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Coastal Vulnerability Analysis of Major Tourist Beaches in Kerala Using GIS (Geographic Information System)

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Abstract

Coastal areas are one of the key systems for global sustainability. These are the transition areas between land and sea. Coastal regions gained importance because of multiple uses, like high productivity of the ecosystem, highly concentrated population, industrial friendly, waste disposal, tourism, transportation, strategic planning in military and many more. These coasts are always in a dynamic state trying to change, and natural ways works for maintaining the equilibrium. India, with most diverse ecosystem, high productivity and thickly populated over coastal region, has gained its very own importance. Despite all of these, Indian coasts are under threat due to multiple stresses like global climate change and human intervention. These stresses are driving vulnerabilities like sea level rise, coastal erosion, frequent extreme events, and saltwater encroachment. In this critical scenario, coastal management has become one of the very important issues in the last two decades. Thus, coastal vulnerability assessment methods have been developed to identify and manage the vulnerable areas over the coast.

GIS mapping is an analysis and display system for data with a geographical reference is called a Geographic Information System (GIS). It makes use of information linked to a certain place. Data mapping provides geographical and population information that is essential for many industries, including industry, insurance, health, and education. With GIS, the most recent mapping information may be shared and put to best use.Data on geographical features and their attributes are stored in a GIS. Usually, the characteristics are categorized as raster images or as points, lines, or regions. Aerial photos or scanned maps might be kept as raster images, while city data could be recorded as points, road data as lines, and postal code borders as regions on a map. Coastal vulnerability index of beaches of Kerala are calculated using AHP and this is plotted on maps using QGIS.

Keywords: Quantum Geographic Information System, Coastal vulnerability index, Geo morphology

1. Introduction

An analysis and display system for data with a geographical reference is called a Geographic Information System (GIS). It makes use of information linked to a certain place. Data mapping provides geographical and population information that is essential for many industries, including industry, insurance, health, and education. With GIS, the most recent mapping information may be shared and put to best use.Data on geographical features and their attributes are stored in a GIS. Usually, the characteristics are categorized as raster images or as points, lines, or regions. Aerial photos or scanned

maps might be kept as raster images, while city data could be recorded as points, road data as lines, and postal code borders as regions on a map.

GIS mapping integrates various types of data, including spatial data (like maps and coordinates) and attribute data (such as population statistics or land use classifications). This integration allows for comprehensive analysis and visualization of complex relationships.It also enables spatial analysis, which involves examining patterns, trends, and relationships within spatial data.
Advances in technology have made GIS mapping more accessible to a broader range of users. Cloudbased GIS platforms, open-source software, and mobile applications have made it easier for individuals and organizations to access, create, and share GIS maps and analysis results. Some of the most popular GIS software include ArcGIS, QGIS, Maptitude, Global Mapper, and MapInfo.

Our study areas , which includes CHERAI BEACH (which lies around 24 kilometers from the industrial district of Ernakulam and to the side of Vypeen island.), SNEHATHEERAM BEACH (which is situated on Thrissur district and lies on Arabian Sea), VARKALA BEACH (which is located on the outskirts of Thiruvananthapuram), KOZHIKODE BEACH (which is on the Western side of Kozhikode, situated on Malabar Coast of India), BEYPORE BEACH (which is located opposite to Chaliyam, the estuary where the river Chaliyar empties into Arabian Sea.) , KOVALAM BEACH (which is located on 16 kilometers away from the state capital Thiruvananthapuram).
The main issues faced by the coastal beaches in Kerala includes extreme natural events such as hurricanes, coastal storms, tsunamis and landslides as well as long-term risks of coastal erosion and sea level rise.

2. Objectives

- To plot six beaches of Kerala according to the parameter value obtained using QGIS.

3. Methodology

QGIS, formerly known as Quantum GIS, is a cross-platform desktop Geographic Information System (GIS) program that is free and open source. It lets users create, edit, and export graphical maps in addition to analyzing and modifying geographical data. Both vector and raster layers are supported by QGIS.
Operating systems: Android, Mac OS X, Linux, Unix, and Windows

Development Environments: Python and C++ Qt library is used extensively in QGIS. QGIS Development Team (global, volunteer) is the developer(s).Qgis offers a comprehensive set of tools for spatial analysis, such as buffering, overlay analysis, interpolation, and geoprocessing. It supports various data formats, including shapefiles, GeoTIFF, GeoJSON, and many others. It can also interact with other GIS software and databases, facilitating data exchange and collaboration. QGIS has a vibrant community that develops plugins and extensions, expanding its capabilities beyond the core features.
Users can customize the appearance of maps and data layers in QGIS using styling options such as color ramps, symbol sizes, and label placements. This flexibility allows for the creation of visually appealing and informative maps.

4. Data Collection And Analysis

4.1 Data collected from study areas

4.1.1 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.

Table 4.1.1: Kozhikode Beach Data

Parameters	**Ranges**
Coastal slope	1.2%
Geomorphology	Coastal
Shoreline change	2.8 m/yr
Sea level change	1.3 mm/yr
Significant wave height	0.52 m
Tidal range	0.92 m

4.1.2 Snehatheeram beach

Table 4.1.2: Snehatheeram Beach Data

Parameters	**Ranges**
Coastal slope	0.96%
Geomorphology	Coastal
Shoreline change	2.8 m/yr
Sea level change	1 mm/yr
Significant wave height	0.5 m
Tidal range	0.92 m

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.

4.1.3 Cherai Beach

Table 4.1.3: Cherai Beach Data

Parameters	**Ranges**
Coastal slope	1.2%
Geomorphology	Coastal
Shoreline change	3 m/yr
Sea level change	1.25 mm/yr
Significant wave height	0.55 m
Tidal range	0.92 m

The Coastal Slope was found to be 1.2. The Geomorphology of the beach was **COASTAL.** The Coastal Shoreline Change was 3. The Sea Level Change was found to be 1.25. Significant Wave Height was 0.55 and the Tidal Range is 0.92.

4.1.4 Varkala Beach

Table 4.1.4: Varkala Beach Data

Parameters	**Ranges**
Coastal slope	1.18%
Geomorphology	Coastal
Shoreline change	2.4 m/yr
Sea level change	1.4 mm/yr
Significant wave height	1.15 m
Tidal range	0.92 m

The Coastal Slope was found to be 1.18. The Geomorphology of the beach was **COASTAL.** The Coastal Shoreline Change was 2.4. The Sea Level Change was found to be 1.4. Significant Wave Height was 1.15 and the Tidal Range is 0.92.

4.1.5 Kovalam Beach

Table 4.1.5: Kovalam Beach Data

Parameters	**Ranges**
Coastal slope	0.96%
Geomorphology	Coastal
Shoreline change	3 m/yr
Sea level change	1.8 mm/yr
Significant wave height	1.15 m
Tidal range	0.92 m

The Coastal Slope was found to be 1.2. The Geomorphology of the beach was **COASTAL.** The Coastal Shoreline Change was 3. The Sea Level Change was found to be 1.8. Significant Wave Height was 1.15 and the Tidal Range is 0.92.

4.1.6 Beypore Beach

Table 4.1.6: Beypore beach data

Parameters	**Ranges**
Coastal slope	1.2%
Geomorphology	Coastal
Shoreline change	2.8 m/yr
Sea level change	1.2 mm/yr
Significant wave height	0.51 m
Tidal range	0.92 m

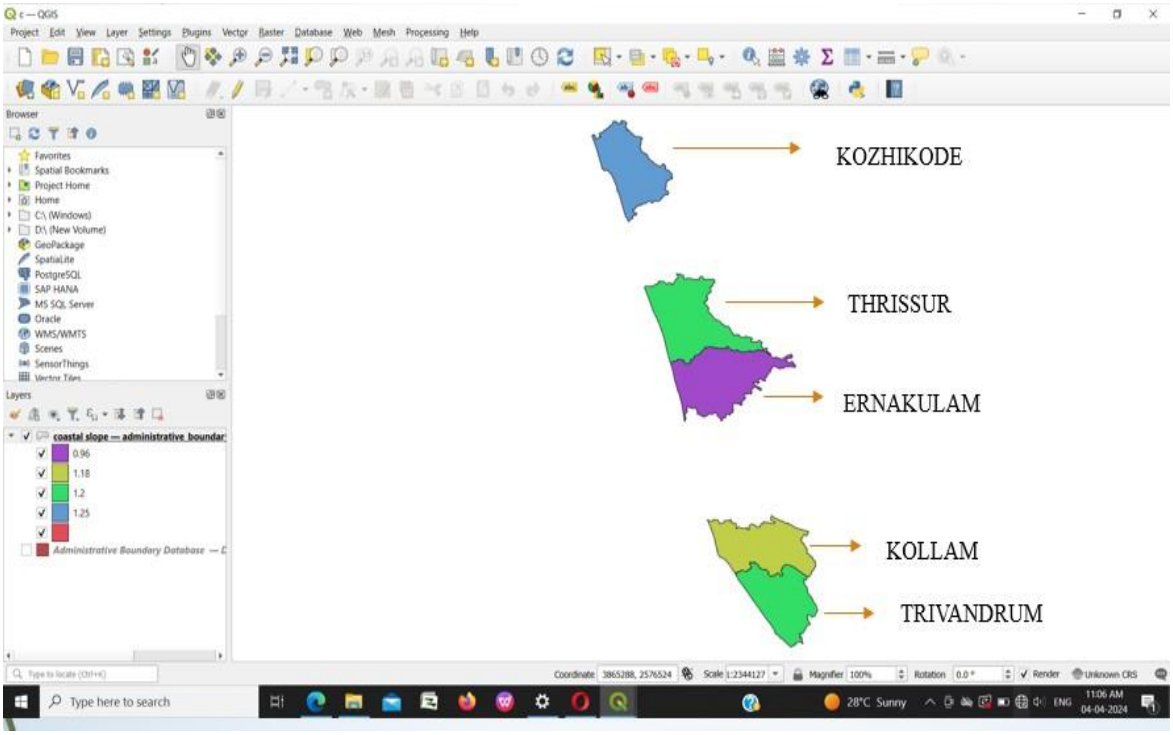
The Coastal Slope was found to be 1.2%. The Geomorphology of the beach was **COASTAL.** The Coastal Shoreline Change was 2.8 m/yr. The Sea Level Change was found to be 1.2 mm/yr. Significant Wave Height was 0.51 m and the Tidal Range is 0.92 m.

5.GIS Mapping

5.1 Plotting of coastal parameters

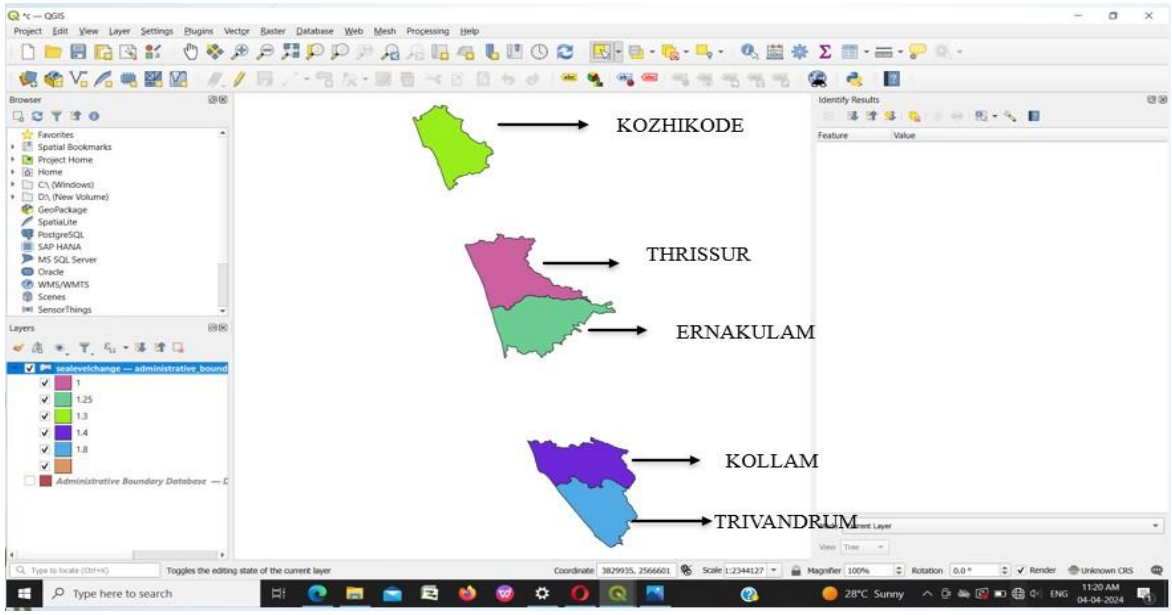
Coastal slope refers to the change in elevation as move from the shoreline towards the inland areas.

Fig:5.1.1 Coastal slope



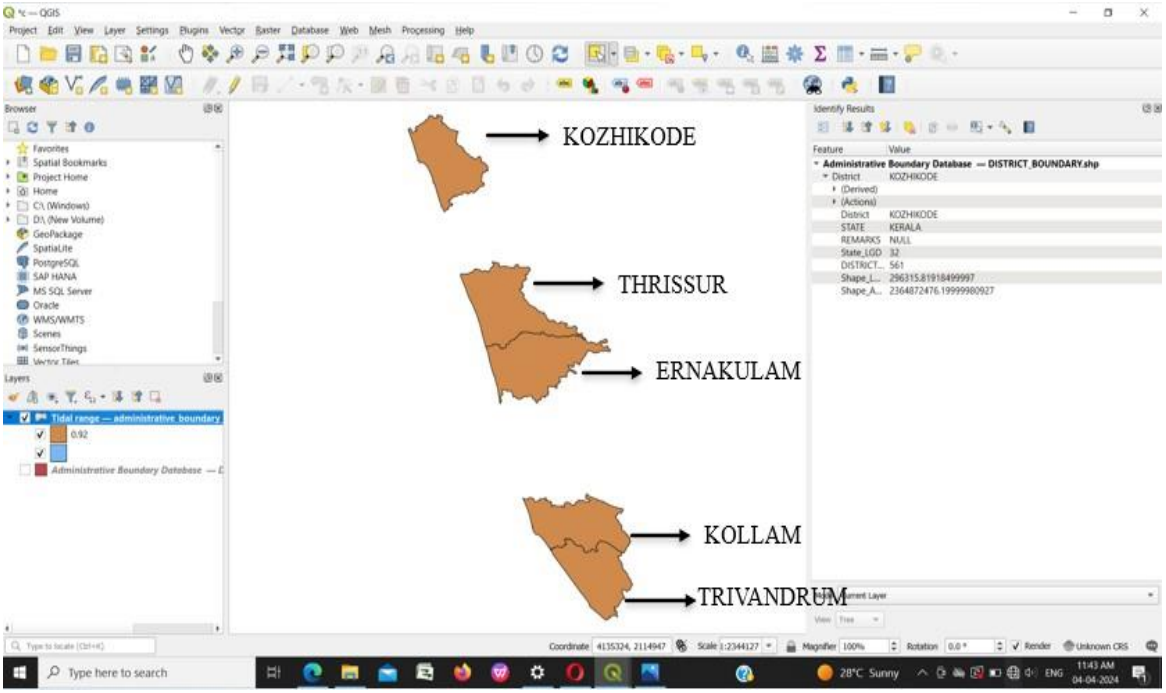
Sea level changes refers to the long term alteration in the average height of the Earth's ocean.

Fig:5.1.2 Sea level change



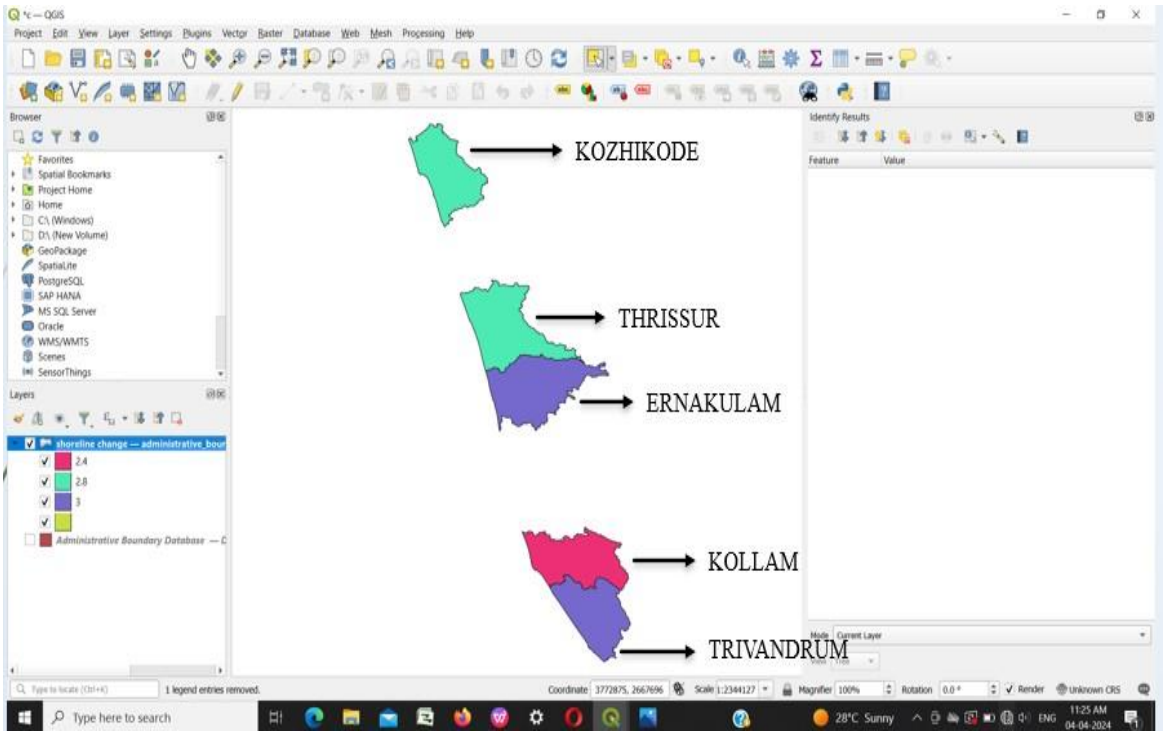
Tidal range refers to the differece in height between the high tide in a given location.

Fig:5.1.3 Tidal range



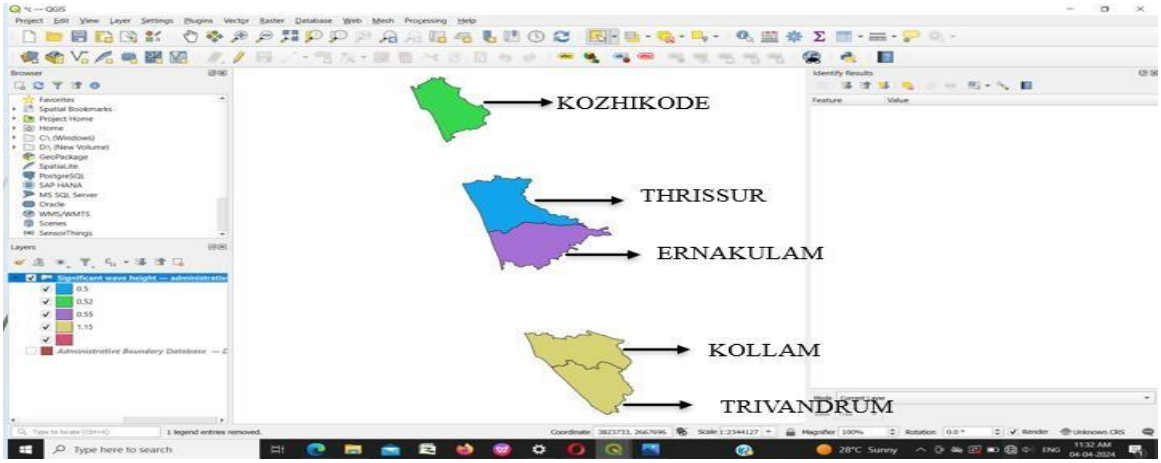
Shoreline change refers to the alteration in the position or configuration of the boundary between land and water.

Fig:5.1.4 Shoreline change



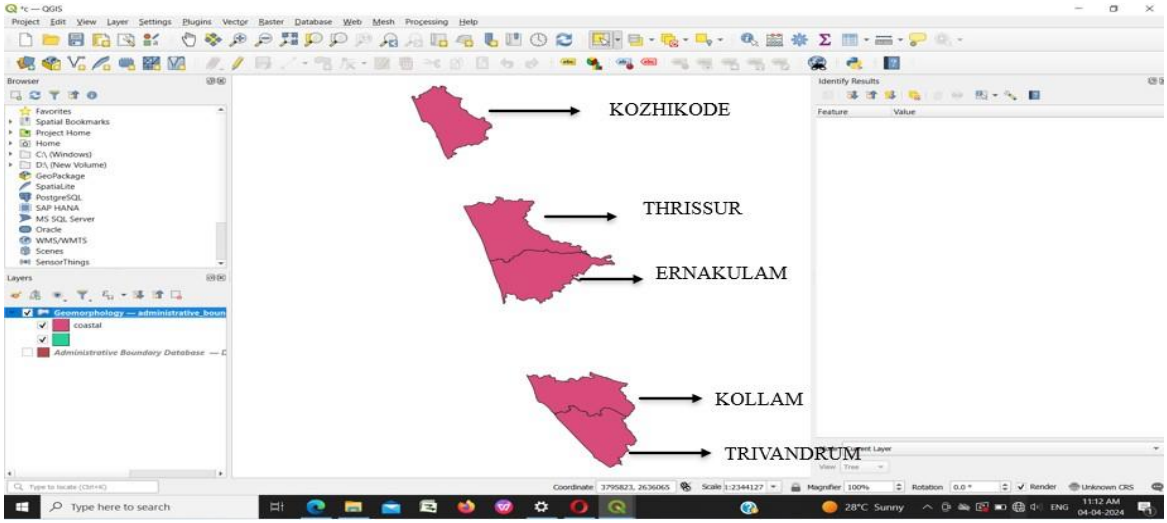
It refers to a statistical measurement used to describe the average height of the heghest one-third of waves in a given wave system

Fig:5.1.5 Significant wave height



The geomorphology of coastal beaches refers to the study of the formation, evolution and characteristics of beach landscapes

Fig:5.1.6 Geomorphology



5. Result And Discussions

Maps are plotted based on the datas obtained regarding the beach features of Kerala Coast. Parameters like tidal range and geomorphology has similar pattern across the coastal line.

Various parameters are plotted across the beaches using QGIS and no beach is found to be high vulnerable under any parameter.

Datasets	Low	Moderate	High
Coastal slope	>1	0.2-1	<=0.2
Sealevel change	1.8-2.5	2.5-3	3-3.4

Tidal range	<2	2-3.5	>3.5
Significant wave height	0.55-0.85	0.85-1.05	1.05-1.25
Shoreline change	>1	1-(-1)	<(-1)

Source : criteria for risk assessment source, A B Yadav et al., 2022

In the case of coastal slope, Cherai, Kozhikode, Beypore, Varkala beaches are low vulnerable and Snehatheeram, Kovalam beaches are moderate vulnerable. Where as in the case of Sealevel change, Cherai , Kozhikode , Snehatheeram , Beypore, Varkala beaches are very low vulnerable and Kovalam beach is low vulnerable. All the six beaches have low vulnerability in tidal range. And in the case of Significant wave height Cherai , Kozhikode , Snehatheeram , Beypore beaches have low vulnerability and Kovalam , Varkala beaches have high vulnerability.
Geomorphology is identified coastal for all the beaches. Also the six beaches have low vulnerability in the case of Shoreline change. Even though no beaches of Kerala comes under high vulnerable beaches, by plotting of maps on the basis of different parameters it is found that beaches can be high vulnerable under a specific parameter and this vulnerability varies according to beaches and parameters. Therefore mitigation measures can be introduced according to this information which makes the process more easier and economical.

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