14. Coastline Dynamics and Urban Erosion Risk Assessment in Reggio Calabria Using Sentinel-2 Data and Artificial Intelligence

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Italian coastal areas, especially those located in Southern Italy, are increasingly affected by degradation processes that influence shoreline stability and coastal landscape evolution. The Strait of Messina, due to its strong marine currents, wind exposure, and intense coastal urbanization, is highly vulnerable to coastal erosion, which causes significant variations in shoreline position and may increase risk for urbanized areas. In this context, the present study aims to develop an integrated approach to analyze and predict coastline dynamics and to assess erosion-related risk along the urban coast of Reggio Calabria, also considering possible scenarios of future coastal morphological evolution. The proposed methodology combines multitemporal remote sensing analysis, shoreline change assessment, and AI-based predictive modeling. Multitemporal analysis was carried out using Google Earth Engine (GEE) and QGIS software. Within GEE, median Sentinel-2 composite images were generated for the summer period, from June to August, for each year between 2018 and 2025. The Normalized Difference Water Index (NDWI) was applied to enhance the distinction between water and land surfaces and to obtain binary water/land masks. These masks were then converted into vector layers and compared with a reference shoreline shapefile to reconstruct historical shoreline positions. Starting from the extracted shoreline layers, transects perpendicular to the reference shoreline were generated to quantify shoreline displacement over time. Several shorelines change indicators were calculated, including Net Shoreline Movement (NSM), End Point Rate (EPR), and Linear Regression Rate (LRR). These indicators provided the basis for developing a predictive dataset aimed at estimating future coastline dynamics Future scenarios were also evaluated, including increased coastal urbanization, coastal protection measures, and renaturalization strategies. The proposed approach supports the identification of high-risk areas and mitigation measures for sustainable coastal management in Reggio Calabria.