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इतिहासाचार्य वि. का. राजवाडे मंडळ, धुळे
या संस्थेचे त्रैमासिक

।। संशोधक।।

पुरवणी अंक १४ – मार्च २०२४ (त्रैमासिक)

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- **वर्ष : ९२**
- **पुरवणी अंक : १४**

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श्री. संजय मुंदडा

कार्याध्यक्ष, इ. वि. का. राजवाडे संशोधन मंडळ, धुळे ४२४००१
दूरध्वनी (०२५६२) २३३८४८, ९४२२२८९४७१, ९४०४५७७०२०
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कार्यालयीन वेळ

सकाळी ९.३० ते १.००, सायंकाळी ४.३० ते ८.०० (रविवारी सुट्टी)

अंक मूल्य रु. १००/–
वार्षिक वर्गणी (फक्त अंक) रु. ५००/–, लेख सदस्यता वर्गणी : रु. २५००/–

विशेष सूचना : संशोधक त्रैमासिकाची वर्गणी चेक/ड्राफ्टने
'संशोधक त्रैमासिक राजवाडे मंडळ, धुळे' या नावाने पाठवावी.

अक्षरजुळणी : सौ. सीमा शिंत्रे, पुणे.

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Geospatial Approach for Vulnerability Assessment of Sindhudurag Coast, Maharashtra

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ABSTRACT:

One of the prediction methods for classifying coastlines that takes into account a variety of coastal factors is the Coastal Vulnerability Index (CVI). Because it makes a lot of complicated parameters simpler, this method is preferred in the coastal inquiry. The development of this evaluation was motivated by three main factors, though: a) managing coastal conditions in the present; b) categorizing possible shoreline reactions to future sea-level rise; and c) managing data storage. Index development is a contemporary approach in coastal study that is influenced by a wide variety of factors and is used to determine the susceptibility of the coast. . Due to the extensive use of modern technologies, environmental risk assessment and coastal vulnerability calculations increasingly take into account the favorable coastal component. This paper provides a detailed discussion of a step-by-step method to CVI development. Coastal communities will ultimately receive assistance from CVI in offering suggestions for the reduction of coastal concerns in future development.

INTRODUCTION :

Maintaining coastal processes is vital because they offer ecosystem services that are considered critical to human well-being and are distinguished by significant ecological and natural value (MEA, 2005; Ramieri et al., 2011). The interactions between the coastal ecology and a large variety of frequently conflicting human activities are already intensifying in the coastal zone. Sea level rise and climate change are also causing stress in coastal areas, which have historically been negatively impacted by significant human activity. According to Din et al. (2019), natural coastal systems may be impacted by a negligible rise in sea level. The coastal property zone, where the majority of people would be residing in the near future of 2040, is particularly affected by the increase, which might reach up to 1 meter in 2100 (Hamid et al., 2018). Vulnerabilities associated with the various coastal states of India are being studied in recent times. The concept of Coastal Hazard Wheel (CHW) framework for the complete coast of the Sindhudurg, their framework had lacuna of the socioeconomic variables for the assessment. The present study attempts to assess vulnerability of the coastal Sindhudurg for various hazards by combining physical, geological, and socio-economical variables using techniques of remote sensing and GIS.

STUDY AREA :

Sindhudurg district is the southern part of coastal area that is known as the Konkan.

Sindhudurg district situated between 15º 37' North latitude to 16 º 40' North latitudes and 73 º 19' east longitude to 74º 13' East longitudes. It is bordered by Ratnagiri district on the north, Arabian sea on the west, Goa state on the south by Belgaum district of Karnataka state and Sindhudurg district on the east also. Total area of the district is 5087 km^2. Sindhudurg district has a coastline about 121 km. Physiographical Sindhudurg district has also divided into three sections that is Khilati, walati and Sahyadri hills region and respectively. The coastal trip of the coastal area called khalati and walati having a width of 20 to 25 km. respectively and also shows with beaches, shores, creeks and mud flats in the seashore. All three sections are north to south direction. Sindhudurg district has 8,48,868 (Male-4,16,695, Female-4,32,173) population as per 2011 census. Mean monthly minimum temperature near about 16^0 C. and mean monthly maximum temperature is about 33^0 C in the study area. Annual rainfall range is 2500 mm to 3500 mm.

OBJECTIVES :

1. To identify vulnerable coastal sites of the study region.
2. To formulate some remedies for dynamic coast for the study region.

DATA BASE :

The study of coastal analysis is also connected with changes is carried out by using various sources. The present study is based upon both primary and secondary sources of data. The primary data is collected through field survey and questionnaire method and secondary data is collected from various sources.

The secondary data is collected from various sources i.e. Survey of India, Census of India, Statistical abstracts of Sindhudurg district, Socio-economic reviews, Town Planning Department, etc.Satellite images are used in many applications like environmental conservation, agriculture, forestry conservation, biodiversity conservation, regional planning, education, urban studies, etc. The development in the field of remote sensing is producing high resolution data and temporal data for users.

METHODOLOGY

The present study adopts the CVI methodology formulated by Thieler and Hammer-Klose. Initially a database of the variables under consideration for the study area was built by compiling data from various sources. The data values of variables under consideration were assigned a vulnerability ranking based on value ranges contributing to coastal vulnerability, while the non-numerical geomorphology variable was ranked qualitatively according to the relative resistance of a given landform to erosion. Later, the key variables were integrated to a single index and categorized based on the relative intensity of risk it imparts to the coast, namely, very low, low, medium, high, and very high. A grid template of 1.5 km by 1.5 km was used to store and analyze data and display the CVI. The variation of each variable within the area was analyzed and suitable risk ratings were awarded for each specific data variable and the coastal vulnerability index was calculated.

CALCULATION OF CVI :

Once each section of coastline is assigned a risk value for each variable, the CVI is calculated as the square root of the product of the ranked variables divided by the total number of variables. The CVI is represented by where a = risk rating assigned to sea level change rate, b = risk rating assigned to shoreline change rate, c = risk rating assigned to coastal slope, d = risk rating assigned to coastal regional elevation, e = risk rating assigned to tidal range, f = risk rating assigned to significant wave height, and g = risk rating assigned to population density.

$$CVI = \frac{\sqrt{a * b * c * d * e * f * g}}{7}$$

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RESULTS AND DISCUSSION :

Relative Sea Level Change Rate. For the available data, it was observed that sea level was falling at a rate of 1.3 mm per year at the Tarkarli station while it was rising at a rate of 0.8 mm per year at the Malvan station as shown respectively. The sea level along the Indian coast has increased at a rate varying between 1.06 and 1.75 mm per year during the period 1960 to 2020, depending on the tide gauge recording site, with an estimated regional average of 1.29 mm per year, subsequent to a global is static adjustment correction. Hence, the study area is considered to be less vulnerable to sea level rise and lowest ranking of 1 was awarded for the entire coast.

Coastal Slope. The regional coastal slope was calculated for a distance of 6 km (3 km each from shoreline on sea and landside) perpendicular to the shoreline at an interval of 1.5 km. A slope greater than 0.6% is assigned low vulnerability and less than 0.3% is assigned high vulnerability.

Regional Elevation. The mean regional elevation within study area varied between 0.69 m in Malvanand 78.94 min Tarkarli. An elevation value greater than 40 m is assigned low vulnerability and less than 10 m is assigned high vulnerability as shown.

Shoreline Change Rate. The shoreline change rate in the study area was calculated. The revealed that about 4.09 km of coastline had a very high-risk rating along the coastal stretch of southern Malvan. About 14.25 km of coastline was of high risk rating, along the coastal stretches near southern parts of Malvan, Devbag, and Chivala and also in Achra.

Table No. 1: Average Wave height for different Places

Sr, No,	Location	Wave height (m)
1	Tarkarli	1.3
2	Malvan	0.7
3	Devgad	1.12
4	Chivala	1.00
5	Achra	1.9

Source – Field Survey -2022

Table No. 5.2: Tidal range for various Places

Sr, No,	Location	Tidal Range (m)
1	Tarkarli	1.4
2	Malvan	1.5
3	Devgad	1.8
4	Chivala	1.9
5	Achra	1.6

Source – Field Survey -2022

COASTAL VULNERABILITY INDEX (CVI) :

Coastal vulnerability index map for the Sindhudurg Coast is shown in Figure 5. The calculated CVI values range from 1.73 to 18.97. Table 5 details the CVI for each taluk with statistical parameters. The mean, mode, and median CVI values are 6.52, 7.34, and 6.92, respectively. The standard deviation is 2.21. The CVI scores are divided into low, moderate, high, and very high vulnerability categories based on the quartile ranges. The 25th, 50th, and 75th percentiles are 4.90, 6.92, and 7.35, respectively. The lower range of CVI values indicates low risk, followed by moderate risk, high risk, and finally the upper range of values indicating the coastal stretches having very high risk.

Table No. 5.3: Ranges of variables for vulnerability ranking.

	Ranking of vulnerability				
Variables	**1**	**2**	**3**	**4**	**5**
Coastal slope (%)	>0.60	0.5-0.6	0.4-0.5	0.3-0.4	<0.30
Mean tide range (m)	<1.0	1.0-2.0	2.0-3.0	3.0-4.0	>4.0
Regional elevation(m)	<10	10-20	20-30	30-40	>40
Shoreline change rate(m yr-1)	>+2.0	+1.0 to +2.0	-1.0 to +1.0	-2.0 to -1.0	<-2.0
Average wave height(m)	<0.7	0.7-1.4	1.4-2.1	2.1-2.8	>2.8
Population (person per 200 m^2)	<19	44-20	80-45	326-81	>326

Source- Risk category formed by Pendleton

The present study is an attempt to categorize the coast of Sindhudurg according to its coastal vulnerabilities. The variables under consideration are sea level change, coastal slope, regional elevation, tidal range, significant wave height, and population density. A total of 298 km of shoreline are ranked in the study. About 68.65 km of the shoreline is very highly vulnerable category and 79.26 km of shoreline is highly vulnerable category of the remaining shoreline, 59.14 km and 91.04 km are of moderate and low vulnerable categories, respectively

Map: Vulnerable Sites :

Table 5 shows variation of CVI for each *location*. The coasts of Malvan fall under high risk category and all other places are under moderate risk. The CVI in the present study was primarily influenced by the risk ranking of the shoreline change rate, population, and the coastal slope. It was observed that coasts of Malvan, Chivala, and Achra were under erosion with an average value of 0.21, 0.13, and 0.14 m per year, respectively, while for another Places accretion

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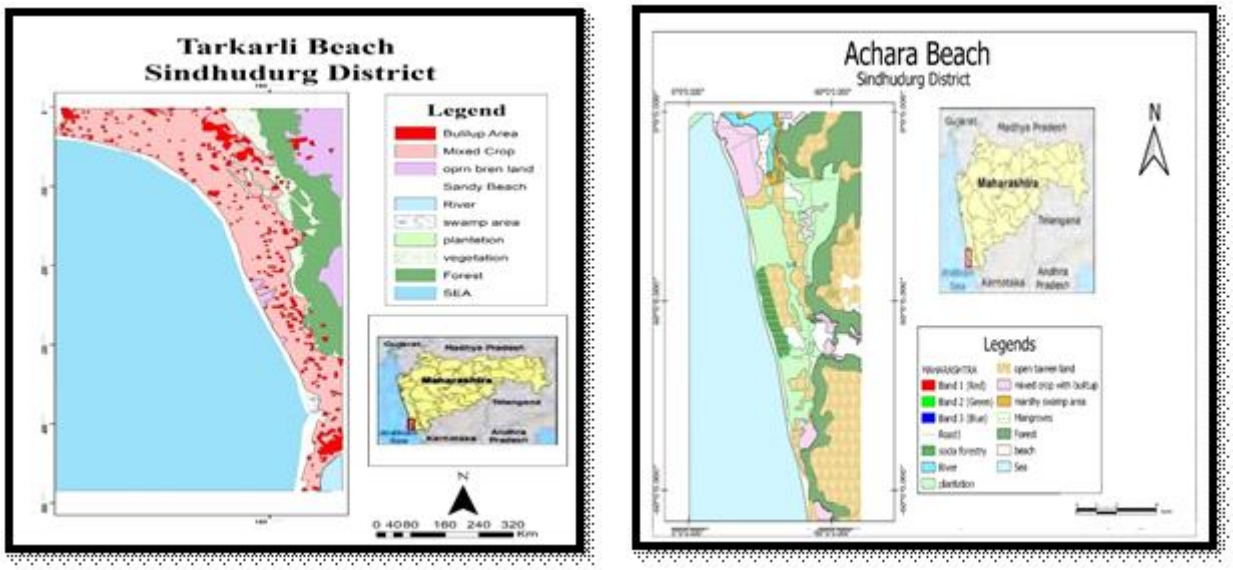
Table No.5.4: CVI For Location

Location	Max.	Min.	Average	Sd
Tarkarli	9.48	3.67	6.28	1.87
Malvan	7.34	3.67	5.20	1.46
Devgad	7.74	1.73	5.34	1.65
Chivala	8.00	2.44	5.89	1.21
Achra	9.79	6.00	7.78	2.41

Source – Field Survey -2022

Map: Vulnerable Sites



was observed. The sensitivity of the CVI to the socioeconomic variable "population" was examined and it was found that CVI significantly decreased in the *talukas* of Malvan and Tarkarli, on omission of variable and on a relative basis. The coastal slope was observed to be steep in beaches, that is, in Devgad, and Chivala, while Devbag,, and Malvanhad mild slope topography. This was primarily because in Tarkarli, and Chivala we find the headlands and cliffs very close to the coast and southern beaches have more open beaches.

CONCLUSION :

In the view of the rising sea levels and other coastal hazards, an assessment of coast for its vulnerability to these threats is necessary in order to take suitable actions to protect the people and property. Sindhudurg district has 121 km sea coast length. It was observed that 20 km of the shoreline of the study area was under very highly vulnerable category and 15 km of shoreline is highly vulnerable category while 26 km and 40 km of coast are of moderate and low vulnerable categories, respectively. Present study also

evaluated the transformation of the Sindhudurg coastline using Landsat satellite images. We have observed that, most populated and tourist location like, Tarkarli, Malavan, Chivala, Devabg and Acahra beaches are presented with vulnerable situation. The CVI developed in the present study provides an understanding about the vulnerability of the Sindhudurg Coast to erosion, coastal flooding, and relative sea level change and as well as facilitates policy options for coastal planners and authorities with regard to prioritizing coastal areas for mitigation.

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