Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

Shoreline Dynamics and Land Cover Transitions at Talsari Sea Beach Using Geospatial and Remote Sensing Techniques

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Abstract - The monitoring of coastal interfaces is crucial due to their susceptibility to both morphodynamical processes and anthropogenic stressors. This research presents a decadal assessment (2014–2025) of the shoreline evolution and Land Use/Land Cover (LU/LC) transformations at Talsari Sea Beach, located in the Balasore district of Odisha. Situated at the dynamic confluence of the Subarnarekha River and the Bay of Bengal, this region faces distinct environmental challenges. The study utilized Landsat 8 Operational Land Imager (OLI) datasets, processed through ArcGIS 10.8.2, to perform Supervised Classification using the Maximum Likelihood Classifier (MLC). The geospatial analysis indicates a heterogeneous pattern of coastal change: the eastern estuarine sector exhibits severe erosion with a shoreline retreat of 50–100 meters, while the western sector displays moderate accretion. Significant LU/LC shifts were quantified, most notably a drastic reduction in vegetation cover from 35% to 20% and a surge in settlement areas from 4% to 14%. These findings highlight the critical need for Integrated Coastal Zone Management (ICZM) to address the dual pressures of erosion and urbanization.

Key Words **: Coastal Geomorphology, Talsari, Landsat-8, Maximum Likelihood Classifier, Erosion-Accretion, LU/LC Dynamics, Subarnarekha Estuary.**

1.INTRODUCTION

Littoral zones represent some of the most fragile and rapidly evolving landscapes globally, shaped by the continuous interplay of hydrodynamic forces and terrestrial inputs. The stability of these shorelines is increasingly compromised by natural phenomena, including tidal surges and wave energy, as well as human interventions such as infrastructure expansion. The coastal tract of Odisha, particularly along the Bay of Bengal, is identified as a high-risk zone for geomorphological instability, frequently subjected to cyclonic disturbances and sea-level variability [1], [2].

Talsari Sea Beach serves as a vital ecological buffer, hosting mangrove ecosystems and diverse wetlands. However, recent trends suggest an accelerated alteration in its physical configuration. To comprehend these changes, Remote Sensing (RS) and Geographic Information Systems (GIS) have emerged as indispensable tools, offering synoptic and temporal capabilities for monitoring inaccessible coastal terrains [3], [4]. This study aims to quantify the shoreline displacement and categorize land cover transitions at Talsari between 2014 and 2025, utilizing multi-temporal satellite telemetry to provide a scientific basis for regional conservation strategies.

2. STUDY AREA

The area of interest is situated in the northeastern periphery of the Balasore district, Odisha, geographically positioned at 21.5°N latitude and 87.5°E longitude. The site is bounded to the east by the Subarnarekha River, which serves as the interstate border between Odisha and West Bengal. This estuarine environment is characterized by a tropical monsoon climate, where seasonal high-energy waves and semi-diurnal tides significantly influence sediment transport and beach morphology. The interaction between fluvial discharge and marine currents creates a highly dynamic sedimentary environment susceptible to rapid morphological adjustments.

3. METHODOLOGY

The research methodology integrated satellite image processing with field-based verification to ensure high classification accuracy.

3.1 Data Acquisition

Primary geospatial data was derived from the Landsat 8 Operational Land Imager (OLI) sensor, which offers a spatial resolution of 30 meters. Cloud-free imagery was selected for the years 2014 and 2025 to minimize atmospheric noise. Ancillary data included administrative maps and ground truth coordinates collected via Differential GPS (DGPS) surveys to validate the satellite interpretations.

3.2 Geospatial Processing

Digital image processing was executed using ArcGIS 10.8.2. The raw satellite data underwent radiometric calibration and geometric correction. For the extraction of thematic layers, a Supervised Classification approach was adopted, utilizing the Maximum Likelihood Classifier (MLC) algorithm. The study area was segmented into six distinct classes: Water, Vegetation, Cropland, Settlement, Sand Patches, and Barren Land. Post-classification change detection algorithms were employed to

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

calculate the percentage area shifts and linear shoreline regression.

4. RESULTS AND DISCUSSION

4.1 Classification of Land Use/Land Cover

The spatio-temporal analysis reveals substantial alterations in the landscape composition over the eleven-year observation period.

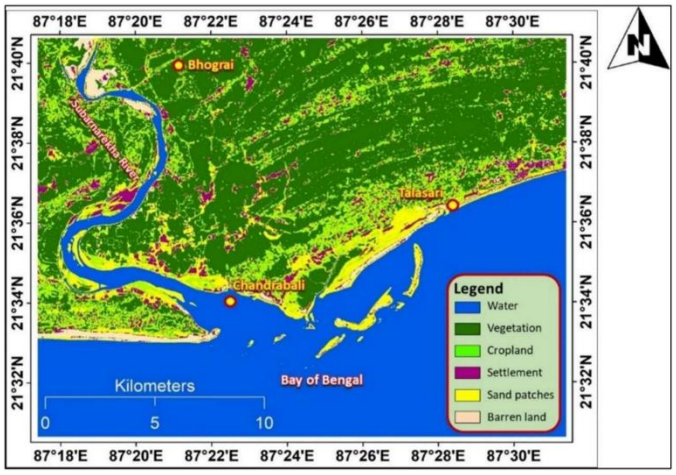

Fig -1: Supervised Classification Map (2014)

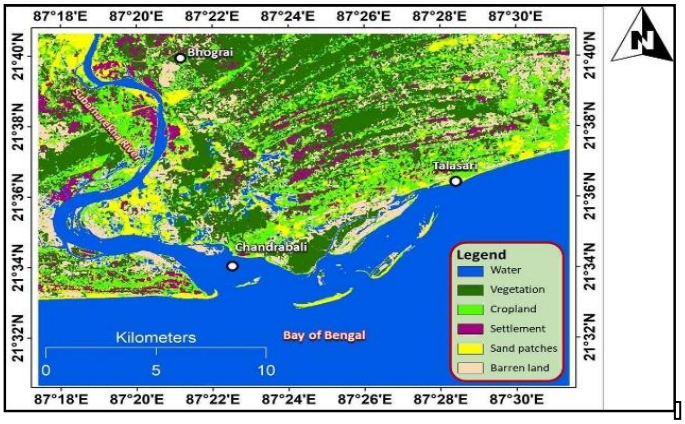

Fig -2: Supervised Classification Map (2025)

As depicted in the classification maps, the landscape has transitioned from a predominantly natural state to one heavily influenced by anthropogenic activity.

4.2 Quantitative Assessment of Dynamics

The statistical breakdown of land cover percentages indicates a clear trajectory of urbanization and environmental degradation.

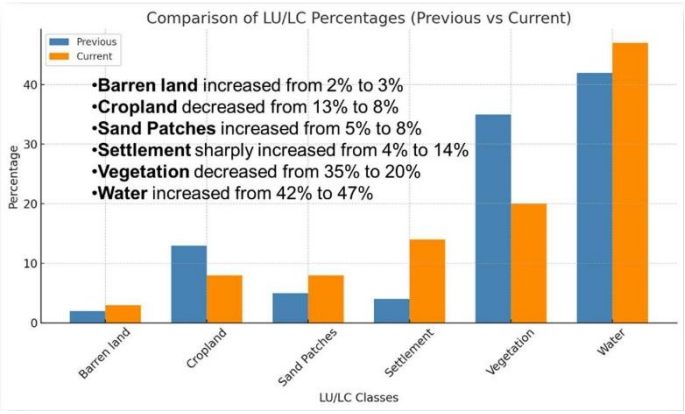

Chart -1: Comparative Analysis of LU/LC Percentages (2014-2025)

Table -1: Land Cover Transition Statistics

Class Category	2014 Coverage (%)	2025 Coverage (%)	Net Change
Water Bodies	42%	47%	+5%
Vegetation	35%	20%	-15%
Settlement	4%	14%	+10%
Cropland	13%	8%	-5%
Sand Patches	5%	8%	+3%
Barren Land	2%	3%	+1%

Note: While total sand area shows a statistical increase, spatial analysis confirms specific loss of protective beach sand to water at the estuary mouth.

The data highlights a concerning 15% decline in vegetation, attributable to the degradation of mangroves and coastal thickets. Concurrently, settlement areas have more than tripled (4% to 14%), reflecting rapid tourism-driven construction near Chandrabali and Talsari. The expansion of water bodies to 47% is indicative of coastal inundation, a trend observed in other parts of the Odisha coast [1], [3].

4.3 Shoreline Morphology

The shoreline analysis delineates two contrasting morphological trends. The eastern flank, adjacent to the Subarnarekha estuary, is experiencing severe retrogradation (erosion). Estimates suggest a landward retreat of 50 to 100 meters in this zone, with an erosion rate averaging -0.5 m/year. This is likely driven by the scouring action of river discharge combined with tidal currents. Conversely, the western segment of the beach demonstrates accretion at a rate of approximately +0.3 m/year, likely due to sediment redistribution by longshore drift, a phenomenon also documented in adjacent coastal districts. Similar erosion-accretion patterns have been observed in other Indian deltas, such as the Sundarbans, where morphological changes are driven by complex hydrodynamic forces [5].

5. CONCLUSIONS

The geospatial investigation of Talsari Sea Beach confirms that the region is undergoing significant morphological and land-use transformations. The study identifies the Subarnarekha estuarine zone as a hotspot for erosion, while the broader area

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 02 , February - 2026

faces immense pressure from urbanization, evidenced by the sharp rise in settlement coverage and loss of vegetation. The current trajectory suggests that without intervention, the ecological integrity of Talsari is at risk. It is imperative to implement sustainable sediment management and enforce coastal regulation zones (CRZ) to mitigate the impacts of erosion and preserve the remaining biodiversity buffers, as recommended for high-vulnerability zones along the eastern coast [2], [6].

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