International Journal of Engineering Research and Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 21, Issue 7 (July 2025), PP 50-52

Comparative Study of LiDAR Bathymetric and Multibeam Echo Sounding for Coastal Erosion Monitoring: Techniques, Applications, and Limitations

Dr. Anyadiegwu, Princecharles C
Department of Surveying and Geoinformatics, Imo State University, Owerri

Abstract
Coastal erosion poses a significant threat to infrastructure, ecosystems, and livelihoods in coastal regions. Accurate, high-resolution, and frequent monitoring of shoreline and nearshore bathymetry is critical in developing effective coastal engineering interventions. This paper presents a comparative study of two leading bathymetric surveying techniques—LiDAR bathymetry and multibeam echo sounding (MBES)—with a focus on their applicability in coastal erosion monitoring. While MBES has long been the standard for detailed underwater mapping, LiDAR bathymetry offers rapid, wide-area coverage from the air. The study compares both methods in terms of resolution, operational constraints, cost, environmental sensitivity, and integration potential. A specific application to the Nigerian coastline highlights the trade-offs and suitability of each method in varying coastal settings. Findings suggest that a hybrid approach leveraging the strengths of both technologies provides the most effective solution for long-term coastal erosion monitoring.
Keywords: *LiDAR Bathymetry, Multibeam Echo Sounder, Coastal Erosion, Coastal Engineering, Hydrographic Surveying, Remote Sensing*

Date of Submission: 06-07-2025 Date of acceptance: 17-07-2025

I. Introduction

Coastal erosion remains a persistent environmental and socioeconomic challenge, particularly in low-lying and densely populated regions. Natural processes such as wave action, sea-level rise, and sediment transport, as well as anthropogenic factors like coastal development and dredging, contribute to the degradation of coastlines. Effective coastal engineering strategies rely on accurate, frequent, and high-resolution bathymetric and topographic data to detect shoreline changes, model sediment dynamics, and plan infrastructure interventions.

Advancements in remote sensing and hydrographic technologies have transformed how coastal environments are monitored. Among these technologies, LiDAR bathymetry (Light Detection and Ranging) and multibeam echo sounding (MBES) have emerged as two dominant tools for capturing bathymetric information. While MBES provides detailed acoustic data from vessels, airborne LiDAR systems offer rapid coverage of both land and shallow waters.

This study aims to present a comprehensive comparison between LiDAR bathymetry and MBES in terms of their technical specifications, environmental suitability, cost-effectiveness, and operational deployment for coastal erosion monitoring. Emphasis is also placed on practical recommendations for coastal engineering projects in Nigeria and similar developing regions.

II. Coastal Erosion Monitoring: Requirements and Challenges

Coastal erosion monitoring involves understanding changes in shoreline position, seabed morphology, sediment transport, and beach volume. The key requirements for effective monitoring include:

- High spatial resolution: To detect micro-topographic features and subtle erosion patterns.
- High temporal frequency: Regular monitoring to capture dynamic changes.
- Nearshore penetration: Ability to map the intertidal and shallow subtidal zones where erosion is most active.
- Environmental adaptability: Capability to operate in various turbidity, wave, and weather conditions.

Challenges include limited accessibility in remote or swampy coastlines, high data acquisition costs, difficulty in mapping turbid shallow waters, and integrating datasets across technologies.

III. LiDAR Bathymetry (Green LiDAR)

LiDAR bathymetry systems use a green laser (typically 532 nm) that can penetrate water to a limited depth, combined with a near-infrared laser to record surface elevation. The major components include:

- Laser scanner (green and infrared)
- GNSS/IMU (for positioning and orientation)
- Airborne platform (helicopter or drone)

Advantages:

- Large area coverage in a single flight
- Rapid data acquisition (~100 km^2/day)
- Integration with topographic data
- High horizontal resolution (typically < 1 m)

Limitations:

- Penetration limited to ~1.5× Secchi depth (typically 1–30 m depending on turbidity)
- High initial cost and maintenance
- Sensitivity to water clarity and surface roughness
- Limited performance in cloudy, rainy, or windy conditions

IV. Multibeam Echo Sounding (MBES)

MBES systems transmit a fan of acoustic beams from a transducer mounted on a vessel. The time delay of the returned signal is used to compute depths across a swath.

Components:

- Transducer array
- GNSS and motion sensors
- Sound velocity profilers

Advantages:

- High vertical accuracy (cm-level in shallow water)
- Excellent bottom detection in turbid and deep waters
- Can capture seabed texture and sediment types
- Resilient to poor weather (to a degree)

Limitations:

- Requires vessel access and line-based survey patterns
- Slower data collection for large areas
- Data gaps in very shallow waters (< 2 m)
- More susceptible to motion-induced noise in high sea states

V. Comparative Analysis

Parameter	LiDAR Bathymetry	Multibeam Echo Sounding (MBES)
Accuracy	Horizontal: ~0.5 m; Vertical: ~0.15–0.3 m	Horizontal: ~0.2–0.5 m; Vertical: ~0.05–0.2 m
Depth Range	0–30 m (in clear water)	0.5 m to >1000 m
Turbidity Performance	Poor	Excellent
Weather Dependence	High	Moderate
Operational Speed	Fast (airborne)	Slower (marine-based)
Cost	High initial cost, low per km^2	Moderate capital, high operational cost
Coverage Area	Wide swath, cross land-water interface	Narrow swath, water-only

VI. Application to a Nigerian Coastal Environment

Nigeria’s coastline, particularly areas such as the Lagos–Badagry axis, Bonny estuary, and Niger Delta, is severely affected by coastal erosion, subsidence, and sedimentation.

Considerations for Nigerian Coastline:

- High turbidity in most estuarine and nearshore waters
- Frequent rainfall and cloud cover
- Large shallow zones (<5 m depth)

Recommendations:

- Use MBES for deep and turbid zones such as estuaries and river mouths
- Deploy LiDAR bathymetry for large-area mapping during dry seasons
- Combine with topographic LiDAR or UAV photogrammetry for land-based monitoring
- Integrate both datasets in a GIS to develop continuous topo-bathymetric models

VII. Discussion

The choice between LiDAR and MBES depends on project goals, environment, and budget:

- LiDAR bathymetry excels in rapid, large-scale surveys across the land-sea interface but is limited in turbid waters.
- MBES provides superior detail and penetration in deeper, sediment-rich waters but requires vessel time and is slower.
- A hybrid approach—using LiDAR for intertidal zones and MBES for deeper waters—maximizes spatial and temporal data resolution.

Integration Strategies:

- Co-register LiDAR and MBES in a common vertical datum
- Use AI/ML for shoreline change detection and sediment modeling
- Deploy fixed-position wave/tide gauges to validate temporal data

VIII. Conclusion

LiDAR bathymetry and MBES each offer unique strengths for monitoring coastal erosion. While LiDAR provides rapid, wide-area data ideal for large-scale shoreline assessments, MBES offers high-resolution underwater mapping suitable for turbid and deeper coastal environments. For effective coastal engineering solutions, especially in erosion-prone regions like Nigeria, a combined LiDAR-MBES strategy is recommended. Integration with GIS, historical satellite imagery, and predictive modeling can enhance understanding and management of vulnerable coastlines.

References

[1]. International Hydrographic Organization (IHO). (2020). *Standards for Hydrographic Surveys (S-44)*.
[2]. Westfeld, P., et al. (2019). Comparison of LiDAR and MBES for Shallow-Water Mapping.*Marine Geodesy*, 42(4).
[3]. Lidar News. (2022). Advances in Bathymetric LiDAR.
[4]. Nwilo, P.C., &Badejo, O.T. (2006). Impacts of Coastal Erosion in Nigeria.*Journal of Coastal Research*.
[5]. NOAA. (2021). Coastal Mapping Technologies.
[6]. Fernandes, L., et al. (2020). Coastal Erosion Mapping using Remote Sensing. *Remote Sensing of Environment*.