# INTISARI

Ekstraksi garis pantai penting untuk menentukan tingkat erosi dan akresi pantai guna mendukung manajemen kawasan pesisir. Ekstraksi garis pantai dapat dilakukan dengan kombinasi citra satelit dan berbagai metode, seperti klasifikasi berbasis piksel, *thresholding,* dan *deep learning*. Sejauh ini, metode klasifikasi berbasis piksel dan *thresholding* memiliki keterbatasan dalam membedakan daratan dan lautan karena kurang peka pada variasi kondisi lingkungan dan tidak mempertimbangkan organisasi piksel. Sementara itu, metode *deep learning*, khususnya U-Net mampu mengatasi keterbatasan tersebut. Di sisi lain, indeks spektral citra satelit telah terbukti mampu membedakan antara perairan dengan non-perairan. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan model *deep learning* U-Net menggunakan kombinasi citra Sentinel-2 dan indeks spektral sebagai dataset untuk mengekstrak garis pantai. Selanjutkan hasil ekstraksi garis pantai digunakan untuk analisis perubahan garis pantai di Pesisir Selatan Yogyakarta.

Data yang digunakan dalam penelitian ini adalah citra median tahunan dari Sentinel-2. Data tersebut diproses dengan 4 tahap utama, yaitu persiapan data, pengembangan model U-Net, implementasi model U-Net, dan Analisis perubahan garis pantai. Tahap pertama, dataset dibuat dengan mengkombinasikan citra Sentinel-2, indeks spektral, dan data referensi garis pantai hasil digitasi. Indeks spektral yang digunakan adalah *Modified Normalize Difference Water Index* (MNDWI), *Normalize Difference Soil Index* (NDSI) dan *Normalize Difference Vegetation Index* (NDVI). Tahap pertama menghasilkan 4 tipe dataset. Tahap kedua, pengembangan model U-Net dikerjakan dengan menggunakan dataset yang telah dibuat, sehingga dihasilkan 4 model U-Net (Model-1 sampai Model-4) sesuai dengan dataset yang digunakan. Keempat model dievaluasi dengan parameter akurasi, *loss*, *precision*, *recall*, F1-score, dan *Intersection over Union* (IoU). Model terbaik digunakan pada tahap ketiga yaitu implementasi model U-Net untuk ekstraksi garis pantai dari Sentinel-2 tahun 2016-2025 di lokasi penelitian. Hasil ekstraksi berupa garis pantai tahunan yang belum memperhitungan pasang surut karena penggunaan citra median tahunan Sentinel-2. Garis pantai hasil ekstrasi kemudian digunakan untuk evaluasi kinerja keempat model U-Net dan analisis perubahan garis pantai.

Hasil evaluasi keempat model U-Net menunjukkan bahwa Model-4 yang dikembangkan menggunakan dataset dengan struktur band RGB+MNDWI+NDSI+NDVI memiliki kinerja terbaik dibandingkan dengan model lain. Model-4 mencapai akurasi dan *loss*, masing-masing, adalah 98,82% dan 4,30%. Sedangkan Model-1 memiliki akurasi 93,79% dan *loss* 10,84%. Hasil *testing* Model-1 sampai Model-4 juga menunjukkan hasil yang konsisten dengan hasil Model-4 sebagai model terbaik. Hasil evaluasi kinerja Model-4 di lokasi penelitian juga menunjukkan hasil yang memuaskan dengan nilai rata-rata *error* berkisar antara 12,88 sampai 24,17 meter di area barat dan antara 15,59 meter sampai 23,49 meter di area timur. Hasil analisis perubahan garis pantai menunjukkan bahwa pesisir selatan Yogyakarta lebih dominan mengalami erosi, terutama di area barat. Sebesar 71,6% area di area barat terkena erosi dan 34,18% area terkena erosi di area timur.

**Kata Kunci**: U-Net, Sentinel-2, indeks spektral, perubahan garis pantai, erosi pantai, dan Pesisir Selatan Yogyakarta

# *ABSTRACT*

Shoreline extraction is essential for determining the level of erosion and acreting to support coastal zone management. Shoreline extraction can be conducted through a combination of satellite imagery and various methods, such as pixel-based classification, thresholding, and deep learning techniques. To date, pixel-based classification and thresholding methods have limitations in distinguishing land from water due to their lack of sensitivity to environmental variations and their failure to consider pixel organization. In contrast, deep learning methods, particularly U-Net, are capable of overcoming these limitations. Additionally, spectral indices derived from satellite imagery have proven effective in differentiating between water and non-water areas. Therefore, this study aims to develop a U-Net model using a combination of Sentinel-2 imagery and spectral indices as the dataset to extract the shoreline. The extracted shoreline results are then used for analyzing shoreline changes in the southern coast of Yogyakarta.

The data used in this study consists of annual median images from Sentinel-2. The data were processed through four main stages: data preparation, U-Net model development, U-Net model implementation, and shoreline change analysis. In the first stage, the dataset was created by combining Sentinel-2 images, spectral indices, and reference shoreline data derived from digitization. The spectral indices used include the Modified Normalized Difference Water Index (MNDWI), the Normalized Difference Soil Index (NDSI), and the Normalized Difference Vegetation Index (NDVI). The first stage resulted in four types of datasets. In the second stage, the development of the U-Net model was carried out using the created datasets, resulting in four U-Net models (Model-1 to Model-4) corresponding to the datasets used. The four models were evaluated using accuracy, loss, precision, recall, F1-score, and Intersection over Union (IoU) parameters. The best model was applied in the third stage, which involved implementing the U-Net model to extract the shoreline from Sentinel-2 images for the years 2016-2025 at the study location. The extraction results consist of annual shorelines that do not account for tidal variations due to the use of annual median Sentinel-2 images. The extracted shorelines were then used to evaluate the performance of the four U-Net models and analyze the shoreline changes.

The results of the study indicate that the U-Net model (Model-4), developed using the dataset with the RGB+MNDWI+NDSI+NDVI structure, outperformed the other models. Model-4 achieved an accuracy of 98.82% and a loss of 4.30%, while Model-1 achieved an accuracy of 93.79% and a loss of 10.84%. Testing results for Models-1 through Model-4 also showed consistent results, with Model-4 performing the best. Performance evaluation of Model-4 at the study site also yielded satisfactory results, with average error values ranging from 12.88 to 24.17 meters in the western area and from 15.59 to 23.49 meters in the eastern area. The coastline change analysis revealed that the southern coast of Yogyakarta is predominantly experiencing erosion, especially in the western area, where 71.6% of the area is affected by erosion, and 34.18% of the area is affected in the eastern area.

**Keywords**: U-Net, Sentinel-2, spectral indices, shoreline change, coastal erosion, and Southern Coast of Yogyakarta.