

Ranking of Two Tourists Beaches of Kerala based on Coastal Vulnerability Index Using AHP

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Abstract - Coastal areas are one of the key systems for global sustainability. Coastal vulnerability assessment methods were developed for the identification and management of vulnerable areas above the coast. In this review, we have focused on various vulnerabilities on coastal areas of India and one of the assessment methods, the Coastal Vulnerability Index methodology, which is used in India. In this article, we discuss the Analytic Hierarchy Process (AHP) to find the coastal vulnerability index of tourist beaches in Kerala.

Keywords— *Coastal vulnerability index, Analytical Hierarchy Process*

I. INTRODUCTION

Beaches along the 580 km long coastline of Kerala are facing erosion during the southwest monsoon months from May to September and minor erosion during the northeast monsoon in December and January. During this time a high energy storm waves drag sediment and soil away from the shore. Article discusses the consequences of climate change and sea level rise on coastal cities already anthropologically facing emphasizes. The objective of coastal indices is classification shorelines into single entities to create a healthy coastline management principles. A vulnerability assessment is an estimate of the degree of loss or damage that might result from a hazardous event of given severity, including damage structures, personal injury and economic disruption activities and normal functions of the headquarters.

Our study areas which include CHERAI BEACH (which lies about 24 km from Ernakulam industrial area and to side of Vypeen Island), SNEHATHEERAM BEACH (which is located in Trissur district and lies on the Arabian Sea), KOZHIKODE BEACH (which is on the western side Kozhikode, located on the Malabar Coast of India), BEYPORE BEACH (which lies between the Arabian Sea and the Chaliyar River located at

Chaliyar, Kozhikode). Major problems faced by coastal beaches in Kerala includes extreme natural events such as hurricanes, coastal storms, tsunamis and landslides as well as long-term risks coastal erosion and sea level rise

II. OBJECTIVES

- To rank the collected parameters (Coastal slope , Geomorphology, Shoreline change, Sea_level change, Significant wave height, Tidal range) using Analytical Hierarchy Process and to obtain the coastal vulnerability index of beaches and identify its vulnerability.
- The project aims to assess the vulnerability of tourist beaches in Kerala to coastal factors, utilizing the Analytical Hierarchy Process (AHP). Tasks include literature review, data collection (topography, climate, erosion rates), AHP model development. The project seeks to provide valuable insights for sustainable coastal management and development.

III. METHODOLOGY

Methodology employed is Analytic hierarchy process (AHP)

3.1 COASTAL PARAMETER STUDIES

Coastal slope:

Coastal slope refers to the slope or slope of the land along a coastline. Describes the change in altitude as you move from the coast inland. Coastal slopes may vary in steepness and may be affected by factors such as type of rock or sediment present, erosional processes and tectonic activity.

Sea level Change:

Sea level change refers to the long-term change in the average height of Earth's oceans and is primarily caused by two factors: thermal expansion and melting of ice on land. Thermal expansion occurs

when ocean water heats up, causing it to expand and take up more space, leading to sea level rise. This is primarily driven by global warming and increasing greenhouse gas emissions..

Geomorphology:

Geomorphology of coastal beaches refers to the study origin, development and characteristics of the beach landscape. It involves understanding the processes that shape and change beaches over time. Coastal beaches are dynamic an environment influenced by various factors, including waves, tides, currents, sediment supply, and coastal landforms. These factors interact to create distinct beach features and landforms..

Significant Wave Height

A significant wave height refers to a statistical measurement used to describe the average height of the tallest one-third waves in a given wave system. It is commonly used parameter in oceanography and wave forecasting. On determine a significant wave height, a large number are individual wave heights in a certain period of time measured.

Tidal Range

Tidal range refers to the difference in height between high tides in the locality. It's a scale the vertical distance the water level rises and falls as a result gravitational forces of the Moon and the Sun. Tidal range can vary significantly depending on several factors, including location, alignment of the Earth, Moon and Sun and local geography.

Shoreline Change

A change of banks refers to a change in position or the configuration of the boundary between land and water, known like the coast. It is a natural process that occurs over time due to various factors including erosion, sediment deposition, sea level rise and human activities. Erosion is one of the main causes of coastline change. This includes carrying away from land by waves, currents and wind. Erosion can result in gradual shoreline retreat, leading to loss of coastal land. Sediments deposition, on on the other hand, it can cause shoreline accretion or expansion.

3.2 RANKING USING ANALYTIC HIERARCHY PROCESS(AHP)

Analytic Hierarchy Process (AHP) is decision making framework developed by Thomas Saaty in the 1970s. Provides a a structured approach to evaluating and prioritizing different criteria and alternatives in complex decision problems. AHP breaks down decision-making into a hierarchical structure consisting of a goal, criteria, sub-criteria and alternatives. It uses pairwise comparisons and mathematical calculations to determine the relative importance or weights of criteria and alternatives.

3.3 IDENTIFYING VULNERABILITY USING COASTAL VULNERABILITY INDEX

V. Gornitz, 1990 proposed a commonly used statistical model for calculating physical CVI. The first step in calculating the CVI is identify the relevant characteristics that determine the risk associated with the coast. The CVI is derived as the square root of the product of the ranking variables divided by the total number of variables after each stretch of coastline has been assigned a rank for each variable. (Pendleton et al., (2004), 1991; V.M. Gornitz et al., 1994).

$$CVI = \sqrt{(a*b*c*d*e*f) / 6}$$

- a = weight of tidal range
- b = weight of significant wave height
- c = weight of sea level
- d = weight of shore line change
- e = weight of geomorphology
- f = weight of coastal slope

IV. DATA COLLECTED FROM STUDY AREAS

KOZHIKODE BEACH

PARAMETERS	RANGES
COASTAL SLOPE	1.2
GEOMORPHOLOGY	COASTAL
SHORELINE CHANGE	2.8
SEA LEVEL CHANGE	1.3
SIGNIFICANT WAVE HEIGHT	0.52
TIDAL RANGE	0.92

Table 1: Datas from Kozhikode beach

The Coastal Slope was found to be 1.2. The Geomorphology of the beach was COASTAL. The Coastal Shoreline Change was 2.8. The Sea Level

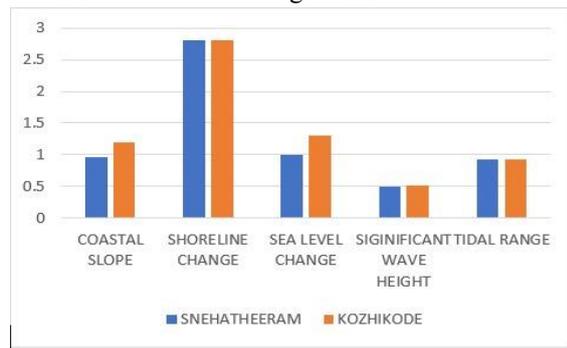
Change was found to be 1.3. Significant Wave Height was 0.52 and the Tidal Range is 0.92.

SNEHATHEERAM BEACH

PARAMETERS	RANGES
COASTAL SLOPE	0.96
GEOMORPHOLOGY	COASTAL
SHORELINE CHANGE	2.8
SEA LEVEL CHANGE	1
SIGNIFICANT WAVE HEIGHT	0.5
TIDAL RANGE	0.92

Table 2. Datas from snehatheeram beach

The Coastal Slope was found to be 0.96. The Geomorphology of the beach was COASTAL. The Coastal Shoreline Change was 2.8. The Sea Level Change was found to be 1. Significant Wave Height was 0.5 and the Tidal Range is 0.92.



Coastal parameters

V. DETERMINATION OF CVI USING AHP

5.1 PAIRWISE COMPARISON MATRIX

	TIDAL RANGE	SWH	SEA LEVEL	SHORELINE CHANGE	GEOMORPHOLOGY	SLOPE
TIDAL RANGE	1	0.5	0.33	0.2	0.11	0.11
SWH	2	1	0.33	0.25	0.13	0.11
SEA LEVEL	3	3	1	0.33	0.17	0.14
SHORELINE CHANGE	5	4	3	1	0.2	0.17
GEOMORPHOLOGY	9	8	6	5	1	0.33
SLOPE	9	9	7	6	2	1
COLOUMN SUM	29	25.5	17.66	12.78	3.61	1.86

Table 3. pair wise comparison matrix

5.2 RANKING

These are the resulting weights for criteria based on your pairwise comparisons:

Cat		Priority	Rank
1	Coastal slope	43.8%	1
2	Tidal range	2.7%	6
3	Significant wave height	3.6%	5
4	Shoreline change	11.4%	3
5	Geomorphology	32.0%	2
6	Sea level change	6.4%	4

Saaty (1977) developed an analytic hierarchy process (AHP) that uses a preference matrix and replicable preference factors. compare all identified relevant criteria with each other to be able to determine the necessary weighting factors. AHP selects optimal options considering both objective and subjective aspects. In this analysis, weights are set for both PVI and SVI according to the general protocol. All elements are compared pairwise in the first stage and the matrix is completed using the score in dependence on the relative relevance of the factors. Each factor is compared with each other in a pairwise comparison matrix by giving the corresponding cell relative dominant value between 1 and 9. Table 4 shows the relevance of the dominant values of the scale. Priority a vector is derived which is the normalized eigenvector of the matrix using a comparison matrix . To achieve this (see Tables 6), divide each column by the appropriate amount. The average values of each row are calculated as the last step and these the average values are used as weights in the objective hierarchy k determine PVI and SVI. AHP allows comparison of primary criteria as well as sub-criteria, although for this study the latter was used and weights were given. CVI is usually given as the square root of the product evaluation criteria in vulnerability studies.

CVI's ability to expand the advantage is the range of values when calculating as a product of parameters. In contrast, Diez et al. (2007) argue that CVI, which is the sum of differentially weighted factors, more accurately captures the variability of the environment. PVI and SVI were estimated in the current study using both methods and it was found that the summation method best captured local conditions.

5.3 COASTAL VULNERABILITY RANKING

Parameter	Very low(1)	Low(2)	High(3)	Very high(4)
Coastal slope	>1	>0.2 and <1	>0.1and < 0.2	>0and<0.1
geomorphology	Rocky coast	Embayed/indented coast	Dunes/estuaries and lagoons	Madflats , mangroves, beaches ,barrier-spits
Elevation(m)	>6	>3 and<6	>0and<3	<0
Shoreline change(m/yr)	Accretion>1	Accretion<1	Erosion<1	Erosion>1
Sea level change(mm/yr)	<0	>0 and<1	>1and<2	>2
Significant wave height(m)	<0.55	>0.55and <1	>1 and <1.25	>1.25
Tidal range(m)	<1	>1 and <4	>4 and <6	>6

Table 4. coastal vulnerability index

5.4WEIGHT BASED ON RANKS

PARAMETER	KOZHIIKODE	SNEHATHEERAM
TIDAL RANGE	1	1
SIGNIFICANT WAVE HEIGHT	2	2
SEA LEVEL	3	3
SHORE LINE CHANGE	4	4
GEOMORPHOLOG Y	2	2
SLOPE	1	2

Table 5. weight based on ranks

5.5 NORAMALIZED MATRIX

parameters	Tidal range	SWH	Sea level	Shoreline change	Geo-morphology	slope	sum	weight	*100
Tidal range	0.03	0.02	0.02	0.01	0.03	0.05	0.16	0.027	2.70
SWH	0.06	0.03	0.02	0.02	0.03	0.05	0.21	0.035	3.50
Sea level	0.08	0.1	0.05	0.02	0.04	0.07	0.36	0.060	6.00
Shoreline change	0.14	0.13	0.14	0.06	0.05	0.08	0.6	0.100	10.00
geomorphology	0.25	0.26	0.28	0.32	0.25	0.16	1.52	0.253	25.33
slope	0.25	0.3	0.32	0.38	0.51	0.47	2.23	0.372	37.20

Table 6. Normalized Matrix

VI. COASTAL VULNERABILITY INDEX

KOZHIIKODE	SNEHATHEERAM
20.66	29.22

VII. CONCLUSION

CVI RANGE	RISK LEVEL
15-26	LOW
27-36	MODERATE
37-46	HIGH
47-57	VERY HIGH

From the comparison of the coastal parameters of Snehatheeram beach and Kozhikode beach it is evident that Kozhikode beach is low vulnerable and Snehatheeram beach is moderate vulnerable.

VIII. MITIGATION MEASURES

For low vulnerability, Vegetation and dunes, Beach nourishment, Groins and jetties can be provided For moderate vulnerability, Breakwaters and seawall, Erosion control structures, Dredging can be provided.

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