the RF algorithm in this study is expected to improve the accuracy of land cover classification in Ternate City. The use of SAGA GIS 9.6 software in this study is also a strategic step. SAGA GIS is an open-source software specifically designed for geospatial analysis and raster data processing [9]. With a variety of available tools and functions, SAGA GIS enables users to perform complex analyses and generate informative thematic maps [9]. The integration of Sentinel-2A satellite imagery and the Random Forest algorithm within SAGA GIS provides a robust platform for efficiently conducting land cover classification.

In the context of climate change and rapid urbanization, monitoring land cover has become increasingly important. Data generated from satellite image classification can be used to support decision-making in spatial planning, natural resource management, and environmental conservation [10]. By understanding land cover change patterns, governments and stakeholders can formulate better policies to protect the environment and improve the quality of life for communities. Additionally, this research contributes to the development of improved land cover classification methodologies [11]. By

exploring the use of multispectral imagery and machine learning algorithms, this study provides new insights into how technology can be utilized for environmental monitoring. The findings of this research are expected to serve as a reference for future studies and provide a strong foundation for more in-depth investigations into land cover in tropical regions. Overall, this study aims to make a significant contribution to understanding land cover dynamics in Ternate City and their environmental impacts. By leveraging remote sensing technology and machine learning algorithms, this research seeks to produce innovative and effective solutions for monitoring and managing land cover while promoting environmental sustainability in the region.

II. METHODS

This research was conducted on Ternate Island, Indonesia (Figure 1). The study utilized Sentinel-2A imagery downloaded from the website https://www.copernicus.eu/en, recorded on December 10, 2024, and the administrative boundaries of Ternate City as the study area boundary. SAGA GIS 9.6 software was used in this study to analyze and classify land cover using the Random Forest algorithm. Random Forest Classification is a method used for land cover classification by leveraging a robust and efficient machine learning algorithm [6].

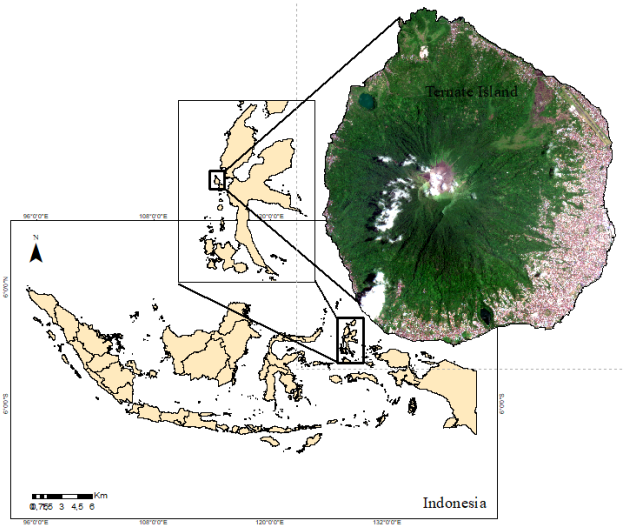

Figure 1. Research Location

This algorithm works by constructing multiple decision trees generated from random sampling of the training dataset, where each tree provides predictions based on features extracted from satellite imagery [6]. The strength of Random Forest lies in its ability to reduce the risk of overfitting and improve classification accuracy through the majority voting technique across all constructed trees [12]. In the context of land cover classification, Random Forest can identify various land cover classes, such as water bodies, agriculture, settlements, and forests, with high accuracy. Research has shown that using this algorithm for satellite image analysis, such as Landsat or Sentinel-2 imagery, can produce significant overall accuracy, often exceeding 90%, making it an effective choice for monitoring spatial land cover changes.

The data processing began with radiometric and geometric corrections, followed by creating an RGB composite using bands 4, 3, and 2 for natural colors before sampling for land cover classification. Using the tools Geoprocessing > Imagery > Classification > Machine Learning > Random Forest Classification, the land cover was classified into five categories: forest, shrubs, open land, water bodies, and built-up areas.

III. RESEARCH RESULT AND DISCUSSION

The classification results show that out of the total area of 10,163.41 hectares in Ternate, built-up land accounts for 2,242.60 hectares or 22.07%. This figure reflects significant infrastructure and residential development in the city, likely influenced by population growth and urbanization. With the increase in built-up land, it is crucial to consider the potential environmental impacts, such as reduced air quality and altered drainage patterns. Meanwhile, forests dominate the area, covering 5,854.76 hectares, equivalent to 57.61% of the total area. These forests are essential for maintaining ecosystem balance, providing habitats for various species, and acting as carbon sinks. This study underscores the importance of forest protection and management to ensure the sustainability of natural resources in Ternate, especially amid increasing development pressures. Additionally, shrubs cover 1,727.11 hectares (16.99%), while open land and water bodies account for only 256.82 hectares (2.53%) and 82.13 hectares (0.81%), respectively. The spatial distribution of land cover in 2024 is shown in Figure 2, and the corresponding area coverage is presented in Figure 3.

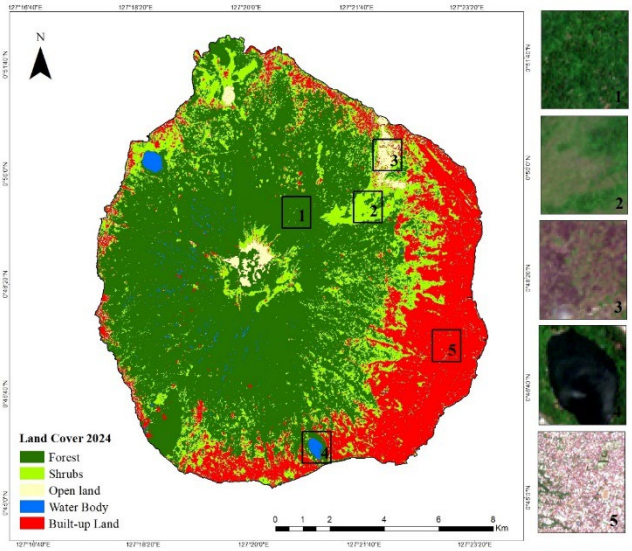

Figure 2. Land Cover of Ternate Island in 2024

The land cover classification results indicate that although forests dominate, there has been a significant reduction in the area of open land and water bodies, which could negatively impact biodiversity and environmental quality. This study

highlights the need for continuous monitoring of land cover changes to identify trends and potential impacts. The classification results also demonstrate that the use of the Random Forest algorithm in satellite image analysis can achieve high accuracy, often exceeding 90% [6]. This indicates that the method is highly effective for land cover classification, enabling the identification of various cover classes with good accuracy [2]. This research contributes to the development of improved land cover classification methodologies by utilizing remote sensing technology and machine learning algorithms.

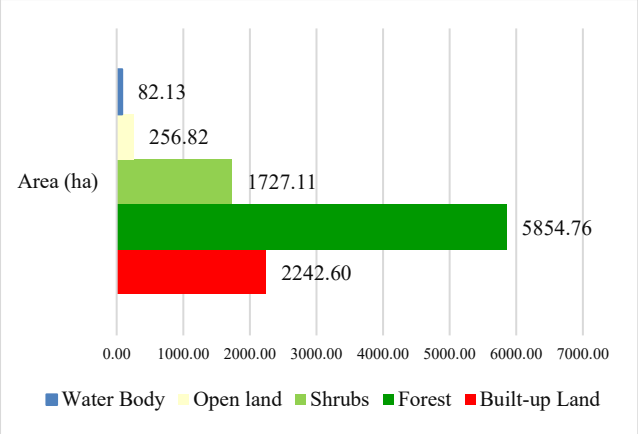

Figure 3. Land Cover Area of Ternate Island in 2024

Overall, the results of this study are expected to make a significant contribution to understanding land cover dynamics in Ternate City and their environmental impacts. By utilizing data generated from satellite image classification, the findings of this research can be used to support decision-making in spatial planning, natural resource management, and environmental conservation. This study also provides a strong foundation for further research on land cover in tropical regions, as well as promoting better policies to protect the environment and improve the quality of life for communities.

IV. CONCLUSION

The conclusion of this study is that land cover classification in Ternate City using Sentinel-2A satellite imagery and the Random Forest algorithm reveals significant changes in land use, particularly with the increase in built-up land, which accounts for 22.07% of the total area. Although forests still dominate with an area of 57.61%, there has been a decline in open land and water bodies, which could negatively impact the local ecosystem. This study emphasizes the importance of sustainable management and protection of natural resources to maintain ecosystem balance amid urbanization pressures. The findings of this research are expected to serve as a basis for better decision-making in spatial planning and environmental conservation in Ternate City, as well as contribute to a deeper understanding of land cover dynamics in tropical regions.

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