Delineation of Shoreline Change along Chilika Lagoon (Odisha), East Coast of India using Geospatial technique

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ABSTRACT

Display contemplate zone is the Chilika Lagoon which is greatest salty water tidal pond in tropical Asia arranged in the Odisha east Coast of India. Current investigation of the shoreline change in the Chilika Lagoon utilizing the Landsat information relating to 1992-2014 is concentrate on the shoreline incline. Chilika Lagoon recorded the bigger shoreline morphology progression in the southern parts contrasted with alternate parts. The shorelines in towards offshore side uncover the bigger changes demonstrate the dynamic marine-fluvial progression are more grounded in this district. The examination additionally conceives the correlation of the consequences of the shoreline change rates completed utilizing EPR and LRR systems of DSAS. The aftereffects of the both the methods uncover practically comparable outcomes aside from the slight varieties in the scope of progress force. The scope of recorded by the EPR was - 91 to 210 m/y, though the LRR recorded - 50 to 144 m/y. The straight relapse strategy is helpless to exception impacts, and furthermore tends to think little of the rate of progress in respect to different measurements, for example, EPR. Similar outcomes were additionally delineated in give think about thought little of esteems by LRR contrast with EPR. Subsequently the EPR is the better alternative for the count of the net shoreline drift for the more drawn out period information.

INTRODUCTION

The Evaluation of shoreline and beach front procedures is essential for a checking research program concerning the littoral territory (Crowell et al., 2007, Bird 2008). Shorelines are persistently moving in light of winds, waves, tides, dregs supply, changes in relative ocean level and human exercises. Accordingly, shoreline changes are by and large not steady through time and every now and again change from disintegration to gradual addition and the other way around. Cyclic and non-cyclic procedures change the position of the shoreline over an assortment of timescales, from the everyday and occasional impacts of winds and waves, to changes in ocean level spreading over decades, or more. As waterfront populace keeps on developing and group frameworks are debilitated by disintegration, there has been an expansion popular for exact data in regards to shoreline development. In this way, a standout amongst the most vital parts of waterfront administration and arranging programs that benefits advance examination is shoreline progression (Morton and Miller, 2005).

The GIS stage was utilized to build up a standard repeatable technique for mapping and examining shoreline development with the goal that intermittent updates can be made locally, in regards to beach front disintegration and land misfortune (Burke et al., 2001). Shoreline geometry stays one of the key parameters in the identification of beach front Erosion, statement and the investigation of waterfront morphodynamics. The investigation of the rate of progress in shoreline position is vital for an extensive variety of beach front examinations, for example, improvement of misfortune arranging, peril zoning, disintegration growth thinks about, provincial residue spending plans and theoretical or prescient displaying of seaside morphodynamics (Zuzek et al., 2003). Remote sensing has evidenced its utility all told fields of geophysical science, which incorporates the study of coastal processes, detection of changes because of seasons, natural disasters and human activities, as a result of the fast, repetitive, synoptic and multi spectral coverage of the satellites (Kanga et al., 2011a, Pandey et al., 2013, Sinha et al., 2014, Singh 2017) . It provides cost-efficient multi-spectral and multi-temporal knowledge, and turns them into info valuable for understanding and watching development patterns and processes (Jiang et al., 2002, Singh 2016, Kanga et al., 2011b). Remote sensing satellites pictures are effectively used for watching boundary changes in several elements of Asian nation (Sun and Zhang, 2004, Kanga and Singh 2017, Kanga et al., 2013, Singh and Pandey 2014). Remote detecting information could be utilized adequately to screen the progressions along the beach front zone including shoreline. The shoreline change extraction and change discovery investigation is an essential assignment that has application in various fields, for example, advancement of mishap arranging, risk zoning, disintegration accumulation thinks about, local residue spending plans and reasonable or prescient demonstrating of seaside transform elements. Shoreline outline is troublesome, tedious, and once in a while unimaginable for whole seaside framework when utilizing customary ground review systems.

The Digital Shoreline Analysis System (DSAS) as a product expansion inside the Environmental System Research Institute (ESRI) ArcGIS has been utilized by specialists in measuring, evaluating, ascertaining and observing shoreline rate-of-progress insights from various noteworthy shoreline positions and sources. Direct relapse Rate (LRR) strategy for deciding shoreline position change rate is observed to be critical among every single such system, as it limits potential irregular mistake and here and now changeability (patterned changes) using a measurable approach (Ruiz and Berlanga, 2003). Late progressions in remote detecting (RS) and geological data framework (GIS) strategies have prompted enhancements in waterfront geomorphological examinations, for example, self-loader assurance of shorelines (Ayad, 2005); recognizable proof of relative changes among beach front units (Kevin and El Asmar, 1999); extraction of topographic and bathymetric data (Guariglia, 2006) and their coordinated GIS investigation (Rao et al., 1986). These systems are alluring, because of their cost-viability, diminishment in manual mistake and nonattendance of the subjective approach of traditional field methods. A scope of factual change measures are inferred inside DSAS, in view of the examination of shoreline positions through time. In spite of the powerlessness of this apparatus to decide the driving of morphodynamics, it has been appeared to be compelling in encouraging an inside and out examination of worldly and recorded development of shoreline positions and bluff geometry. This work condenses the recorded changes in the Chilika shoreline, as far as both gradual addition and disintegration. Shoreline change along Chilika Lagoon has been examined utilizing the End Point Rate (EPR) strategy in Digital Shoreline Analysis System (DSAS) in ArcGIS 10.3. Benchmark was made along the shoreline to create general pattern of shoreline. The concise records of beach front land misfortune for each considered part, Chilika site give a far reaching perspective of coastland examination of growth and disintegration and more about waterfront change in a more extensive setting. To be sure, 3 zones of Lagoon Chilika (North, Middle, and South) were analysed as case work. The strategy for examination and translation of the outcomes can likewise give clarifications in regards to long haul and here and now rates. The main role of this work was to discover the relevance of a consolidated method. In the present investigation, multi determination satellite pictures, which are effortlessly accessible, have been used to delineate shoreline positions amid various circumstances previously. In view of evaluated shoreline change rates, future forecasts of shoreline positions have been computed.

STUDY AREA

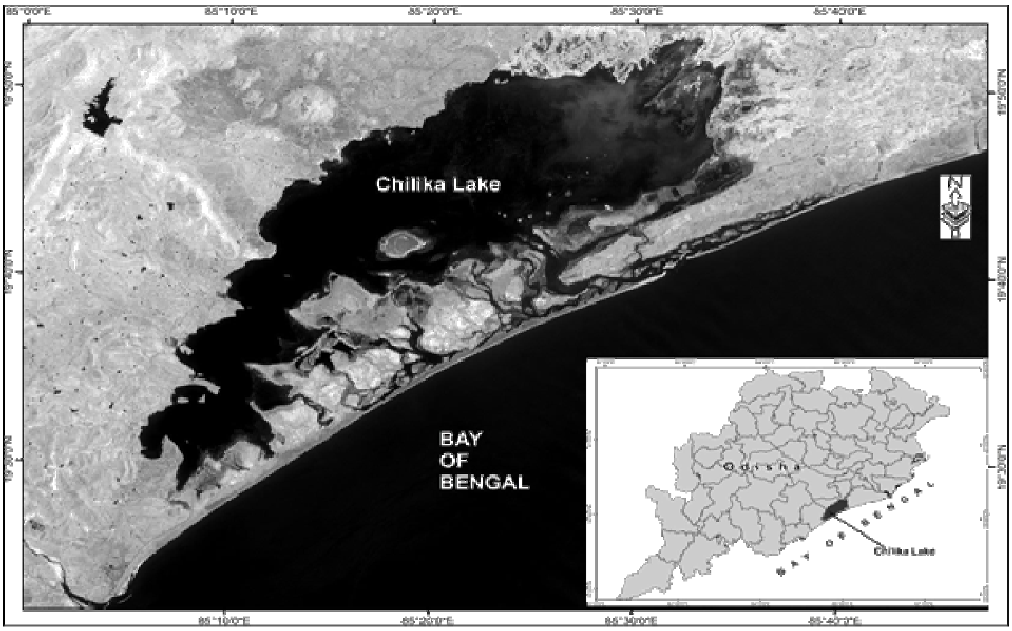

Figure 1 Map showing the location of Chilika Lagoon along the Odisha, East Coast of India

The Chilika Lagoon, (19°28'–19°54' N latitude and 85°05'–85°38' E longitude), situated in the east coast of the State of Odisha, India, is the largest brackish water Lagoon in tropical Asia and covers a part of just about 4300

km^2. The north shore of the Lagoon is a component of Khordha district, and therefore the western shore is a component of Ganjam district of Odisha. Abrupt changes within the morphology of the coast on north of the Lagoon because of shifting of the sand to towards the shore by robust wind and longshore drift and therefore the presence or absence of robust watercourse and periodic event currents in numerous area unit as area unit the explanations that are attributed to the expansion of the spit. The water depth within the Lagoon varies from 0.9 to 2.6 m within the season. The watershed boundaries lie between the water flowing into the Mahanadi and therefore the Chilika within the north, whereas areas debilitating into the Bhargavi watercourse structure the northeast watershed; within the west and southwest, the watershed boundary lies between streams flowing into the Rushikulya watercourse and people flowing into the Chilika (Figure 1).

DATA USED AND METHODOLOGY

Eleven Landsat imageries were used for analyzing the shoreline change for this study. The imageries span of 23 years (1992, 1993, 1994, 1 995, 1996, 2001, 2002, 2006, 2007, 2011, 2012 and 2014) and were acquired from Landsat Look Viewer, GLOViS and Earth Explorer. The main objective was to identify the rate of shoreline changes along the study area using remote sensing and GIS. In this study, the multi-temporal Landsat satellite images acquired with 30 meters spatial resolution from 1992 to 2014 were used as primary data source for shoreline extraction In the process of carrying out this study, the use of satellite images and GIS tools to extract the shorelines for Eleven different years. This range of time and years selected due to deliberated tide data availability and it was based on approximately similar tide height. For the delineation of shorelines the images were processed for the given years with a view to determining their rate of changes over the study period. Shorelines were digitized using ESRI’s ArcMap 10.3 software. The defined shoreline perimeter of the coast was digitized on screen from the Landsat Satellite image. As we know here 23 years (1992- 2014) images are used for the shoreline digitization. The high water line was considered the indication of the shoreline. The high water line is usually selected as the shoreline indicator for mapping purposes because it is visible in most images. Shoreline delineation through remote sensing techniques relies on the varied spectral behaviour or spectral response of water and other land surfaces at different wavelengths. Generally, water bodies absorb most of the radiation in near-infrared and mid-infrared regions of the spectrum. Hence, the reflectance of water is almost equal to zero in these wavelengths; meanwhile, the reflectance of various land covers in both regions is higher than water. According to this concept, coastline can be extracted from FCC band combination image, since the reflectance of water is nearly equal to zero in the reflective infrared bands. It is processed in ArcGIS 10.3 to display erosion/accretion patterns and calculate the annual retreatment rate along the shoreline of Chilika Lagoon. All desired shorelines are digitized using same scale on 1:24,000. The Digital Shoreline Analysis System (DSAS) is a GIS tool that can be used to examine past or present shoreline positions or geometry, one of the main benefits of using DSAS in coastal change analysis is its ability to compute the rate-of change Statistics for a time series of shoreline positions. The statistics allow the nature of shoreline dynamics and trends in change to be evaluated and addressed. DSAS has been developed as a freely available extension to Environmental System Research Institute (ESRI)’s ArcGIS. The detailed methodology used for the shoreline change study using the geospatial technology has been provided as flow-chart in the Figure. 2.

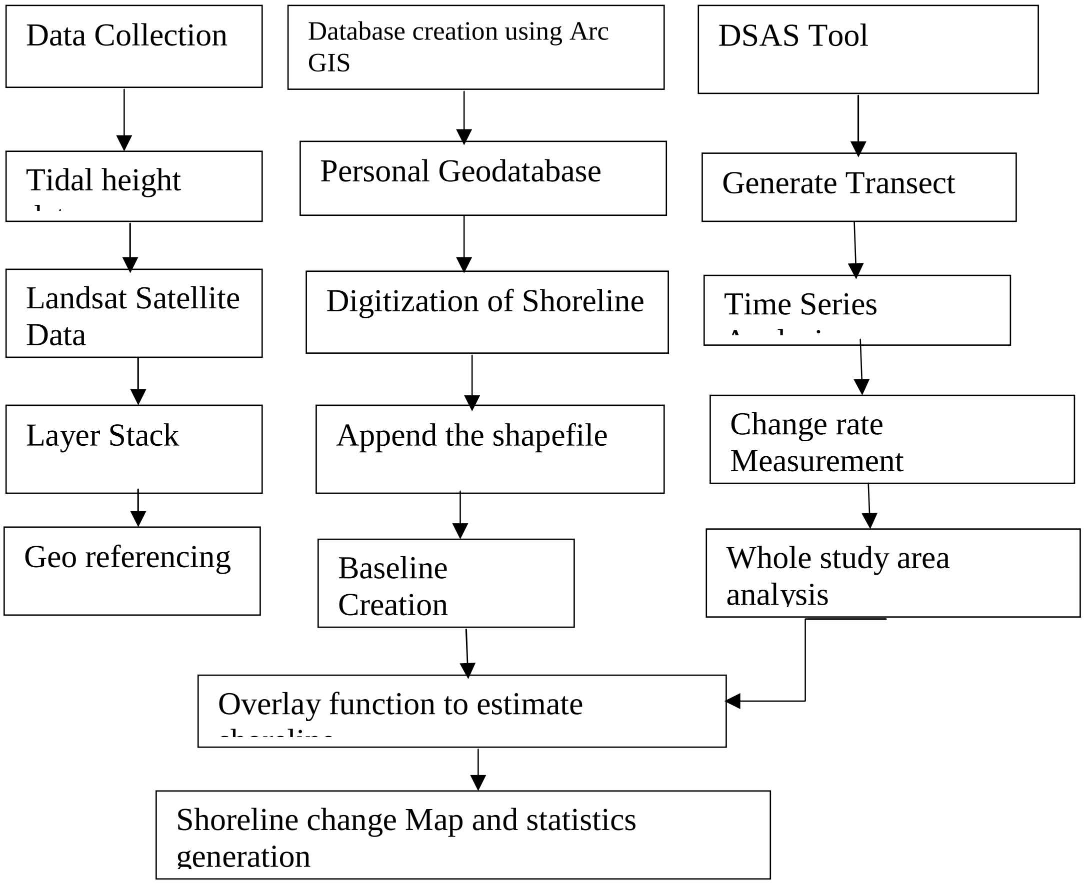

Figure 2. Methodology adopted for the study

RESULT AND DISCUSSION

The Digital Shoreline Analysis System (DSAS) is an extension that enhances the normal functionality of ESRI ArcGIS software, and enables users to calculate Shoreline rate-of-change statistics from a time series of multiple shoreline positions. The extension was used in historic shoreline change analysis. After the digitization of all shorelines we have to need for append. Append add all the shorelines in a single file. For this process we have to select a single shapefile and all files will be appended in that selected shapefile. First off all before append confirm that all shoreline files have the same spatial reference and feature type. It is a good idea to make a copy of all shapefiles in other folder and renamed it. Append is a tool added in arc info. For append open the append tool from arc toolbox (Data Management Tools- General- Append) then add all the shorelines shapefile to the input feature list in the append window. The baseline is the starting point for all transects and is therefore one of the most important components of the shoreline change analysis process. Basically we can generate a baseline by three ways i.e. start with new shapefile, buffer of a shoreline and use a pre-existing baseline. Here second option was adopted for creating the baseline. For generate the baseline from an existing shoreline we selected most recent shoreline. Then specified a distance that will offset the resulting buffer entirely landward or seaward of all other shoreline then converted it in polyline from polygon and split, remove the unwanted part of created buffer. Its shape and relative location to the shorelines impacts the rate calculations determined by the transect /shoreline intersections. The baseline must be contained in a single shapefile (and therefore is a single feature class once imported into the geo database). Then take the time to manually edit and smooth the baseline based on their particular study area. Before generating the transects we have to put and complete the some parameters that are compulsory for baseline and shoreline like transect length , transect spacing, baseline smoothing distance etc.

Figure 3. Baseline parameters

The baseline can be drawn off-shore, on-shore or can be a combination of both. By checking off-shore, rate calculations will be determined assuming transect origins are seaward of shorelines. The casting direction will be determined by the default parameters described on the previous page. Onshore transect origins are considered to be landward of the shorelines in rate calculations. The chosen baseline parameter adjusts the reported statistics for positive and negative values to correctly indicate accretion and erosion. At the time of cast transect one main factor also play a vital role called shoreline. Shorelines have also some parameters that are very important to select these parameters (figure 3).

In this study farthest intersection in selected because of a Lagoon size, type and composition. Important Shoreline attributes are given below date. Finally just before generating the transect we have to select one option from simple baseline cast and smoothed baseline cast. Fig: showing the selected option for this study. After all the default parameters setting transects can be cast. In the study we take the 100m. Of transect spacing and 500 m. of transect length. Then specified the location of the geodatabase where the resulting transect and intersect files will be stored. The user is able to select either simple or smoothed baseline casts for newly generated transects (whose length and spacing parameters. we select the smoothed baseline for transect. Some transect are moved, changed, deleted or edited individually using standard Arc GIS editor toolbar (figure 4).

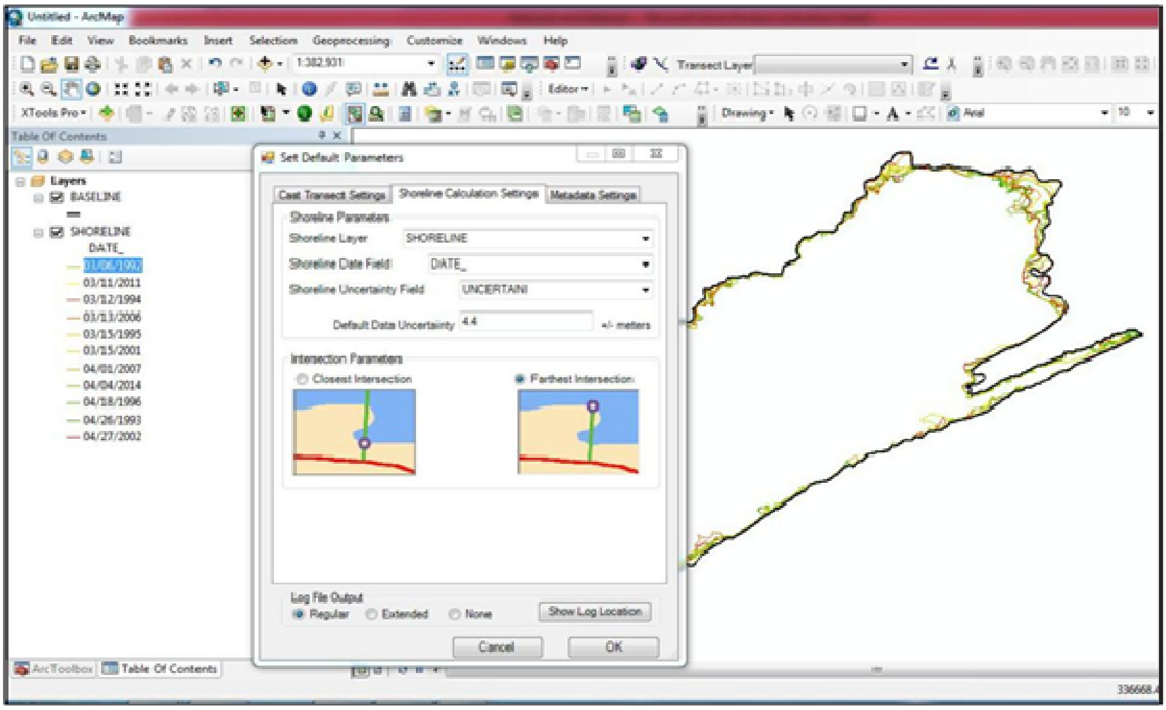

Figure 4. Shoreline Parameters

Figure 5. Transect map

A simple Linear Regression Rate and End Point Rate (EPR) have been adopted to take out the rate of change of shoreline and its future positions, based on empirical observations at 2383 transects along the Chilika Lagoon coast. It is found that the northern eastern part of Lagoon undergo high rates of shore line shift. For the prediction of future shoreline, the model has been validated with the present shoreline position (2014). The rate of shoreline movement calculated from the fixed base line to shoreline position of 1992, 1993, 1994, 1995, 1996, 2001, 2002, 2006, 2007 and 2011 and based on this, the estimated shoreline of 2014 was calculated (figure 5 and 6). The estimated shoreline was compared with the actual shoreline delineated from satellite imagery of 2013. The positional shift at each sample point is observed. The positional error varies from −206 m to 91 m. It has been found that model prediction error is higher in the left hand side of river Subarnarekha. Shoreline change rate using End Point Rate (EPR) Technique: The EPR is a method for estimating the per year rate of shoreline change. It is calculated by taking the difference between the first (closest) and last (farthest) shoreline to the baseline at a specific transect and dividing by the total number of years. In DSAS analysis, the EPR statistic is performed by dividing the distance of net shoreline movement (NSM) at transects) by the total period of interval elapsed between the oldest and most recent shorelines. The magnitude and cyclical trends of the EPR values represent the trend of erosion and accretion processes in the coastal zone. Shoreline change rate using Linear Regression Rate (LRR) Technique: The LRR is used to represent the trend of shoreline changes during the short-term periods. This is determined by fitting a least squares regression line to all shoreline points for a particular transects. The slope of the regression line is placed according to the sum of the squared residuals that calculated from the values of squaring the offset distance of each data point from the regression line and adding the squared residuals together (Dolan et al. 1991). However, the estimated values may be susceptible to outlier effects and the rate of change tends to underestimate the trend of shoreline changes during the period of observations (Morton, 1991).

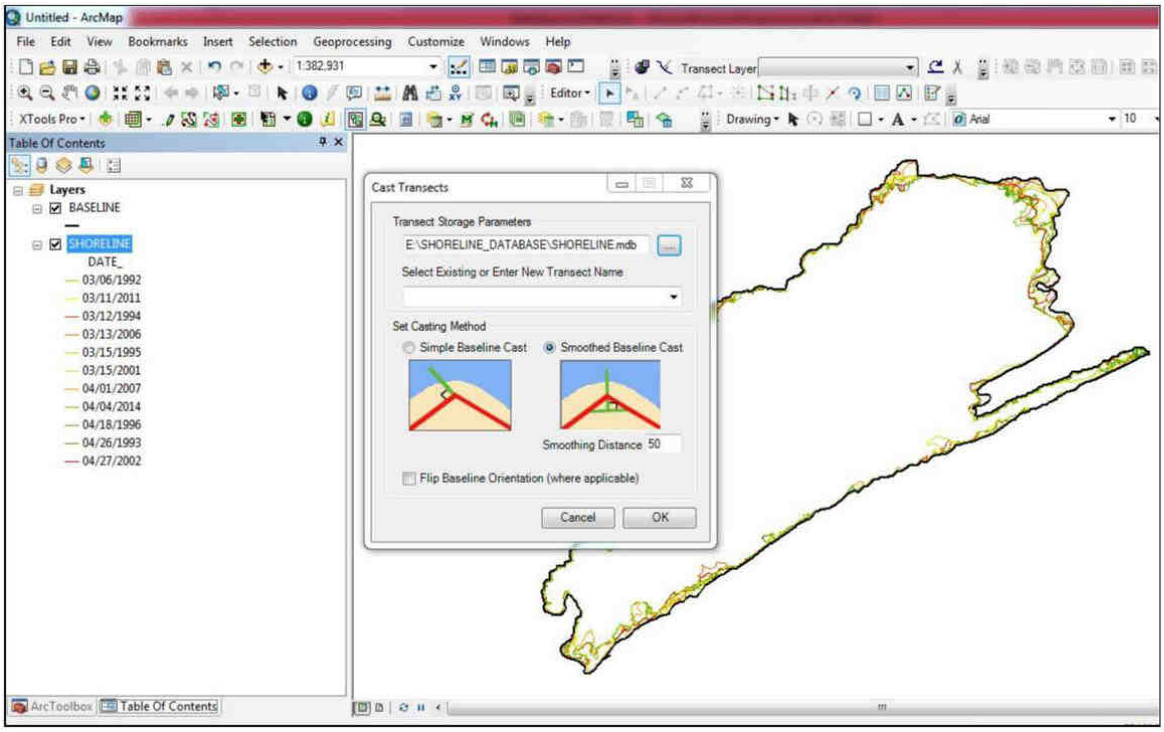

Figure 6. Cast Transect (Transect Storage Parameters)

Sr. No.	Rate of Shoreline Change	Shoreline Classification
1.	Below -10	Very High Risk
2.	-10 to -2	High Risk
3.	-2 to 2	No Risk
4.	2 to 10	Low Risk
5.	Above 10	Very low Risk

Table 1. Criteria used for the classification of shoreline change rate
Note: -negative values depict erosion and positive accretion

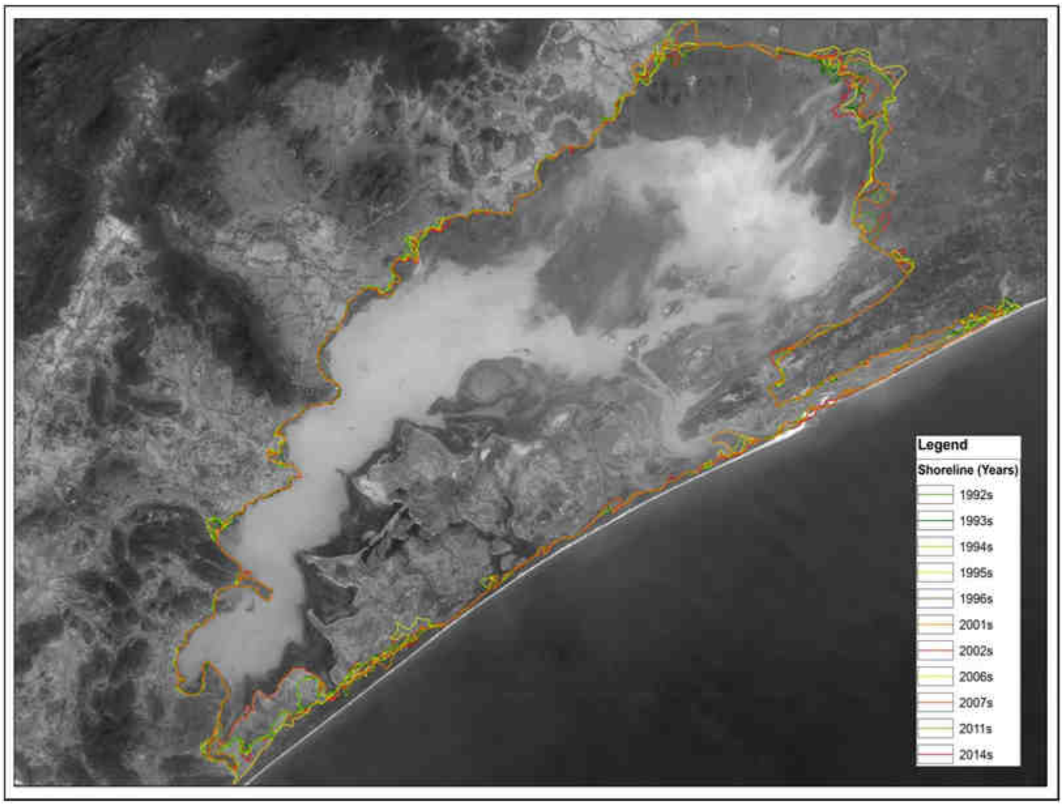

Figure 7. Showing Shoreline changes

Results of the study reveals that the maximum coast are stable , however the low to high erosion in the entire study area corresponds to 52.28 km length representing nearly 21% coast is under erosion. There is stretch just South west to the landfall point in Chatrapur district showing the more erosion and area just north of the landfall point showing more accretion (Figure.7 and Table.1).

SHORELINE CHANGE ANALYSIS USING THE EPR

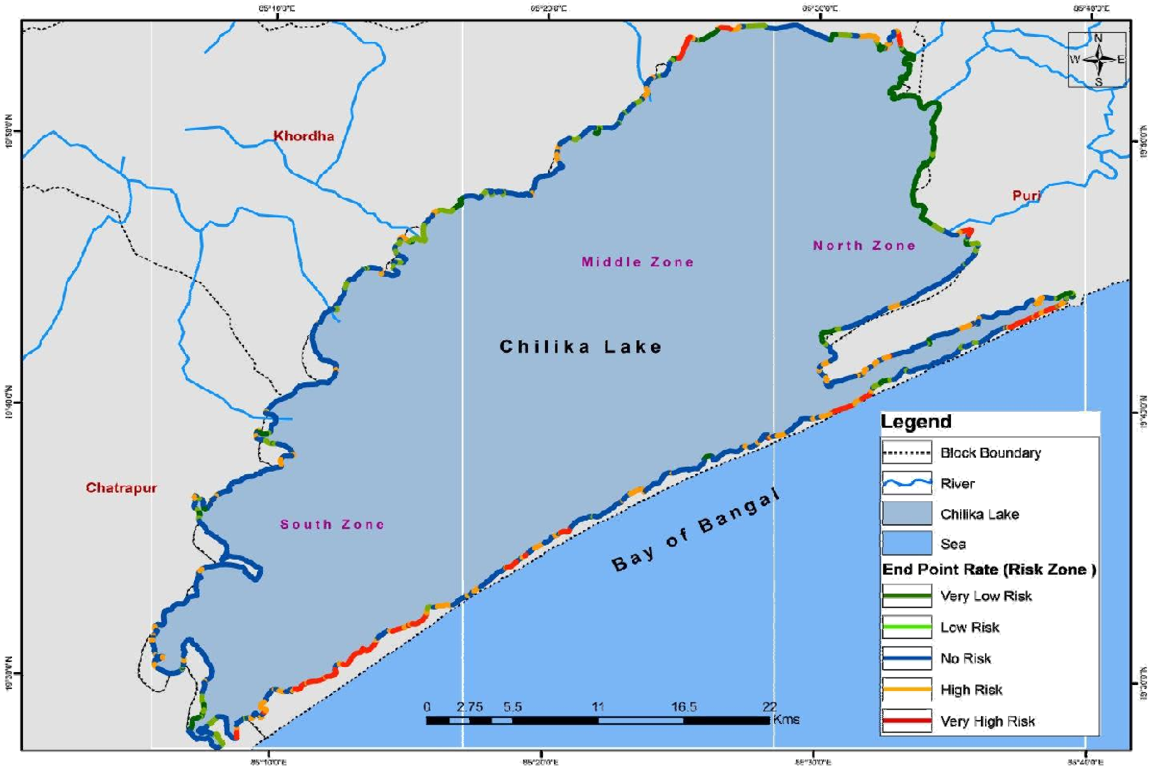

Figure 8. Map showing the shoreline change rate by EPR method

The shoreline change rate using the EPR method of the study area is shown in Figure 8. Results reveal the high erosion in the southeastern parts of the lagoon followed by the northeastern parts. The coast towards the seaward side is recorded comparatively higher erosion rates and put under high to very high shoreline change risk rate. This suggests the high dynamics along these coasts due to interplay of the marine and fluvial processes. The northern parts were also recorded high risk rates, this could be probably due to the morphology of the lagoon basin that converges the energy and impact in these parts of the coast. However, maximum erosion and accretion recorded by this EPR technique are 91 and 210 m/y respectively. The graph highlights the EPR in both positive and negative values which indicates accretion and erosion, respectively EPR result is showing that stable area is more than erosion / accretion. Further the shoreline change in different proximity were recorded and listed in Figure 8. The result shows very Low risk area is 13.0% and very high risk area is 8.5%. Majority of the coast with a length 158 km is under no risk constitutes 58% of the total coast. This study carried out also zone wise and here study area divided into three parts, (South, Middle and North) as shown in the Figure 9. The results of shoreline change EPR pertaining to different zones is being discussed in the following sections.

SHORELINE CHANGE IN DIFFERENT ZONES

South Zone: Results of the EPR in the south zone (Figure 10 A) shows Low risk area is 10.3% and high risk area is 10.1% near about same .Out of total area mostly in southern part are eroded and in north west part of this zone approximately stable and very less deposition in these area. Southern zone has covered more of total length. It is having 109.24 km out of 258.51 km.

Middle Zone: In middle zone the percentage of deposition is very less and it is showing (Figure 10 B) that it

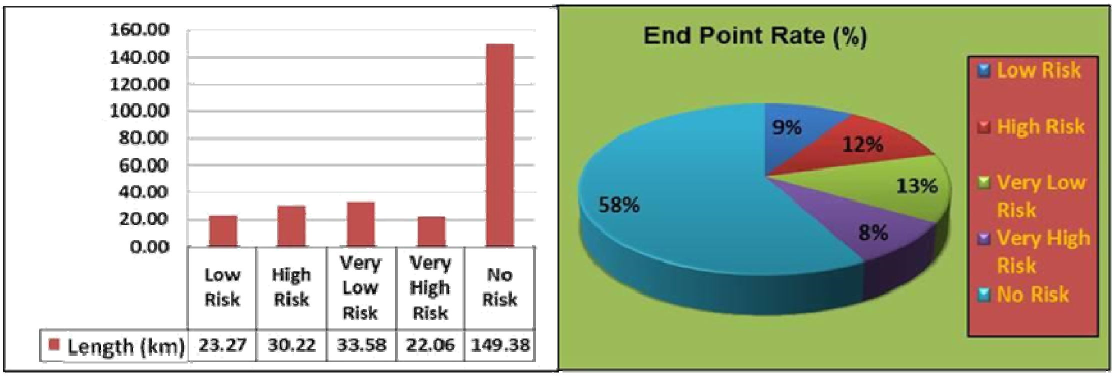

Figure 9. Bar-diagram and Phi-chart depicting the length and percentage of shoreline change classes recorded by EPR method

is very low risk area. But it is clearly visible most of the accretion area along with eroded area. If considered total eroded area (Risk area) is more than accretional area after no risk area. Middle zone having 54.68km out of 258.51km.This is approximately half of southern zone of Chilika Lagoon**.**

North Zone: The north zone lies in the east side of Lagoon. It shows clearly the periodically difference between two shore line of 1992 and 2014 due to accumulation. This zone have more changed zone in Chilika coast area. In northern zone erosion activities are almost occurred along with Bay of Bengal coast. Due to highest depositional activity than others zone, stable zone area is less than half of total area. (Figure 10 C).

LINEAR REGRESSION RATE (LRR)

The shoreline change rate calculated by LRR result using DSAS and corresponding map is presented as Figure 13.It determines a rate-of-change of shoreline position by fitting a least square regression to all temporal shorelines on a specific transect. Maximum erosion and accretion recorded by this LRR technique are 50 and 144 m/y respectively. The results of the shoreline change risk classes estimated by the LRR method reveal erosion sites along the southeastern parts of the study area. The erosion is also recorded along the northeastern parts as well. By enlarge the shorelines of the lagoon towards the sea are showing high erosion are at high risk. This is due to the same reason explained in the previous section i.e. high coastal dynamics towards the seawards side. Interestingly there are small stretches even towards west (landward side) are also recorded erosion with high risk rates. Whereas these areas recorded as low risk categories in the EPR technique. LRR result is also showing large variations in the shoreline change rate during 1992 to 2014. It is defined in given Figure 15 that highest area covered by very low risk zone (very high accretion) except stable zone. Further the statistics of shoreline change rate in different classes were recorded and listed in Figure 12. A total of 19% of the coast is under high to very high risk categories recording 12% and 7% respectively.

ZONE WISE LRR ANALYSIS

Study area has been divided into three zones viz: south, middle and north zones as shown in the Figure 11 for convenience of results discussion. The detailed results in these three zones are being discussed in the following sections.

South Zone: Result of the LRR shoreline change in south zone (Figure 12A) shows that Low risk area is 12% and high risk area is 12%.In southern zone approximately accretion is high. Accretion covered the north east and south west part of Lagoon of southern zone and the most of erosion movement occurred in west part of this zone. Very high risk class recorded 8% corresponds to a length of 8.75 km coast in the south zone.

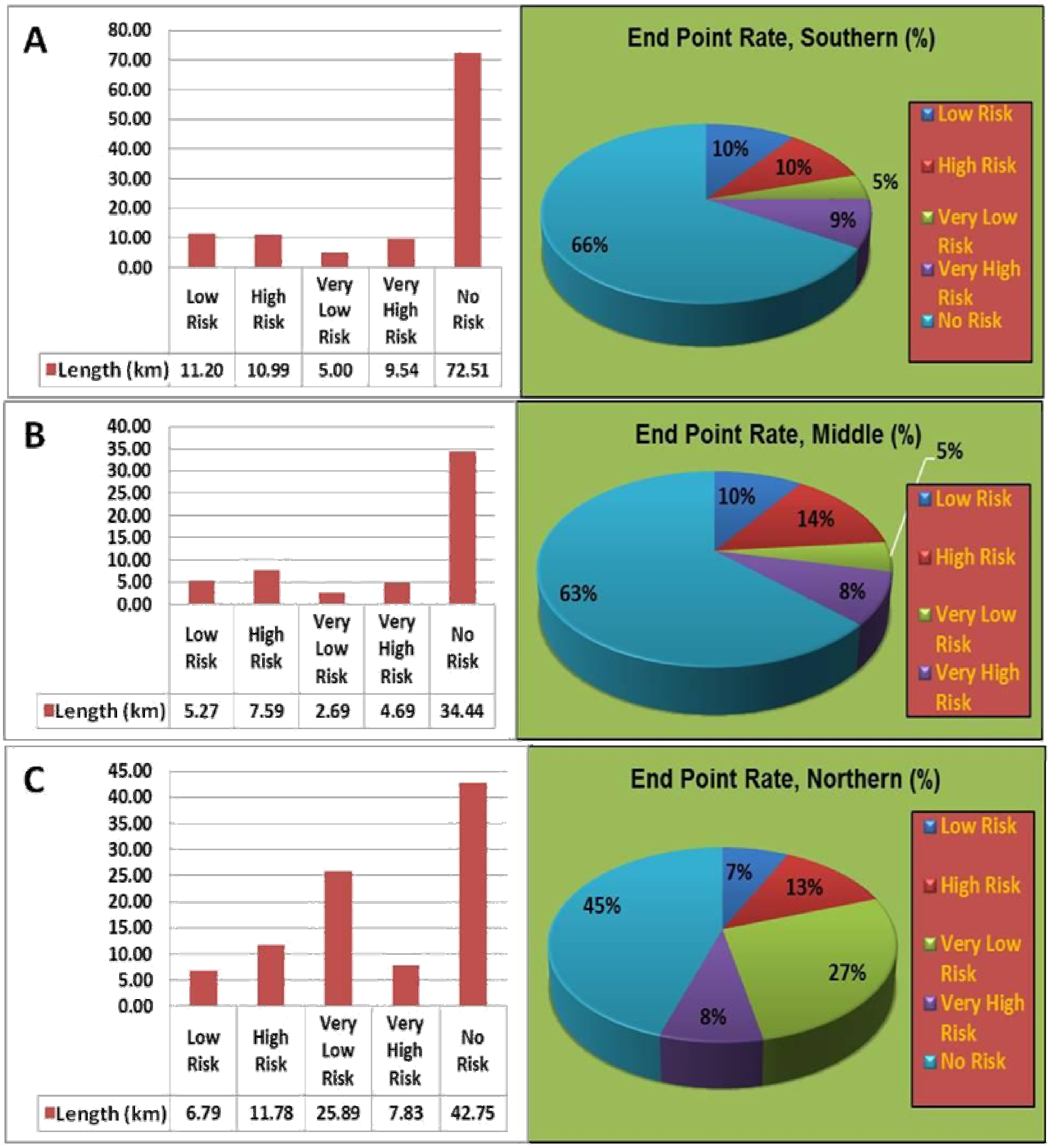

Figure 10. Bar-diagram and Phi-chart depicting the length and percentage of shoreline change classes in the three zones by EPR method

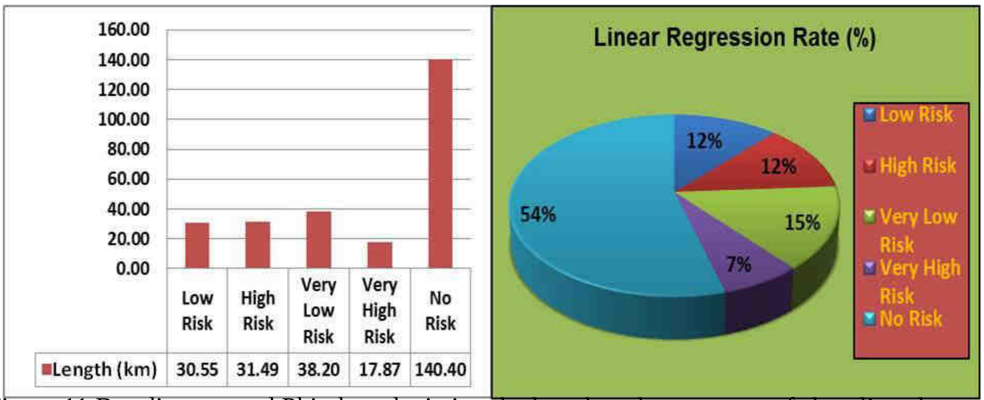

Figure 11 Bar-diagram and Phi-chart depicting the length and percentage of shoreline change classes recorded by LRR method

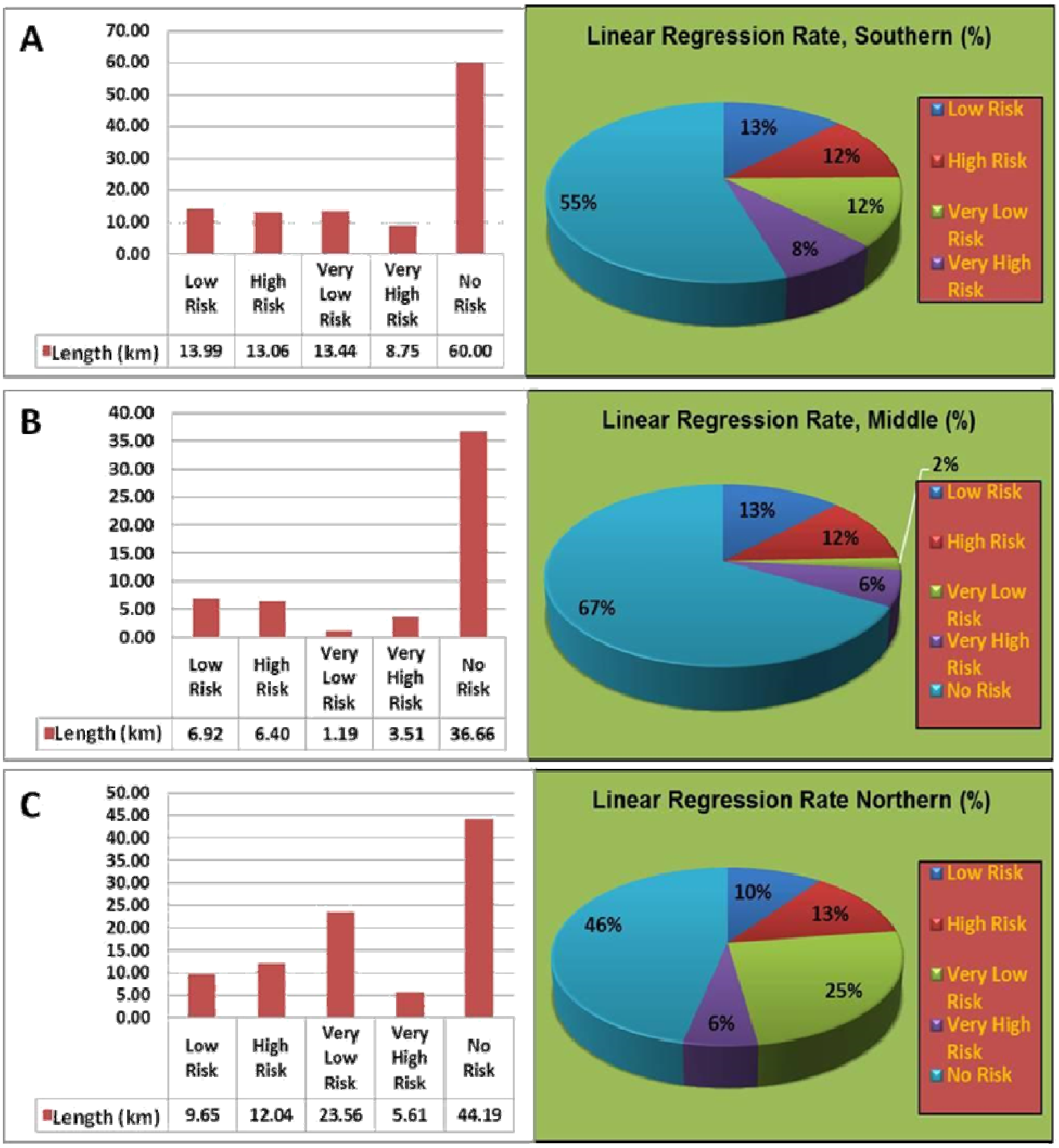

Figure 12 Bar-diagram and Phi-chart depicting the length and percentage of shoreline change classes in the three zones by LRR method

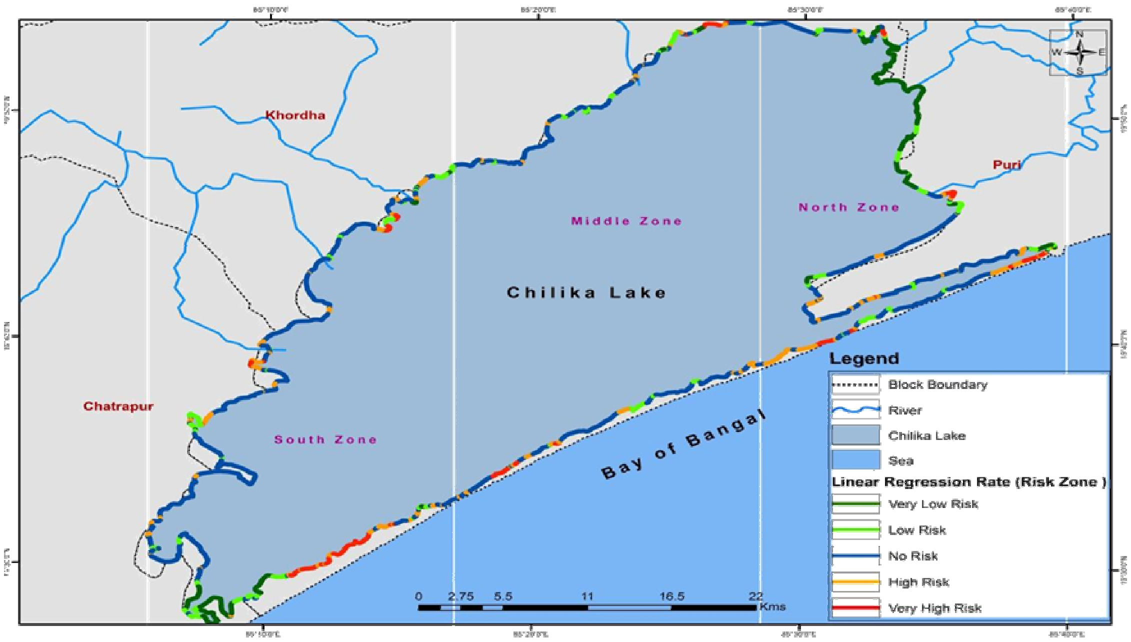

Figure 13. Map showing the shoreline change rate by LRR method

Middle Zone: Shoreline change based on LRR at middle zone (Figure 12 B) shows the less risk comparative to other two regions. High and very risk shoreline change rates recorded the length of coast 6.4 and 3.5 km respectively. The major category is no risk corresponds to 36.6 km.

North Zone: change based on LRR at middle zone (Figure 12 C) recorded the 19% of coasts in this zone arte in high to very high risk rates of erosion. The dominant category in this region is no risk zone followed by very low risk zone. The overall zonal analysis of shoreline change using the LRR technique reveals the maximum erosion in the south zone and followed by north zone.

Conclusions

Current study of the shoreline change in the Chilika Lagoon using the Landsat data pertaining to 1992-2014 is focus on the shoreline trend. Chilika Lagoon recorded the larger shoreline morphology dynamics in the southern parts compared to the other parts. The shorelines in towards seaward side reveal the larger changes indicate the dynamic marine-fluvial dynamics are stronger in this region. The study further envisages the comparison of the results of the shoreline change rates carried out using EPR and LRR techniques of DSAS. The results of the both the techniques reveal almost similar results except the slight variations in the range of change intensity. The range of recorded by the EPR was -91 to 210 m/y, whereas the LRR recorded -50 to 144 m/y. EPR considers the nearest and farthest shorelines from the baseline and based on the net displacement of the shoreline the rate will be estimated. A linear regression rate-of-change statistic can be determined by fitting a least squares regression line to all shoreline points for a particular transect. The rate is the slope of the line. The linear regression method is susceptible to outlier effects, and also tends to underestimate the rate of change relative to other statistics, such as EPR. The same results were also depicted in present study with underestimated values by LRR compare to EPR. Hence the EPR is the better option for the calculation of the net shoreline trend for the longer period data. The study of the shoreline change dynamics using the historical Landsat data pertaining to 1992-2014 based on geospatial techniques reveals the variations in the shoreline dynamics. This was recorded as the shoreline change rate in the current study. The comparative study of the shoreline change studies carried out using the EPR and LRR techniques of the DSAS reveals the underestimating of LRR values. This was confirming the already published literatures. Hence it is being concluded to use the EPR technique for the long-term shoreline studies to estimate the shoreline change dynamics and its trends. The data and geospatial techniques used in the current study are feasible in understanding the shoreline change dynamics in the Chilika Lagoon. The study can be further enhanced using the higher resolution data pertaining to the longer period. The results of the current study are highly useful for the Chilika Lake Development Authority for the better management. These results can further provide inputs for the coastal management authority, policy, academia and etc. Remote Sensing and Geographical data system (GIS) techniques are wide utilized in varied coastal morph-dynamic studies as they're price effective, cut back manual error and are helpful within the absence of field surveys. The applications of remote sensing and GIS have evidenced significantly effective in delineation of coastal morphology and coastal landforms, detection of boundary positions. Remote sensing satellites pictures are used effectively for coastal boundary amendment watching on the coast. The approach portrayed here gives valuable data about shoreline of Chilika Lagoon to look at the first wellsprings of shoreline information (Satellite Images) to assess both the utility of various shoreline intermediaries (Geomorphic Features, Tidal Data,) and the vulnerability related with every strategy, to create and actualize enhanced techniques for surveying and checking shoreline development to acquire a superior comprehension of the procedures controlling shoreline development to build up an intelligent GIS database with the reported seaside data and to go into key organizations to encourage information dispersal. Observing changes in shoreline recognizes the nature and procedures that caused these adjustments in a particular zone, to evaluate the human effect and to design administration techniques.

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