Future coastline prediction of Mahanadi Delta using Digital Shoreline Analysis System (DSAS): A Fractal Dimension Index (FDI) approach

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Abstract: Mahanadi delta, the second largest delta in the Indian subcontinent is gradually losing its coastal lands mainly due to sea-level rise and erosion. To comprehend the coastal dynamics of the delta and to forecast the future, Digital Shoreline Analysis System (DSAS) coupled with Fractal Dimension Index (FDI) have been used on the historical shorelines. From 1990 onwards, the historical shorelines of the delta have been extracted from the satellite imageries using semi-automated classification technique. The historical shoreline alteration trend has been calculated using Endpoint Rate (EPR) method. The shoreline for a year whose position is known is calculated from the previous two year's data and the value is compared with the actual position. The rate of change in position is modified accordingly to reflect this difference and it is used to predict the future coast lines. FDI of the historical shorelines of the delta have been calculated, an empirical relation with FDI and the rate of erosion has been established and from this the future trend of the coastline derived from EPR method have been validated. Using EPR, shorelines of the Mahanadi Delta have been predicted for the 2040. The result shows significant loss of area near Puri, Konarak, Saharabdei, Naugaon, Uttampur.

Key Words: Digital Shoreline Analysis System (DSAS), Fractal Dimension Index (FDI), Erosion, Endpoint Rate (EPR), Mahanadi Delta

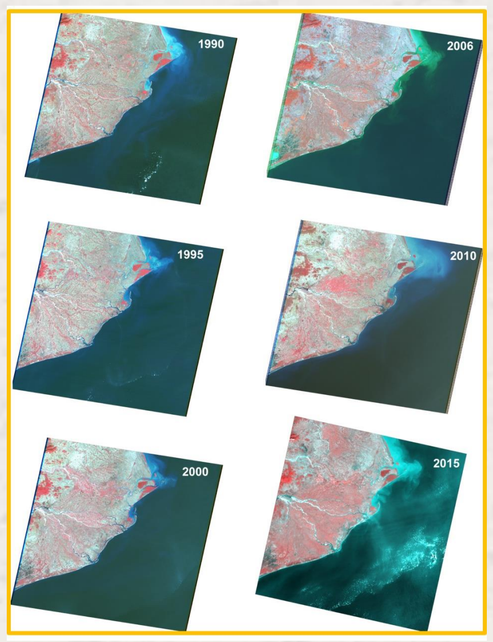


Fig: Satellite images of Mahanadi delta

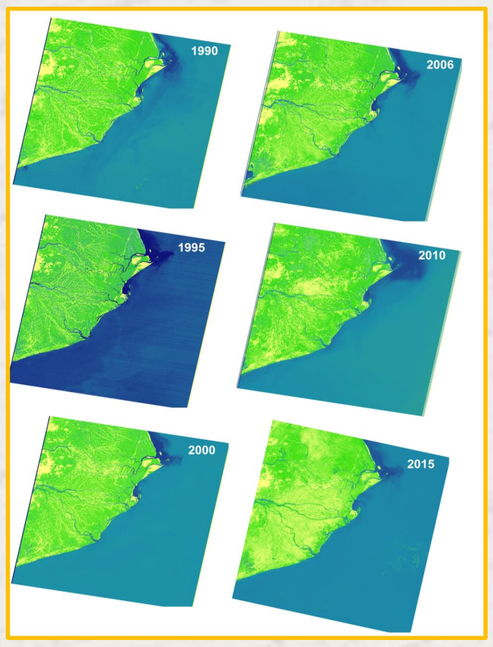
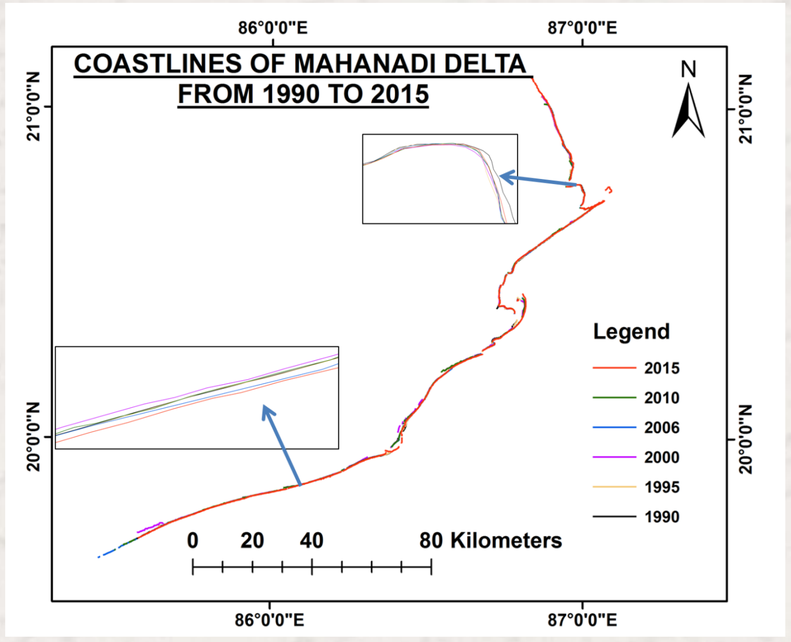
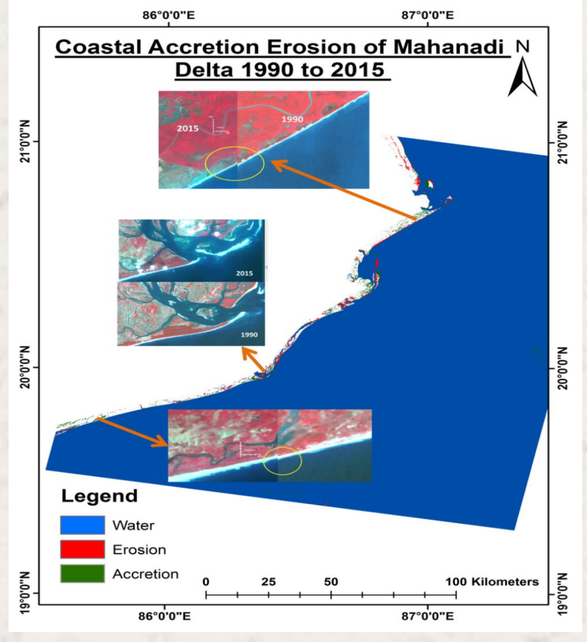


Fig: NDVI of the Mahanadi delta





Parameters	Application in this study	Formula Used	Software Used
NDVI	Negative values of NDVI (values approaching -0.1 to -1) correspond to water. Values close to zero (-0.1 to 0.01) generally correspond to barren sand with no vegetation i.e. beach, end of the beach face is taken here as coast line	(Ir-R)/(Ir+R) Where Ir is infrared Band and R is Red band	ERDAS IMAGINE
EPR	The model is based on the assumption that the observed periodical rate of change of shoreline position is the best estimate for prediction of the future shoreline and no prior knowledge regarding the sediment transport or wave interference is required because the cumulative effect of all the underlined processes is assumed to be captured in the position history The position of the future shoreline for a given data is estimated using the rate of shoreline movement (slope), time interval between observed and predicted shoreline and model intercept	$EPR = (Y_1-Y_2)/(X_2-X_1)$ Where Y_1, Y_2 are coast line position and X_2, X_1 are time difference Predicted position $= EPR * (X_t-X_2)+Y_2$ Where X_t is future time Y_2 last position of the coast	ARC GIS & DSAS
FD	FD is a measure of how fragmented a fractal object (here coastline) is, which may be understood as a characterization of its self-similarity. This aspect of irregularity is quantified by measuring the fractal dimension index (FDI). Higher FDI values which indicate more fragmented coastlines are always more vulnerable to erosion and those having lower values are more stable.	$(FDI) = \frac{LogN}{Log(\frac{1}{r})}$ where r is the self-similarity ratio and N is the number of step size here	FRAGSTATS 4.2.1

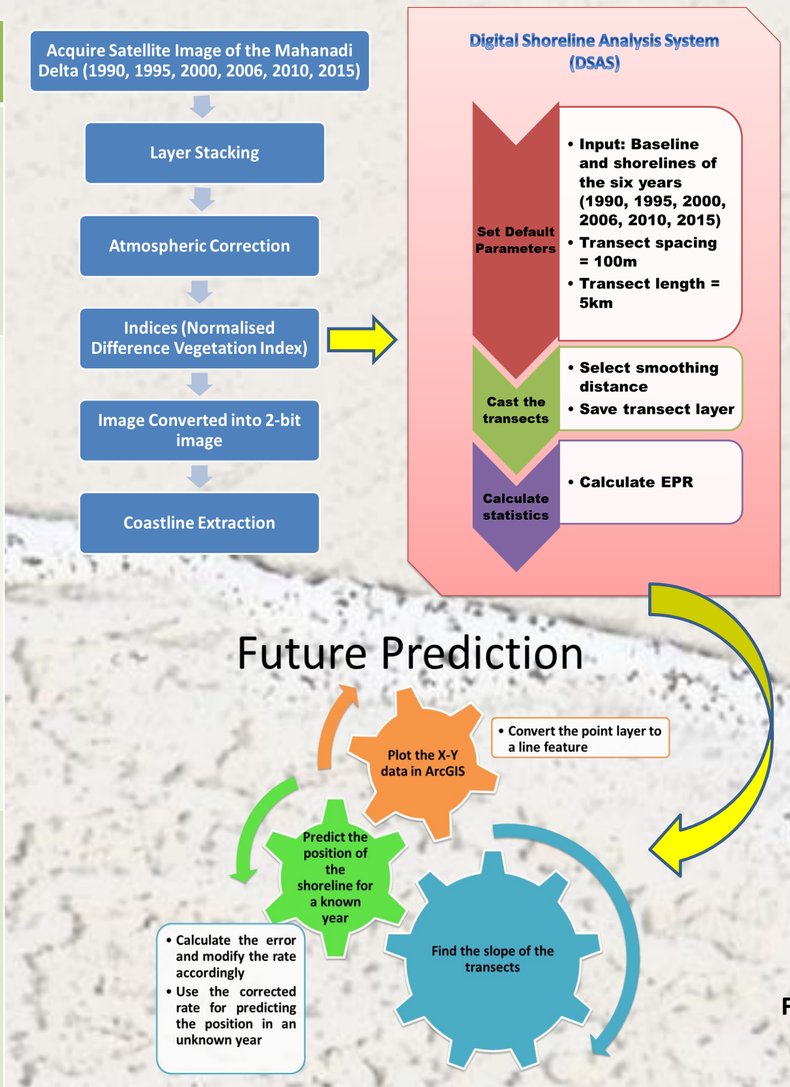


Image Date	Sensor	Spatial Resolution	Tide
1990/12/23	LANDSAT-TM	30m	1.18m
1995/12/21	LANDSAT-TM	30m	1.20m
2000/12/2	LANDSAT-TM	30m	1.17m
2006/12/3	LANDSAT-TM	30m	1.21m
2010/4/18	LANDSAT-TM	30m	1.22m
2015/11/26	LANDSAT-OLI	30m	1.9m

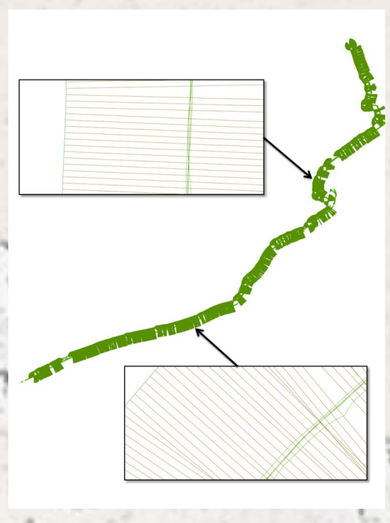
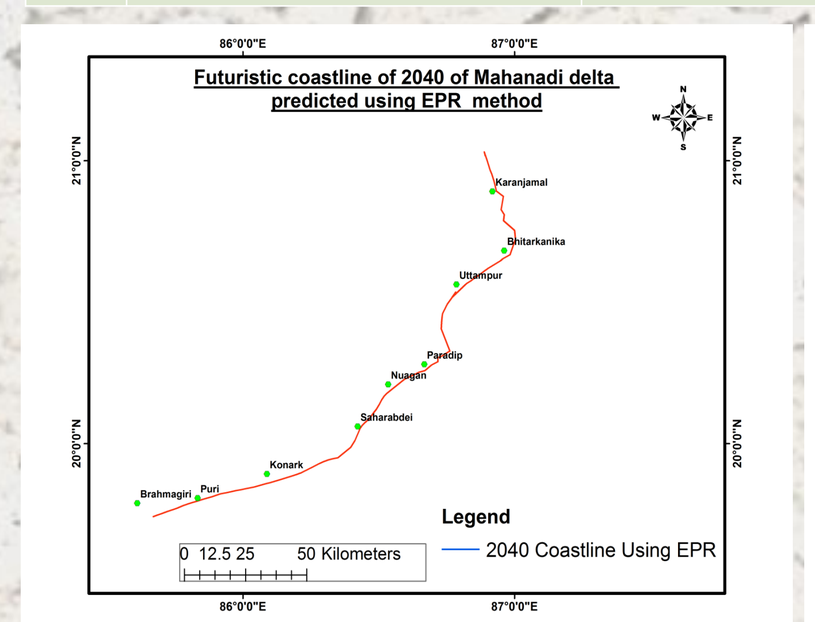


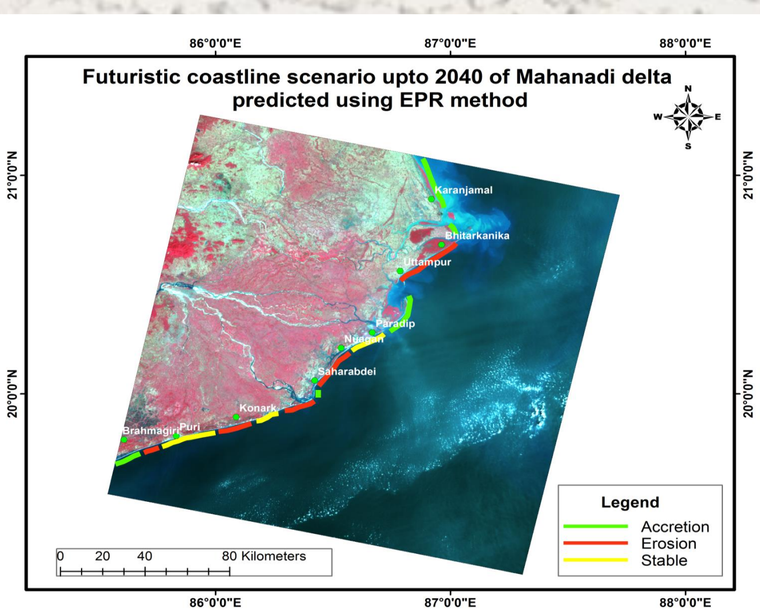
Fig: Segmentation of the coastlines of Mahanadi delta

1. Beach near Puri city
2. Beach north of Puri city
3. Beach south of Puri city

4/5 . Beach near Konark

6. Chilika





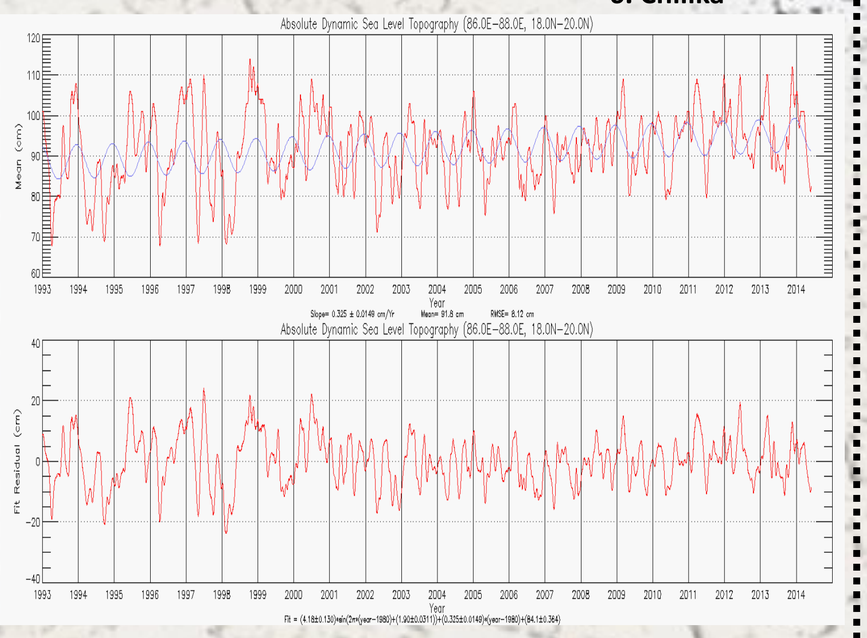


Fig: Condition of the Sea Level of the nearby sea from 1993 to 2014 using TOPEX/Poseidon jason-1 data, showing 0.325cm Positive slope

Conclusion: Future coastline position has been predicted by the analysis of historical data using EPR method. Historical data extracted from satellite images dating 1990, 1995, 2000, 2006, 2010, and 2015. Subsequently, FDI of the coastline is calculated for the purpose of validation of the EPR results. It is found that for FDI >1.34 shows erosion; for FDI between 1.1 and 1.3 the coastline remains unaltered and for FDI < 1.1, accretion takes place. The predicted coastline of 2040 has been validated with the range of FDI. Using the predicted coastline future coastal scenario of the Mahanadi delta have been mapped.

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