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Research paper

Assessment of Sea Level Rise Along Nigeria's Economic Exclusive Zone Using Nasa Sea level Rise Tools

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Abstract

Sea level rise poses significant threats to coastal nations globally, particularly those with extensive economic exclusive zones (EEZ) and vulnerable coastal infrastructures like Nigeria. This study assesses sea level rise along Nigeria's EEZ using NASA's advanced sea level rise tools and satellite data. The research integrates NASA's altimeter satellite data and digital elevation models (DEMs) to quantify historical trends and project future sea level rise impacts along the Nigerian coastline. Findings indicate the Rate of Sea Level Rise has increased by 12cm Sea level rise 1993-2023), with 18cm Sea level rise projected for 2050. This indicates a consistent upward trend in sea level, with an average rise rate exceeding global averages due to regional variations. This rise threatens Nigeria's coastal ecosystems, economic activities , including the oil and shipping industries, and coastal settlements. Strategic adaptation and mitigation planning based on satellite data and predictive modelling are crucial to safeguarding Nigeria's coastal and marine assets.

Keywords: *Sea Level Change; Nigeria; Economic Exclusive Zone; NASA Tools; Remote Sensing; Climate Change; Coastal Vulnerability.*

1. Introduction

The rising sea level, driven primarily by climate change-induced melting of glaciers and thermal expansion of oceans, represents one of the most pressing environmental challenges of the 21st century (IPCC, 2021). Coastal regions, particularly in the Global South, face heightened vulnerability due to exposure to storm surges, coastal erosion, and inundation (Nicholls and Cazenave, 2010). Nigeria, located along the Gulf of Guinea, possesses a vast Economic Exclusive Zone (EEZ) covering approximately 200 nautical miles from its coastline, supporting significant economic activities such as fisheries, oil and gas exploitation, and maritime transport (NIMASA, 2022). However, limited research has focused specifically on the influence of sea level rise within Nigeria's EEZ and its implications. The Nigerian EEZ supports vital economic activities such as petroleum exploration, fishing, and maritime trade, assessing sea level change crucial for sustainable development and maritime security.

Modern advancements in satellite altimetry and remote sensing, spearheaded by organizations like NASA, have improved the precision of sea level measurements globally. Utilizing these tools allows for detailed analysis of spatial and temporal sea level variations, facilitating informed coastal risk management (NOAA, 2021).

This research aims to assess the sea level rise trends within Nigeria's EEZ using advanced NASA sea level rise tools, including satellite altimetry and digital elevation models, to deepen the understanding of present and future coastal dynamics. This study contributes to coastal management strategies by providing vital data for policymakers and stakeholders.

2. Literature review

Sea level monitoring has evolved substantially with advancements in satellite technology. NASA's satellite missions, such as TOPEX/Poseidon, Jason series, and ICESat, have provided accurate global sea level data over the past three decades (Nerem et al., 2018). Combined with regional tide gauges and topographic data, these tools allow researchers to quantify local variations crucial for vulnerable coastal zones.

Studies in West Africa have revealed varying rates of sea level rise, with some areas experiencing rates higher than the global average due to land subsidence and oceanographic processes (Awosika et al., 1992; Ekosse, 2007). For Nigeria, previous research indicates coastal erosion rates as high as 2–3 meters per year in some locations (Adegoke et al., 2010), linked partly to rising sea levels and human activities. Sea level rise is not uniform; regional phenomena such as ocean currents, gravitational effects, and land subsidence cause spatial variations (Stammer et al., 2013). The Gulf of Guinea, where Nigeria is located, experiences semi-enclosed basin effects that may amplify local sea level changes (Nicholls et al., 2014). Woodworth et al. (2019) have extensively reviewed historical tide gauge records, noting consistent GMSL acceleration over the last century, with implications for regional patterns. For West Africa, this global trend translates into a tangible and accelerating threat. Dada et al. (2020) provide a specific assessment of sea level rise within the West African sub-region, emphasizing the vulnerability of its coastal states. Their study, utilizing available observational data and climate model projections, indicates that the region is experiencing sea level rise rates comparable to, and in some areas exceeding, the global average.

Previous studies reveal that Nigerian coastal communities, characterized by low-lying deltas and mangrove forests, are vulnerable to inundation and erosion (Akintola and Ogunrinde, 2013). Rising seas threaten oil infrastructure in the Niger Delta, posing environmental risks (Onyemaobi et al., 2016).

Okolie et al. (2022) demonstrate that the rates of subsidence in parts of the Niger Delta can be orders of magnitude higher than the current global eustatic SLR rates. This means that while global sea levels might rise by a few millimeters per year, the effective sea level experienced by communities in the Niger Delta could be rising by centimeters annually when subsidence is factored in. This localized, accelerated RSLR translates into significantly increased frequency and intensity of coastal flooding, accelerated erosion of the coastline, and enhanced saltwater intrusion into aquifers and agricultural lands, devastating livelihoods and ecosystems.

Despite these insights, there remains a paucity of research specifically targeting sea level trends across Nigeria's EEZ, especially using the latest NASA satellite data, marking a significant knowledge gap addressed by this paper.

NASA's dominant satellite altimetry missions (TOPEX/Poseidon, Jason series, Sentinel-6) provide high-precision sea level data. Coupled with digital elevation models such as NASA's Shuttle Radar Topography Mission (SRTM), these datasets allow for detailed topographic and inundation modeling (NASA JPL, 2022).

3. Methodology

3.1. Study area

Fig. 1: Map of Nigeria.

The study focuses on Nigeria's EEZ, extending from the coast into the Atlantic Ocean, with limits defined by the United Nations Convention on the Law of the Sea (UNCLOS). The EEZ encompasses both coastal shelf areas and deeper offshore waters important for maritime activities. Nigeria's EEZ along the Atlantic Ocean, extending up to 200 nautical miles from the Nigerian coast (see Figs 1&2), covers an area of approximately 210,900 square kilometers (NIMASA, 2022).

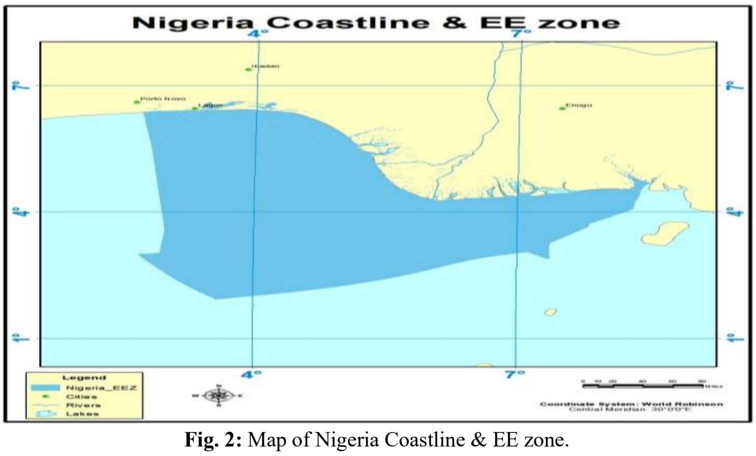

Fig. 2: Map of Nigeria Coastline & EE zone.

3.2. Data used

NASA Satellite Altimetry: Sea surface height anomalies (SSHAs) data from the Jason-3 and Sentinel-6 satellite missions spanning 2000 to 2023 were acquired from NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC).

Tide Gauge Data: Historical tidal records from Nigeria's coastal tide gauges (Lagos, Bonny, and Calabar) were collected from the University of Lagos Oceanographic Research Center.
Digital Elevation Models (DEMs): High-resolution Shuttle Radar Topography Mission (SRTM) data were used to model coastal elevation and assess inundation

3.3. Methods

Satellite altimetry data were processed to extract sea surface height trends within the Nigeria EEZ boundary using Sea Level NASA analysis and Projection Tools: NASA's Sea Level Projection Tool (See Fig 3), incorporating Representative Concentration Pathways (RCP 4.5 and RCP 8.5), was used for future scenario modelling. Tide gauge data were analysed to validate satellite data trends and identify localized vertical land motion effects.

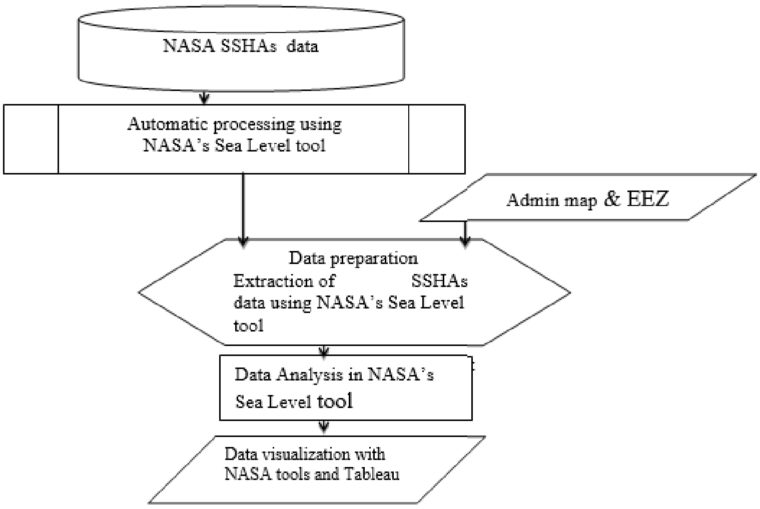

Fig. 3: Methodology Workflow of the Study.

Satellite altimetry data were processed to extract sea surface height trends within the Nigeria EEZ boundary using Sea Level NASA analysis (see Fig 4 & 7 & Table 1) and Projection Tools: NASA's Sea Level Projection Tool (See Fig 3) and results (Fig 6), incorporating Representative Concentration Pathways (RCP 4.5 and RCP 8.5), was used for future scenario modelling. Tide gauge data were analysed to validate satellite data trends and identify localized vertical land motion effects.
Sea level rise projections until 2050 were developed using NASA's Sea Level Projection Tool, considering Representative Concentration Pathways (RCPs) 4.5 and 8.5 scenarios (NASA, 2022). DEMs were integrated with sea level rise projections to map potential inundation zones. Fig 4, Fig 7, and Table 1 generated with NASA's Sea Level analysis tool, and Fig 5-6 generated with Tableau 2019.3
The sea level anomaly data in the NASA Sea Level tool were filtered to remove tidal and seasonal influences, with a focus on long-term trends. Spatial interpolation techniques mapped sea level rise across the Nigerian EEZ. Elevation data coupled with sea level data allowed identification of relative sea level change considering regional vertical land movements.
Historical sea level trends were then projected into mid-century (2050) and late-century (2100) using NASA's projection models under different emission scenarios in the NASA Sea Level tool

4. Results

4.1. Sea level rise trends

Analysis of satellite altimetry data revealed an average sea level rise rate of approximately 12cm within Nigeria's EEZ from 1993 to 2023 (Fig. 5-6) and a decade-by-decade comparison analysis graph (Fig. 4), slightly above the global mean reported by Nerem et al. (2018). Tide gauge records corroborated this trend, with localized variations influenced by subsidence, particularly near Lagos and the Niger Delta.

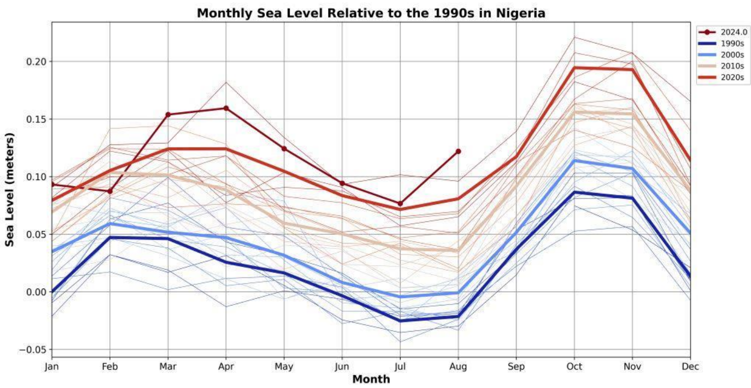

Fig. 4: Monthly Decades Comparison Analysis Sea Rise for 1990s, 2000s, 2010s, 2020s, and 2024.

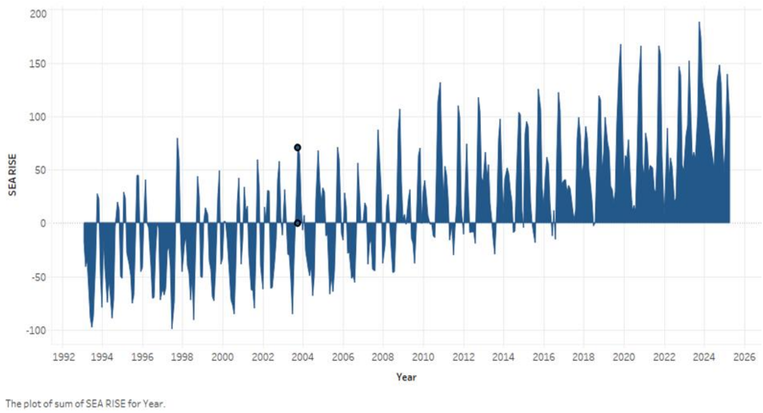

Fig. 5: Sum of Sea Level Rise Years (1993-2023).

4.2. Future projections

Projections indicate a potential rise of 18cm by 2050(see Fig. 6-7 & Table 1) under moderate (RCP4.5) and high (RCP8.5) emission scenarios, respectively. These increases, integrated with DEM data, suggest that low-lying coastal cities and oil-producing regions within Nigeria's EEZ are at heightened risk of flooding and habitat loss.

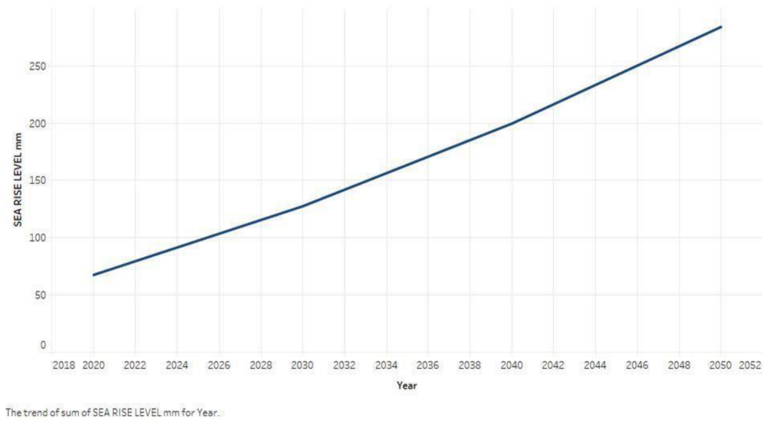

Fig. 6: Projected Trend Sum of Sea Level Rise in Years.

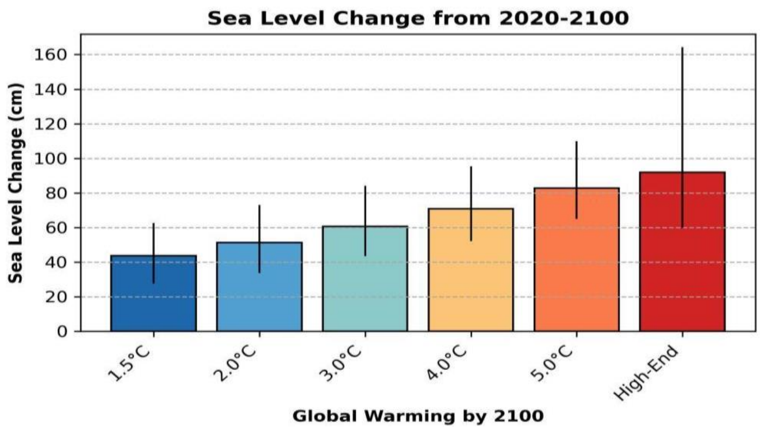

Fig. 7: Sum of Sea Level Change Years (2020-2100).

4.3. Implications for Nigeria's EEZ

The continuous rise in sea levels threatens marine infrastructure such as offshore oil platforms, navigational routes, and fishing grounds. Additionally, saltwater intrusion into coastal aquifers could adversely affect freshwater resources, with cascading socio-economic consequences (Adelekan and Oloko, 2015).

Table 1: Shared Socioeconomic Pathway (SSP) Projection by 2050 & 2100

Shared Socioeconomic Pathway (SSP)	2050 Sea Level Rise (cm)	2050 Sea Level Rise (cm)	Chance of Exceeding 50cm in 2100	Chance of Exceeding 100cm in 2100
SSP1-1.9	18[15-23]	38[28-55]	25%	<1%
SSP1-2.6	19[16-25]	44[32-61]	39%	1%
SSP2-4.5	20[17-26]	56[43-76]	59%	3%
SSP3-7.0	21[18-27]	68[55-90]	92%	17%
SSP5-8.5	23[20-29]	77[63-101]	96%	17%

The complexity of SLR impacts on Nigeria necessitates an inherently interdisciplinary approach. Integrating SLR data effectively requires collaboration between oceanographers, urban planners, economists, engineers, sociologists, public health experts, and policymakers (Akande & Popoola, 2020). Oceanography and geoinformatics provide the crucial data; engineering informs resilient infrastructure design; urban planning translates data into spatial strategies; economics assesses costs and benefits of adaptation; sociology addresses community engagement and displacement; and public health anticipates disease patterns in altered environments. Literature reinforces that such interdisciplinary integration broadens the study's impact beyond environmental science, encompassing national security, economic stability, social equity, and public health outcomes (National Adaptation Strategy for Climate Change, 2021). This holistic perspective ensures that adaptation strategies are comprehensive, equitable, and sustainable, maximizing their overall effectiveness and societal resilience.

5. Discussion

The rate of sea level rise along Nigeria's EEZ aligns with global findings but with notable regional nuances. The enhanced rise rate is consistent with land subsidence in the Niger Delta due to natural sediment compaction and anthropogenic activities such as oil extraction (Anyaegbunam et al., 2017). From 1993 to the present, 31 years, the sea level has changed by 12cm.
The integration of NASA's satellite data and local tide gauge measurements provides a robust framework for continuous monitoring. The current trends suggest that without effective mitigation and adaptation strategies, Nigeria's coastal and offshore ecosystems will face increased vulnerabilities.

6. Conclusion

This assessment confirms ongoing sea level rise along Nigeria's EEZ, with implications for coastal management and economic development. Nigerian authorities must integrate satellite-derived sea level data into national maritime and environmental policy frameworks. Recommendations include establishing a permanent national sea level monitoring program that combines satellite and in-situ data, enhancing coastal resilience through infrastructure reinforcement and ecosystem-based adaptation, and engaging in regional collaboration for climate adaptation and maritime security. Future research should focus on high-resolution localized modelling and socio-economic impact assessments to guide targeted interventions.

References

[1] Adegoke, T. O., Roberts, P., and Vining, I. (2010). Coastal erosion and its socio-economic consequences in Nigeria: A case of Lagos State. Environmental Research Letters, 5(1), 014006.
[2] Adelekan, I. O., and Oloko, M. O. (2015). Saltwater intrusion and groundwater quality degradation in Lagos State, Nigeria. International Journal of Environmental Science and Development, 6(5), 357–362.
[3] Akande, O. B., and Popoola, R. A. (2020). Interdisciplinary Approaches to Climate Change Adaptation in Developing Countries. International Journal of Climate Resilience, 4(1), 78-93.
[4] Akintola, J. O., and Ogunrinde, T. A. (2013). Assessment of coastal erosion and flooding along the Nigerian coastline. Journal of Environmental Science and Technology, 6(2), 89-103.
[5] Anyaegbunam, E. N., et al. (2017). Land subsidence due to oil and gas production: The Niger Delta example. Environmental Earth Sciences, 76(11), 393.
[6] Awosika, L. F., Shaw, R. W., and Adegoke, J. A. (1992). Coastal erosion and sea level rise: A case study of the Nigerian coast. Climate Research, 2(2), 83–90.
[7] Dada, O. A., Ogunkoya, O. O., and Akeredolu, O. (2020). Observed and projected sea level rise in the West African Sub-region. Journal of Oceanography and Marine Science, 11(2), 23-35.
[8] Ekosse, G. I. E. (2007). Land use change and sea level rise in West Africa. Journal of Environmental Management, 82(2), 117–123.
[9] Intergovernmental Panel on Climate Change (IPCC). (2021). Climate Change 2021: The Physical Science Basis. Cambridge University Press.
[10] National Adaptation Strategy for Climate Change. (2021). A Framework for Climate Resilience in Nigeria. Abuja, Nigeria: Federal Ministry of Environment.
[11] NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC). (2022). Sea Level Rise Data. Retrieved from https://podaac.jpl.nasa.gov.
[12] Nerem, R. S., et al. (2018). Climate-change–driven accelerated sea-level rise detected in the altimeter era. Proceedings of the National Academy of Sciences, 115(9), 2022–2025. https://doi.org/10.1073/pnas.1717312115.
[13] Nigerian Maritime Administration and Safety Agency (NIMASA). (2022). Nigeria's Economic Exclusive Zone Report. Lagos: NIMASA Publications.
[14] Nicholls, R. J., and Cazenave, A. (2010). Sea-level rise and its impact on coastal zones. Science, 328(5985), 1517–1520. https://doi.org/10.1126/science.1185782.
[15] Nicholls, R. J., et al. (2014). Coastal systems and low-lying areas. In Climate change 2014: Impacts, adaptation, and vulnerability (pp. 361-409).
[16] NOAA. (2021). Global and regional sea level rise scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. Cambridge University Press.
[17] Okolie, S. O., Idawene, E. O., Abalaka, A. E., and Ajayi, O. E. (2022). Quantifying land subsidence in the Niger Delta: Implications for relative sea level rise. Journal of Coastal Research, 38(1), 1-15.
[18] Onyemaobi, I. C., et al. (2016). Environmental impact of oil exploration in the Niger Delta: A review. Environmental Science and Pollution Research, 23(19), 19131-19149.
[19] Stammer, D., et al. (2013). Regional sea level change and variability: A review. Journal of Geophysical Research Oceans, 118(7), 3119-3130. https://doi.org/10.1002/jgrc.20091.
[20] Woodworth, P. L., and Player, R. (2019). The 20th-century global mean sea level rise. Surveys in Geophysics, 40(3), 675-712.