PENDEKATAN ENSEMBLE LEARNING MODEL UNTUK DETEKSI SAMPAH BERBASIS PIXEL CITRA SATELIT SENTINEL-2 DI PERAIRAN LOMBOK

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Abstrak

Sampah plastik telah menjadi isu lingkungan global yang mendesak, menyumbang mayoritas polusi di lautan dunia. Di Indonesia, permasalahan ini sangat krusial; data SIPSN KLHK 2024 mencatat 40,16% dari 33 juta ton timbunan sampah nasional belum terkelola dengan baik. Khusus di destinasi wisata prioritas seperti Lombok, peningkatan volume sampah menyebabkan penumpukan di kawasan pesisir yang mengancam ekosistem laut dan ekonomi pariwisata. Penelitian ini bertujuan membangun model ensemble learning untuk deteksi sampah laut (marine debris) berbasis piksel menggunakan citra satelit Sentinel-2 (resolusi 10 m) di perairan Lombok. Metodologi penelitian memanfaatkan dataset MARIDA (Marine Debris Archive) dan menerapkan teknik SMOTE untuk mengatasi masalah ketidakseimbangan kelas (data imbalance). Tiga model ensemble—Random Forest, XGBoost, dan LightGBM—dievaluasi menggunakan metrik F1 Score dan Balanced Accuracy. Hasil pengujian menunjukkan bahwa LightGBM adalah model paling optimal, mencapai F1-Score 0.8284 dan Balanced Accuracy 0.9904 pada data testing. Temuan ini diimplementasikan ke dalam prototipe dashboard interaktif yang mampu menyajikan informasi spasial objektif dengan potensi pembaruan data setiap 10 hari, sehingga mendukung perumusan kebijakan mitigasi sampah yang responsif dan berkelanjutan di Pulau Lombok.

Kata kunci: Ensemble Learning, Deteksi Sampah, Citra Satelit Sentinel-2, LightGBM, Perairan Lombok.

Abstract

Plastic waste presents an urgent global environmental threat, contributing significantly to total marine litter. In Indonesia, this issue is critical, with national waste accumulation reaching 33 million tons in 2024, of which approximately 40.16% remains unmanaged. Tourist destinations like Lombok face heightened challenges due to increasing waste volumes, leading to accumulation on beaches that harms marine ecosystems and threatens the local tourism economy. This study aims to develop an ensemble learning model for pixel-based waste detection in Lombok's coastal waters, leveraging the efficiency of remote sensing technology. The model utilizes 10-meter spatial resolution Sentinel-2 satellite imagery, allowing for potential data updates every 10 days. The methodology involved training the model using the MARIDA (Marine Debris Archive) dataset and applying the SMOTE technique to address significant data imbalance. The research evaluated multiple boosting algorithms, including Random Forest, XGBoost, and LightGBM. Evaluation results identified LightGBM as the most optimal model, demonstrating the best balance between training and testing performance with an F1-Score of 0.8284 and a Balanced Accuracy of 0.9904. This outcome signifies robust generalization capabilities for detecting marine debris. The model was subsequently integrated into an interactive web dashboard prototype, providing objective spatial insights crucial for continuous monitoring and supporting evidence-

Keywords: Ensemble Learning; Waste Detection; Sentinel-2 Satellite Imagery; LightGBM; Lombok Coastal Waters.