Coastal Erosion Assessment Using Three-Dimensional Octree-Duality Voxel Data Structure

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Abstract

Shoreline changes are primarily impacted by the transformation of coastal areas due to waves, tides, storm surges and mean sea levels driven by the global and regional climate changes over time. This results in the occurrence of coastal erosion. Advanced technology, such as Geographic Information Systems (GIS), has become essential in mitigating this condition due to its capability for handling spatial data. Hence, this chapter aims to assess the volume of eroded coastal areas using a GIS-embedded voxel data structure for the coastal erosion monitoring process. This can be achieved by obtaining Sentinel-2 satellite imagery of the coastal area, followed by processing and conversion into a three-dimensional (3D) perspective, thereby presenting the coastal area in a volume-based representation for coastal erosion volume assessment. The 3D Octree-Duality Voxel Data Structure (3D ODVDS) is a GIS data structure that facilitates this volume computation. In addition, this volumetric 3D structure employs the octree and duality concept to discretize the model and the voxel

concept to calculate the volume of coastal erosion within the generated 3D model of the coastal area. The difference in volume, m^3, between several models allow for the observation of the coastal erosion. The precise computed volume of the coastal area will aid the mitigation process by providing the accurate rate of changes in eroded volume and supporting the selection of appropriate strategies to minimize its impact. In conclusion, integrating GIS-based techniques for coastal erosion monitoring in the mitigation process can ensure the sustainability of coastal areas. © The Author(s), under exclusive license to Springer Nature Switzerland AG 2026.

Author keywords

Coastal erosion; GIS; Remote sensing; Shoreline changes; Three-dimensional data structure; Voxel

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