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COMPARATIVE ANALYSIS OF DEEP LEARNING FOR PIXEL-LEVEL ILLEGAL DUMPSITE DETECTION USING SENTINEL-2

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ABSTRACT

Illegal waste disposal represents a persistent environmental challenge that demands scalable and automated monitoring solutions. While traditional inspection methods are often spatially constrained and resource-intensive, satellite remote sensing offers a cost-effective alternative for tracking dumpsite dynamics. In this study, we evaluate deep learning (DL) architectures, specifically U-Net and Feature Pyramid Network (FPN), for high-fidelity spatial segmentation of illegal dumpsites using Sentinel-2 multispectral data. This work builds upon our previous research that explored the use of traditional machine learning methods for this use case.

The dataset used for model development was derived from a publicly available repository of reported illegal dumpsites in Serbia. The reported locations were first filtered based on geographic coordinates and subsequently validated through manual inspection using high-resolution satellite imagery in Google Earth Pro, resulting in a curated dataset of confirmed dumpsite instances.

In the previous study, using the same dataset, traditional machine learning models, most notably XGBoost, achieved baseline performance of an average F1-score of 0.83 and an Intersection over Union (IoU) of 0.70, highlighting both the feasibility and limitations of classical approaches. Building on these benchmark results, this work conducts a comparative analysis to assess whether the spatial-feature extraction capabilities inherent in DL models can improve upon the benchmarks set by the pixel-based classification techniques.

The methodology of this study is structured in two complementary phases. First, U-Net and FPN models are trained to generate high-resolution spatial masks of illegal dumpsite areas, enabling pixel-level segmentation of the observed sites. Second, the resulting spatial outputs are integrated into a temporal analysis spanning quarterly observations from 2023 to 2025. This component extends time-series modelling from the prior study where linear forecasting approaches achieved a MAPE of 10.83%.

By focusing on the transition from traditional gradient-boosting to advanced spatial-convolutional models, this research provides insights into the trade-offs between computational complexity and detection accuracy.