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Innovative Remote Sensing Techniques for Coastal Erosion Assessment

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ABSTRACT

Remote sensing has emerged as a critical tool in coastal erosion assessment, providing large-scale, repeatable, and precise observations of shoreline changes over time. This paper explores advanced remote sensing techniques—including multispectral, hyperspectral, LiDAR, and Synthetic Aperture Radar (SAR)—for accurate monitoring and analysis of coastal erosion processes. Emphasis is placed on integrating satellite and aerial data to improve spatial and temporal coverage, enhancing predictive models, and supporting coastal zone management. A comparative analysis of these techniques is presented, highlighting their strengths, limitations, and applications in different coastal environments. The findings suggest that a multi-sensor approach, combined with GIS analysis, offers the most robust framework for sustainable coastal monitoring.

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Keywords: *Remote sensing, coastal erosion, multispectral, LiDAR, SAR, shoreline monitoring, GIS*

INTRODUCTION

Coastal erosion is a significant geomorphological process driven by natural forces such as wave action, tidal currents, and storms, as well as human-induced activities including sand mining and infrastructure development. It poses serious environmental, economic, and social challenges, particularly in densely populated coastal zones. Remote sensing technologies offer an effective means to monitor, quantify, and predict coastal erosion patterns. With advancements in spatial resolution, sensor capabilities, and processing algorithms, remote sensing has transitioned from basic shoreline mapping to comprehensive coastal change analysis.

REMOTE SENSING TECHNIQUES

Several remote sensing techniques have been developed and refined for coastal erosion assessment. Multispectral imagery enables the classification of land and water boundaries with high accuracy. Hyperspectral sensors provide detailed spectral information, improving sediment type identification. LiDAR offers precise elevation models of coastal topography, while SAR penetrates cloud cover and operates day or night, making it ideal for all-weather monitoring. Each technique serves specific roles in coastal studies, and their integration often yields the most reliable results.

APPLICATIONS IN COASTAL EROSION ASSESSMENT

Remote sensing is applied to detect shoreline retreat, estimate sediment transport, assess storm impact, and predict erosion risk zones. By analyzing multi-temporal datasets, scientists can quantify erosion rates and evaluate the effectiveness of coastal protection measures. GIS integration enhances spatial analysis, enabling policymakers to visualize erosion hotspots and prioritize intervention areas.

COMPARATIVE ANALYSIS

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A comparative evaluation of different remote sensing techniques reveals that while optical sensors are cost-effective and widely available, they are limited by cloud cover. SAR overcomes atmospheric limitations but requires complex data processing. LiDAR provides unmatched elevation accuracy but at a higher operational cost. An integrated approach that combines optical, radar, and elevation data maximizes the accuracy and applicability of erosion assessments.

Technique	Advantages	Limitations
Multispectral	Wide coverage, high availability	Cloud cover interference
LiDAR	High-accuracy elevation data	High cost, limited coverage
SAR	All-weather, day/night capability	Complex data interpretation

CONCLUSION

Remote sensing provides a powerful framework for coastal erosion assessment, offering diverse tools for monitoring and predicting shoreline changes. A multi-sensor approach, incorporating optical, radar, and elevation data, combined with GIS analysis, ensures robust, comprehensive, and sustainable coastal monitoring strategies.

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