Impact of Marine Sand Mining on Coastal Morphology: A Case Study on Alappad Coast, Kerala

K. K. Basheer Ahammed[1*], Arvind Chandra Pandey[1]
Department of Geo-Informatics, Central University of Jharkhand, Ranchi, Jharkhand 835 205
*basheer.kk@yahoo.com

Abstract

The modern world witnessed an increasing trend of mining on the onshore sand deposits, including beaches for extracting minerals. Sand mining in the Alappad coast started in late 1960, which is blessed with titanium ores. Since then, the area becomes eroded by the overexploitation of the marine resource. The present study conducted shoreline change analysis within the 16 km of the coastline between Alappad and Chavara, where mining takes place. The study observed that among the 671 ha coastal area, 85 hectares of land was dug out from the Alappad beach. Whereas, the highest rate of erosion was observed between 2001 and 2012, around 42.81 hector land area eroded. The present study canvassed the horrible change experienced in the study area. The study will give a benchmark to the policymakers who are still between the decisions.

Keyword: Alappad; Marine Sand Mining; Shoreline Change; Remote Sensing; GIS

Introduction

Complex and diverse types of marine sand mining processes that occur on the sensitive coastal zones bring in physical, chemical, and biological changes to the fragile coastlines. The western coast of India is undergone higher erosion by on several human interventions [1], [2]. Overexploitation of the marine resources is not suitable for the dynamic coast, and the significant change resulted in the coastline during the past decades. Climate change and an increasing trend of sea level will lead to permanent inundation in the low laying area [3]. The mining zone will be the first in the list of potential climate change affected the region as the marine sand mining process washed off the top layer sands and by that, the topography will change accordingly. Remote sensing and geospatial applications are widely used for land cover mapping, environmental impact assessment, ecosystem services, and monitoring of mining activities [4]. Different from conventional survey techniques, remote sensing techniques are cost-effective, robust and reliable.

Methodology

The present study conducted along the sand mining region between Alappad and Chavara, which is lying within the coastal regulation zone (Figure 1). The area lays between 8°58'52.318" to 9°2'7.064" north latitude and 76°30'26.723" to 76°32'3.689" east longitude. Alappad and Chavara are coastal villages situated in the Karunagapalli taluk. Coastlines of these villages have been extremely utilized for marine sand mining since 1965 by various mining agencies. Most of the study area exhibit low elevated topography within the relief of 0 to 10 meter depicts highly sensitive to marine sand mining and seawater intrusion. The present study carried out in the 671 hectors laying 16 km long coastline and within the 1 km buffer zone.

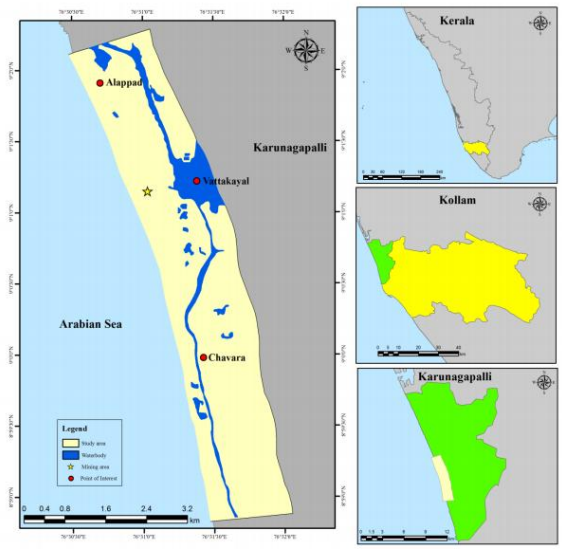

Figure 1 Study area

This study delineates the rate of shoreline changes between 1973 and 2019 using Landsat and Sentinel satellite images. After the geometric correction and image enhancements, shoreline corresponding to a particular period (1973, 1988, 1997, 2001, 2012, and 2019) was generated using the on-screen point mode digitization technique by using standard False Color Composite using blue, green and near infra-red bands to separate land-water boundary distinctly. The rate of shoreline change was calculated by End Point Rate statistical tool provided by mining onDigital Shoreline Analysis System and the area calculated by the geospatial tool.

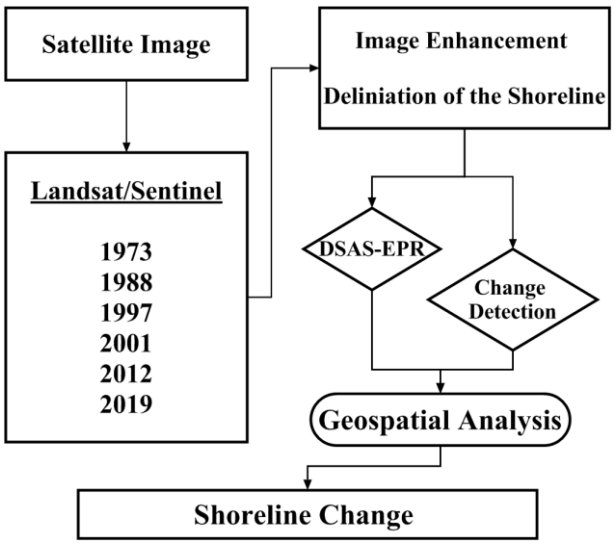

Figure 2 Schematic representation of the methodology

Results and Discussion

The study observed significant changes in the coastline. During the period 1973 to 1988, the highest erosion rate was -6.97 whereas, in the period 198-1997, shoreline

change rate was recorded -6.66 meter. However, post-1997, the rate of erosion is increased rapidly, from 1997 to 2001; around -11.86 meter per year shoreline gets eroded. Since 2001, mining activity reached its peak, and shoreline gets eroded with -21.04 meter per year during 2001-2012 and -21.22 meter/year during 2012-2019 (Figure 3, Table 1).

Table 1 Historical shoreline change rate calculated by the EPR statistical tool (unit: meter)

	1973-88	1988-97	1997-01	2001-12	2012-19
Transect	68	68	68	68	68
Transect Interval	100	100	100	100	100
High Erosion	-6.97	-6.6	-11.86	-21.04	-21.22
High Accretion	1.59	2.72	5.69	2.22	10.43
Mean	-2.43	-0.48	-2.47	-5.96	-2.03
SD	2.34	2.29	4.05	6.24	4.64

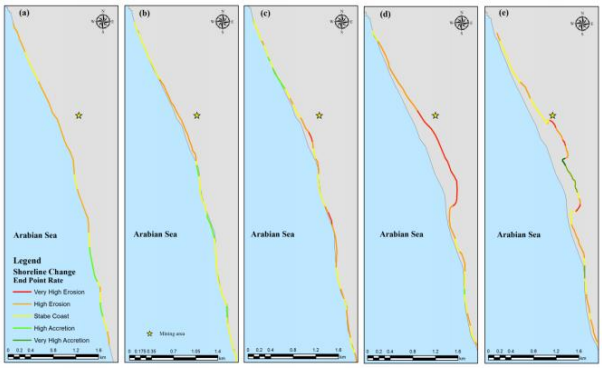

Figure 3 Shoreline Change rate during the Period 1973 to 2019 using EPR: a) 1973-1988, b) 1988-1997, c) 1997-2001, d) 2001-2012, and e) 2012-2019

In terms of areal extension, a total 96.16 ha land area got erosion, and 10.84 ha area got accretion from 1973 to 2019. A higher rate of accretion was observed during the period 2001-2012, with 42.81 ha land area got erosion within the 10 years (Figure 4, Table 2). The study observed that the trend of the shoreline during the period and revealed that the erosion rate was rapidly increased since 1977, whereas accretion is stable during the period. (Figure 5)

Table 2 areal extension of the shoreline changes between 1973 -2019 (in hector)

Year		Erosion					
		1973	**1988**	**1997**	**2001**	**2012**	**2019**
Accretion	**1973**		25.82	28.11	33.74	71.72	85.33
	1988	1.57		6.58	10.59	51.88	61.08
	1997	2.13	3.74		8.2	49.04	58.24
	2001	1.06	1.75	1.35		42.81	51.84
	2012	8.55	0.078	0.032	0.62		12.75
	2019	0	0	0	0.44	3.55	

Conclusion

Increases in levels of developmental activities are putting the coastal communities into the critical stage, over and over again lead to communities that depend on the fishing and allied activities, therefore making sustainable development an essential consideration for the coastal community. The need for economic and ecological balance has never been greater, with growing pressure to protect ecosystem services and resource while allowing development needed for economic health and natural resource management.

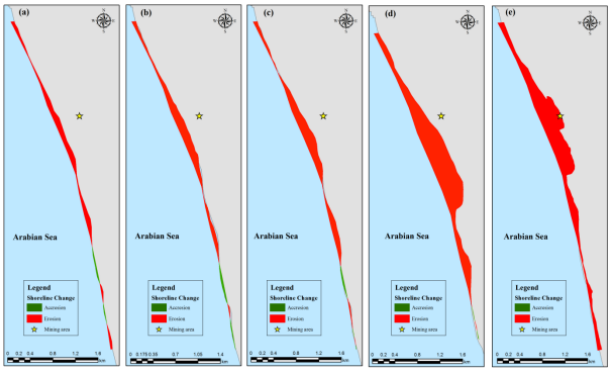

Figure 4 Spatial distribution of the erosion and accretion landforms a) 1973-1988 b) 1973-1997 c) 1973-2001 d) 1973-2012 and e) 1973-2019

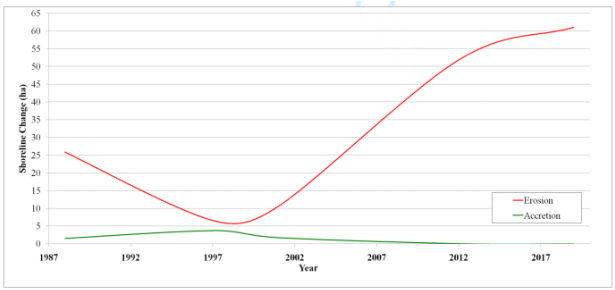

Figure 5 Trend of the Shoreline Change between 1973 and 2019

Since 1973, around 3.90 hector beach was dug out in annual average; the coastal community of the Alappad coast is in the mainstream to protect their homeland from the mining authorities. The use of remote sensing data and geospatial application will provide a quantitative assessment of the shoreline dynamic and land use pattern. The result of the present study may serve as baseline information for the decision-makers and government authorities for the sustainable.

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