COASTAL STABILITY AND MICRO MORPHOLOGY; DISTURBANCES DUE TO HUMAN INTERVENTIONS ALONG WEST COAST OF INDIA

Rafeeque MK[12]; Akhil T[1]; Mintu E George[1]; Suresh Babu DS[1]; TK Prasad[2]
[1]National Centre for Earth Science Studies, Thiruvananthapuram, INDIA
[2]University of Kerala, Thiruvananthapuram, INDIA
(Corresponding Author: rafeeque.mk@ncess.gov.in)

INTRO:

Coastal areas are known as cradles of civilization from the beginning of human settlements and the coastal belts in tropics experiences high density of population all over the world

- The western coastal zone of India (>3000km) having a diverse coastal morphology like;
  - Backwaters and barrier reefs of recent formation at southern coastal region of Kerala
  - Narrow cliffs and pocket beaches at Konkan region
  - Wide extensive coastal mudflats of northern states
- With a dramatic tidal ranges from less than 1 meter at Southern Kerala coast to greater than 7 meter in Northern Gujarat Coast

West Coast:
36.72 % of total coastline – erosion
34.65 % of coastline – accretion
28.62 % of coastline - stable coast
Source: Shoreline Change Atlas of the Indian Coast, Central Water Commission of India

Sl. No:	State	Stable (%)	Erosion (%)	Accretion (%)
1	Gujarat, Daman, Diu	47.075	32.820	20.105
2	Maharashtra	6.506	60.558	32.936
3	Goa	52.371	17.395	30.234
4	Karnataka	24.594	35.601	39.805
5	Kerala	12.568	37.227	50.205
	Total	28.622	36.720	34.657

Source: Shoreline Change Atlas of the Indian Coast"; Central Water Commission of India

Kerala coast:
45 % of shoreline - coastal erosion
29 % of shoreline - coastal accretion
26 % of shoreline - stable coast
Source: Sheela et all

Kerala Shoreline Change (1968-2014):

1 Very High Erosion	1.8
2 High Erosion	9.9
3 Moderate Erosion	38.9
4 Stable	23.8
5 Moderate Accretion	17.2
6 High Accretion	4.8
7 Very High Accretion	3.5

Source: Sheela et all

- **Kozhikode Coastal Area** is considered as stable coast
- The reported erosion is mainly associated with different artificial/natural coastal structures
- The important coastal features of this coast includes 3 estuaries, 3 harbours and two main capes and many micro geomorphic and artificial features like promontories, sea pier, groins
- Almost all artificial coastal structures were constructed since 1970, except two sea pier

Objectives:

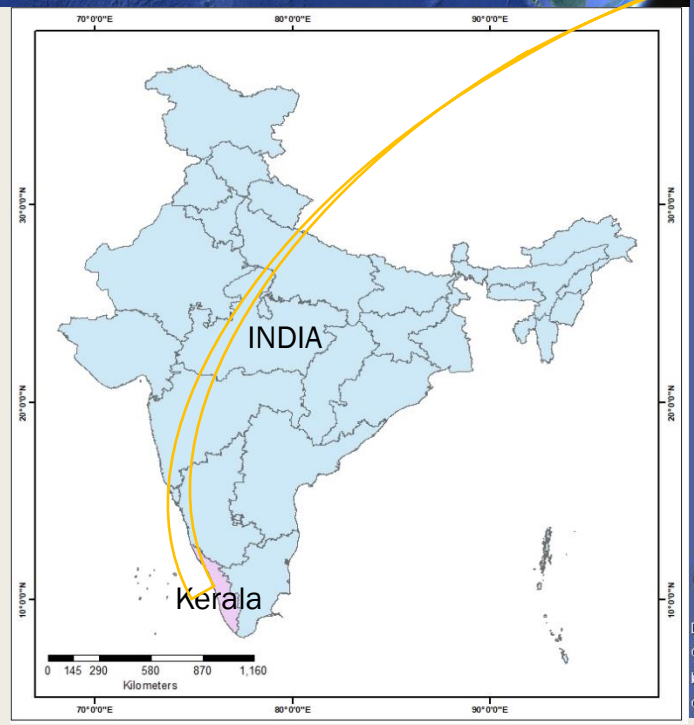
- Evaluate the **near shore *dynamism*** related to Kozhikode coast
- Understand the **stability of Kozhikode coast** for the recent years and analyze the shoreline change
- Examine the disturbances of stability of the coastline due to human interventions on a fast growing urbanized coast

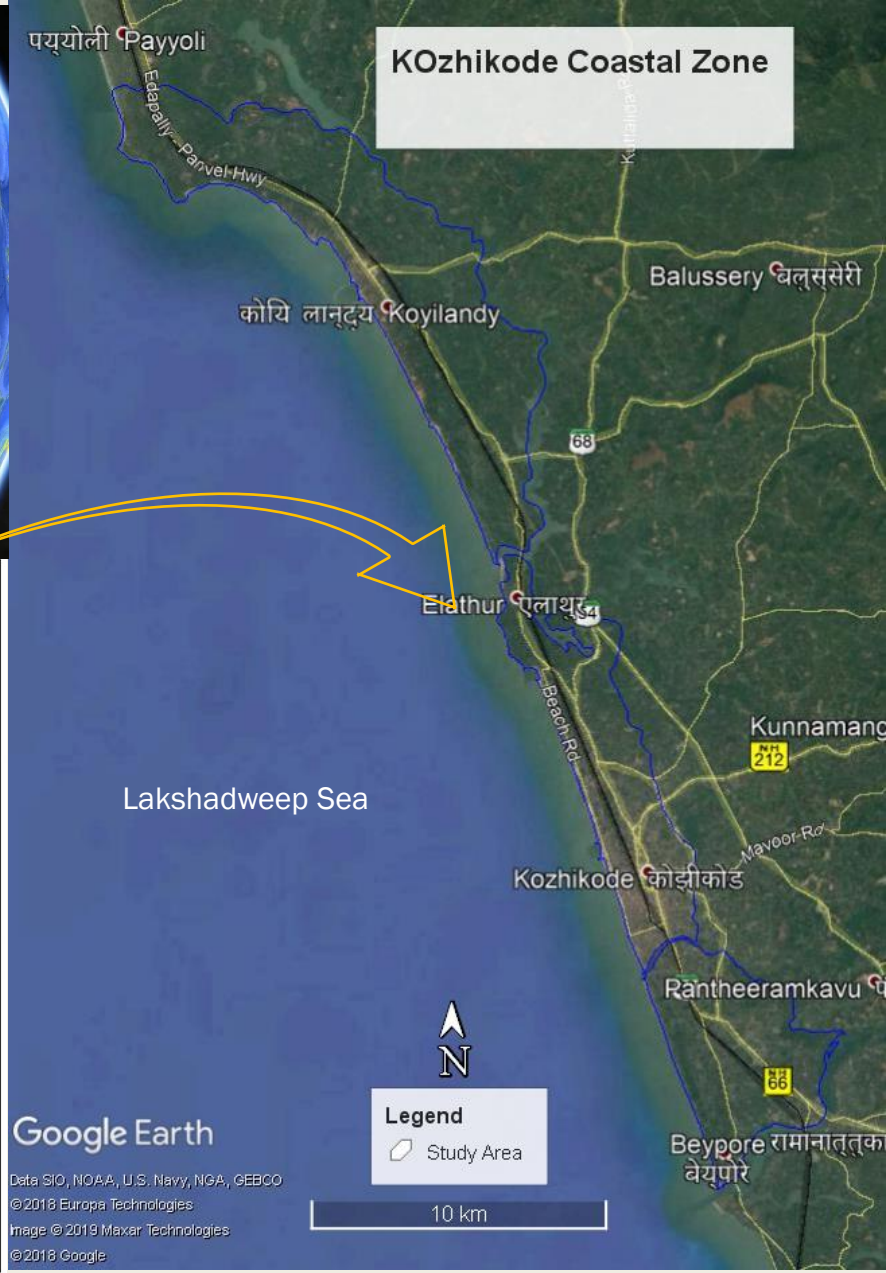
Scope of the Study:

- Being second largest populated nation of the world, Indian coastal region is one of the most populated coastal belt of the world
- The population density of Kerala coastal region of South West Peninsular India, one of the most populated sate of India, is 2931 person per sq. km.
- The paleo-shoreline of Kozhikode coast is identified as 2.5 to 5 km landward from the modern shoreline in the *Beypur – Kozhikode* sector, 1 to 2 km in the *Kozhikode – Elathur* Sector and 1 to 2.5 km in the *Kappad –Quilandi* Sector
- It proves the coastline of Kozhikode is a beach gaining area in historical period
- **It shows a drastic change in the coastal stability of Kozhikode for the last 50 years**

Study Area:

The coastal zone of North Kerala extending from Nandhi Hills in North and Kadalundi Estuary in South





It Consits of:

- Chaliyar River, Kallayi river, Korapuzha
- Kadalur Headlands, Elathur Headlands
- Cannoley Canal and Korapuzha Wetlands
- Harbours and associated features of Quilandy, Puthiyappa, Vellayil

Methodology and data sets used:

- The presently available reports and studies were used to first hand evaluation and understanding
- Environmental Atlas of Kerala (NJK nair et all) is describing the paleo-shoreline and evolution and development of Kozhikode coastal plain during Holocene period
- Hydrographic Chart no. 2053 published by National Hydrographic Office in 1:50,000 scale was used to generate nearshore morphology, by interpolating depth points and contours with ArcGIS spatial analysis tool, it is generated contour of one-meter interval for near shore bathymetry up to 10 meter depths, 2-meter interval up to 20 meter depths and 5-meter interval beyond 20 m
- Nearshore bottom features are identified from generated bathymetric map and validated through local information from fishermen and coastal community

- For shoreline analysis shoreline of different period from 1968 to 2018 is extracted from different sources (The data sources is given in the table)

Sl. No.	Name	Data Source	Publisher	Year	Survey/ Acquisition	Scale/ Resolution
1	Shoreline 1968	Toposheet	SOI	1967-168	1963-1965	1:50000
2	Shoreline 1990	Landsat TM mosaic	GLCF	2002	1988-1992	30 m, 90m
3	Shoreline 2000	Landsat 7	GLCF		2000	30m
4	Shoreline 2007	CARTOSAT	NRSC	2007	2007	2.5 m
4	Shoreline 2010	CARTOSAT	NRSC	2010	2010	2.5 m
5	Shoreline 2014	CARTOSAT	NRSC	2014-2015	2015	2.5 m
6	Shoreline 2017	ArcGIS World Imagery	ESRI	2017	2016-2017	<1 m

- **D**igital **S**horeline **A**nalysis **S**ystem, a add in tool to ESRI ArcGIS developed by **USGS** is used to shoreline analysis
- The scale disparity was considered for different data sources and appropriate uncertainty value was applied in DSAS
- The statistics of End Point rate (EPR) and Least Regression rate (LRR) are studied for shoreline analysis

EPR / LRR Value	Class
< -5	Very High Erosion
-5 to -2.5	High Erosion
-2.5 to -0.5	Moderate Erosion
-0.5 to 0.5	Stable
0.5 to 2.5	Moderate Accretion
2.5 to 5	High Accretion
>5	Very High Accretion

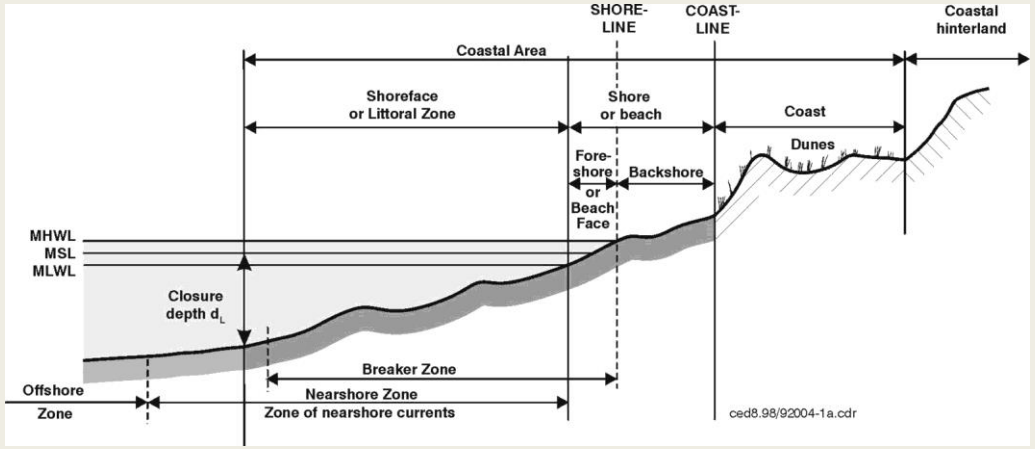
- In this study, an onshore baseline was created at a distance of approximately 0.5 km behind the shorelines
- Orthogonal transects of 100 m interval across the coastline from this baseline were generated
- The EPR and LRR computations were carried out at each of the transects for understanding of the shoreline changes
- The **rate of change of shoreline** derived for each transect is then compiled to understand the stability of the coast by demarcating the erosion/accretion regimes
- For ease of presentation, the shoreline changes observed are classified into 7 classes as given in Table

Then Coastal stability is analysed with artificial coastal structures for interpreting the influence of human intervention

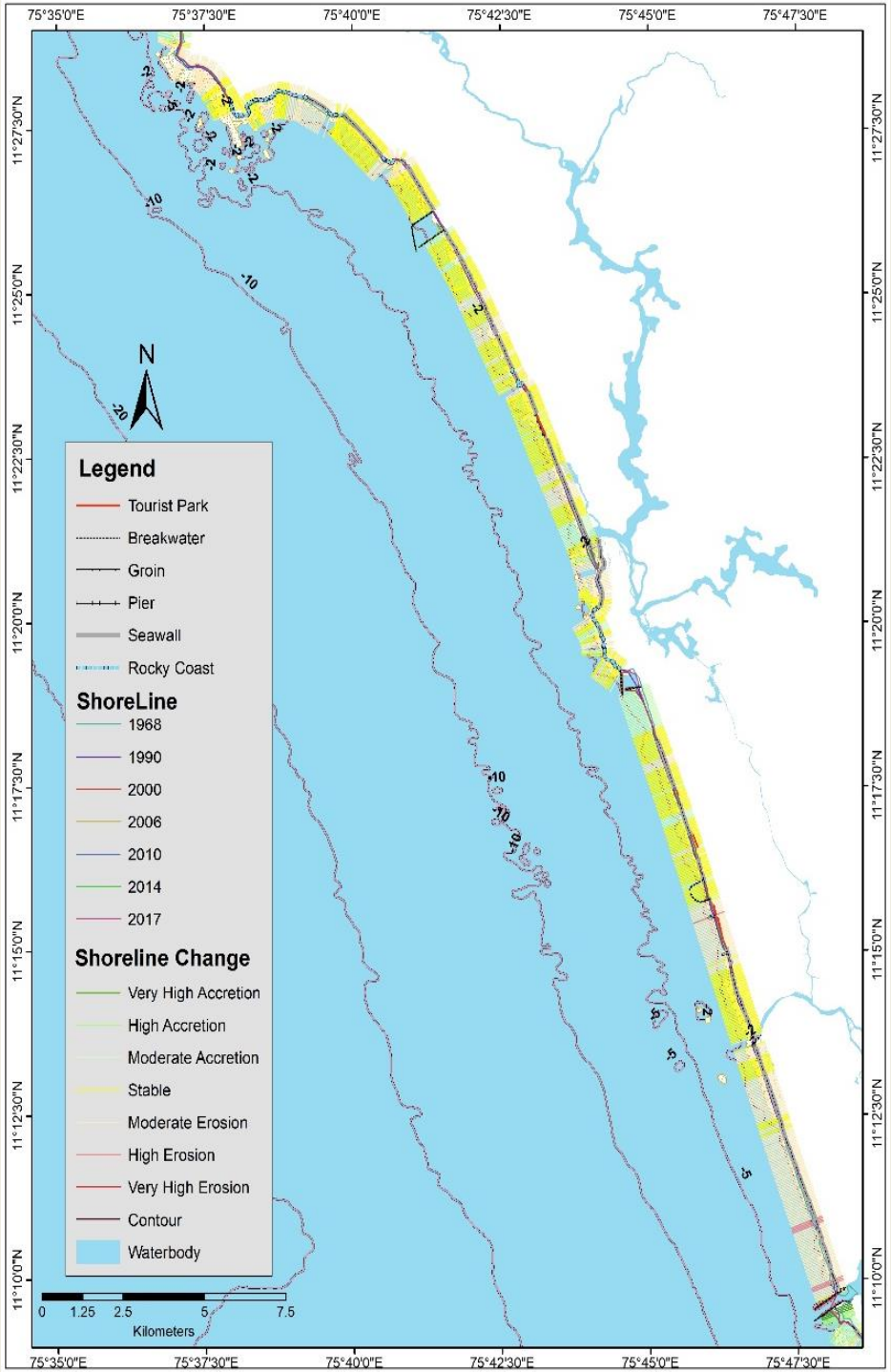
Analysis and Discussion:

I. Coastal Geomorphology:

- ✓ The Current coastline of Kozhikode is formed during Holocene period
- ✓ The paleo-shoreline of Kozhikode coast is identified 2.5 to 5 km landward from the modern shoreline in the Beypur – Kozhikode sector, 1 to 2 km in the Kozhikode – Elathur Sector and 1 to 2.5 km in the Kappad –Quilandi Sector
- ✓ Paleo channels of this area changed its direction in many places during Holocene – Pleistocene period under the tidal influence
- ✓ The promontories/Hills of weathered rock formation like Kadalur Hills, Thoovappara and Elathur Hills regulates the coastal dynamism and controls the Fluvio – Marine sediment movements
- ✓ North of this area formed as barrier reef while the south portion formed as a young coastal plain as the result of combined action of fluvial and marine forces
- ✓ The two main harbors (*Quilandi* and *Puthiyappa*) and 3 estuaries along with artificial coastal measures play a key role in defining the micro-geomorphology of the area.



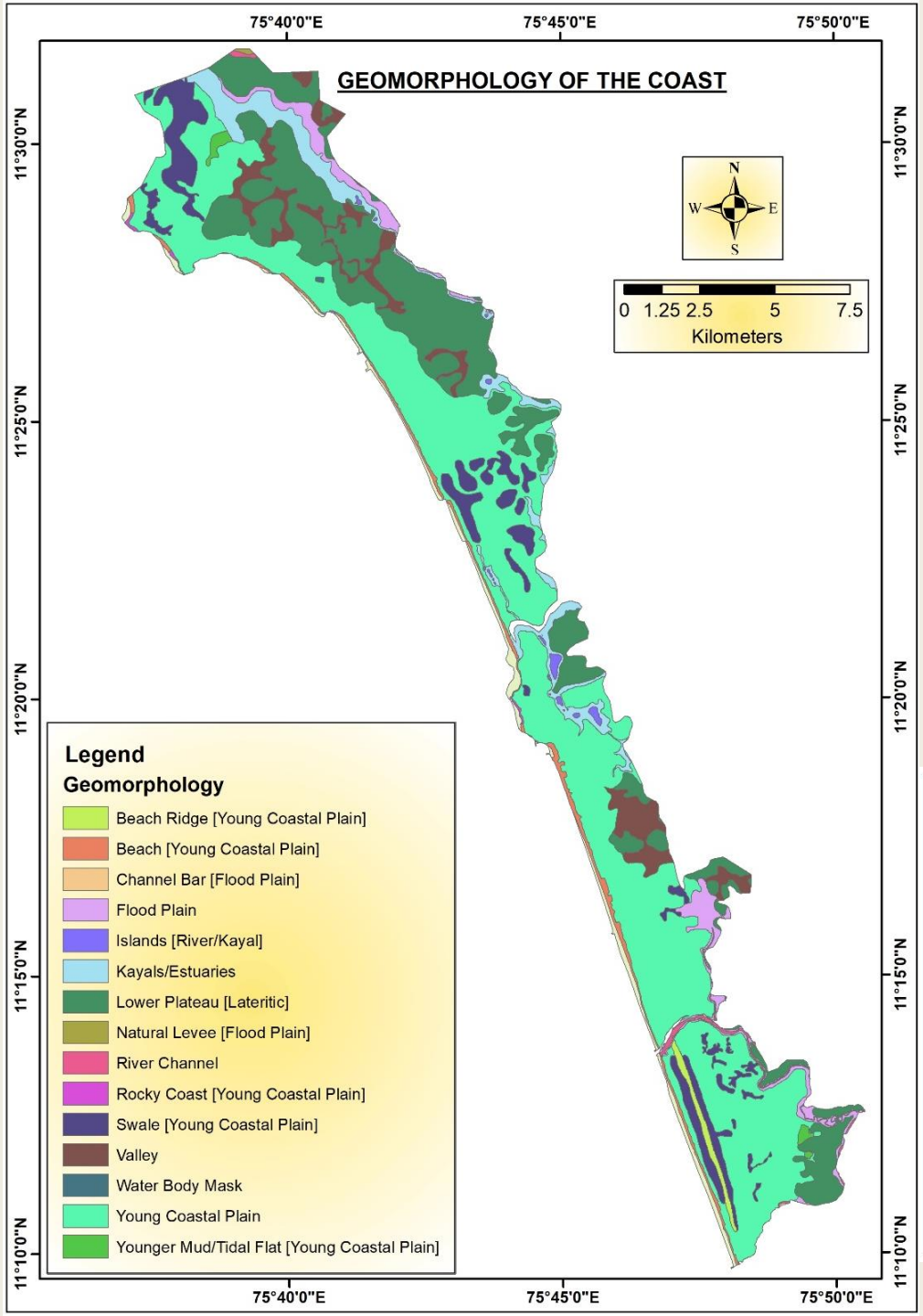
Source: http://www.coastalwiki.org/wiki/Definitions_of_coastal_terms



II. Shoreline analysis and coastal modification

Current study shows that the **48.216 %** of the total coastline is demarcated as **stable coast**, while only **35.788 %** is recorded as **erosion prone area**. And **15.995 &** area is reported as beach gaining area

- The long-term shoreline changes along the Kozhikode coast for the 46 year period, 1968–2017 has been studied in detail using the data derived from multi-dated satellite images and the 1968 SOI topographic sheet
- For the estimation of rate of shoreline changes, the DSAS software of USGS was used adopting the End Point Rate (EPR) and Linear Regression Rate (LRR) methods
- As per the study it can be concluded that almost the entire stretch of the study area has undergone drastic changes over the years, of which the anthropogenic activities like construction of hard structures along the coast, beach and river sand mining, construction of dams across major rivers etc., have contributed to the deterioration of the coast
- The reduction in availability of sediment all along the coast (beach / nearshore) is a matter of growing concern as it directly affects the natural equilibrium of the coast and thereby its stability

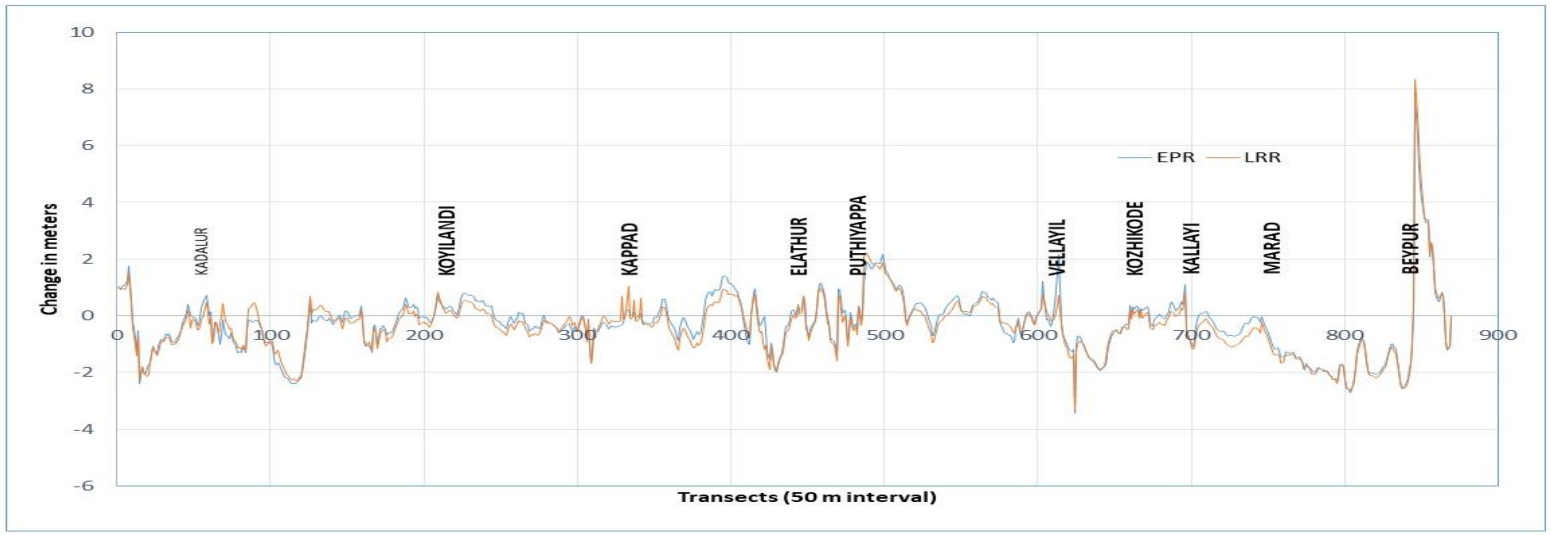


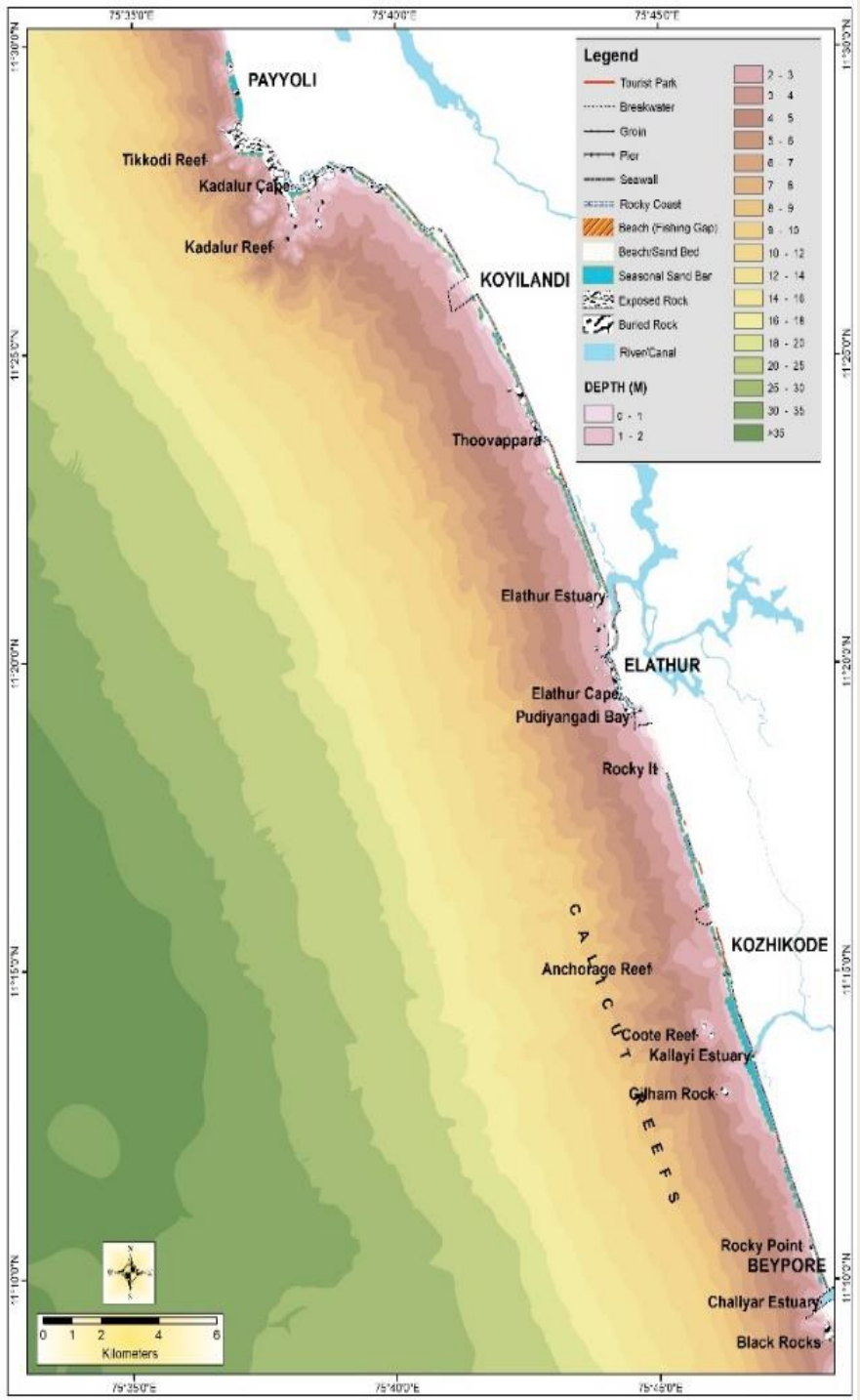
The beach gaining trend of Kozhikode coastline since *Holocene* period is stopped during 1970s and erosion starts

The erosion trend is boosted over years as the results of increasing human interventions along coastline

Comparison between EPR based and LRR based Classification:

Sl. No.	Class	Shoreline Changes as per	
		EPR %	LRR %
1	Very High Erosion	0	0
2	High Erosion	0.805	0.920
3	Moderate Erosion	34.983	39.125
4	Stable	48.216	48.677
5	Moderate Accretion	14.845	10.126
6	High Accretion	0.805	0.690
7	Very High Accretion	0.345	0.460





III. Nearshore Landforms:

- ✓ Nearshore bottom features of the area are diversified with parallel and transverse bars, reefs, exposed and buried rocks etc
- ✓ The major nearshore features are demarcated as Kadalur Cape, Thoovappara, Elathur Cape, Thikkodi reef, Kadalur reef, Anchorage reef, Coote reef, Calicut reef, Rocky It, Gilham rocks, Rocky points, Black rock and Puthiyangadi bay
- ✓ Three major estuaries discharge a remarkable sediment to the sea and it determines the sediment movements of the coast along with three estuaries, three harbours, two main headlands and many small promontories and rock exposures of the area
- ✓ Even if the sediment drift is reversing its direction twice in a year according to monsoon, the net sediment transport is resulting from south to north
- ✓ One of the major sediment cells of the area formed between Kadalur headland and Elathur headland and one between Elathur headland and Beypur estuary
- ✓ The northern Kadalur headland blocks the movement of sediments from south to north.

IV. Coastal Structures:

- Nearly 65% coastline of the study area is experiencing as stable/ accretion coast as per the current study
- But, the erosive trend of Kozhikode coast is boosted after 2000. The artificial coastal structures due to increased demand of seawalls and groins from inhabitants of coastal zone after 2004 tsunami re diverted the coastal dynamism and the shoreline movement
- Almost all artificial coastal structures were established after 1970s, except two sea pier.
- The reported erosion is mainly associated with different artificial/natural coastal structures
- Accordingly the rate of coastal erosion increased during last two decades

CURRENT STATUS OF COATLINE ALONG STUDY AREA

Coast length (as on 31.03.2017)

Total Length: 47.12 km

Protected Coast: 45.03 km

Unprotected Coast: 2.09

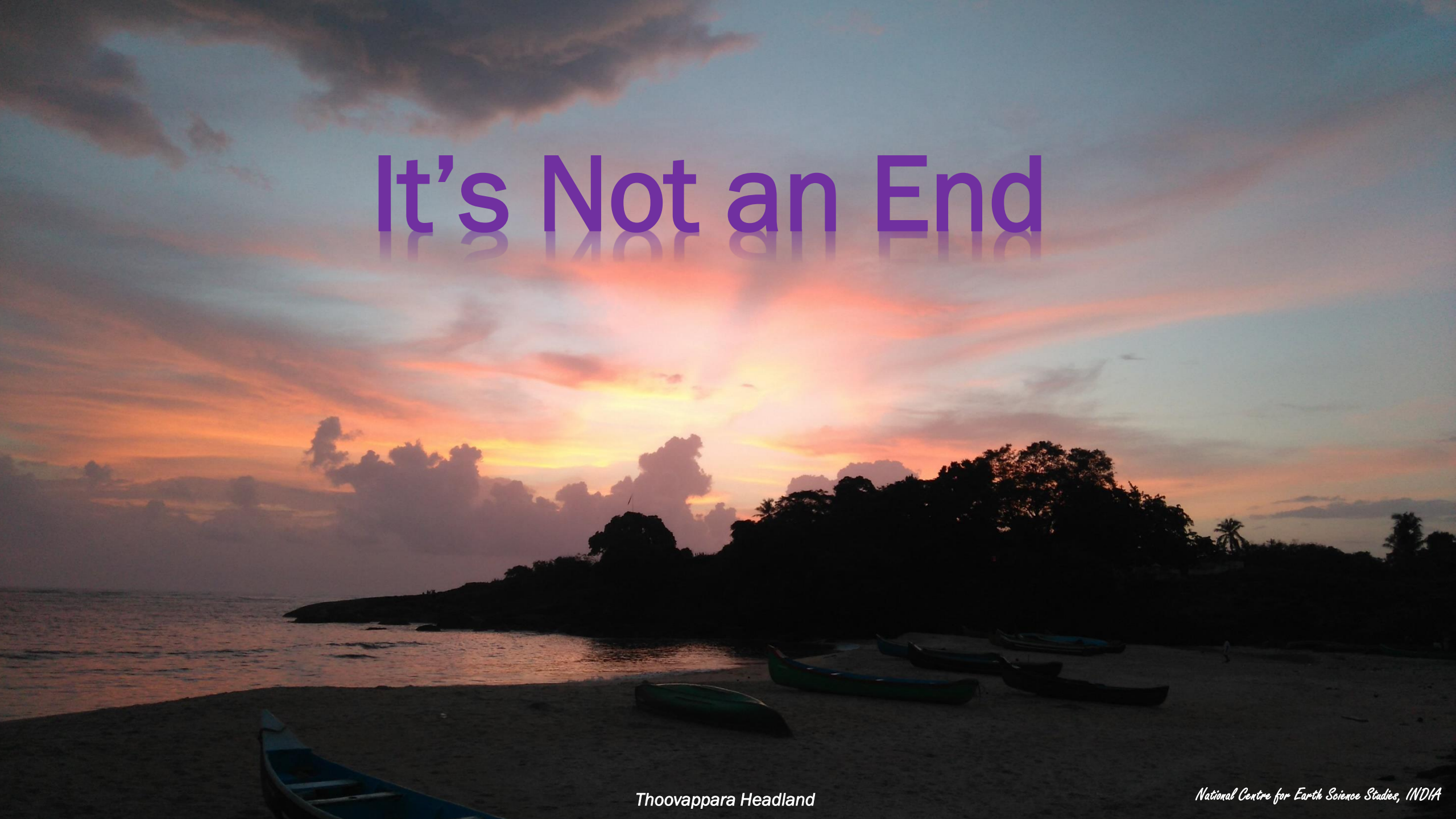
Sl. No.	Type	Total
1.	Ports/Harbours	5
2.	Breakwaters	9
3.	Groins	19
4.	Pier	2
5.	Esturies/Inlets	3
6.	Seawall (Length)	27.308 (km) (Active Seawall)
7.	Tourist Park	5

Results and Conclusion:

- As a fast growing urbanised coastal city of the state, recent human interventions disturbances the sustainability of the Kozhikode coastline
- Construction of two major fishing harbours, vis. *Puthiyappa* and *Quilandi* and *Beypur* breakwater in 1990s re-defined the coastal morphology and nearshore bottom features of the sector
- Shoreline towards the south of *Puthiyappa* harbour and *Beypur* breakwater is accreted and vast beach was developed while the *Quilandi* harbour doesn't have much influence on sediment drift
- Rocky coast, sand bed, seasonal sand bar and exposed and buried rocks were properly demarcated. Along with those natural features the artificial landforms and coastal protection measures plays a key role in the re defining the micro geomorphology of the coastal area and have majore role in the recent disturbances in the coastal stability of the area
- *Quilandi - Elathur* Sector and *Elathur – Kallayi* Sector is identified as more stable coast of the area, while moderate erosion is more prominent in the *Kallayi – Beypur* Sector

Since the Holocene period Kozhikode coast is accreted as 2.5 to 5 km in the *Beypur – Kozhikode* sector, 1 to 2 km in the *Kozhikode – Elathur* Sector and 1 to 2.5 km in the *Kappad –Quilandi* Sector. The study shows that the 48.216 percent of the total coastline is demarcated as stable coast, while 35.788 percent is recorded as erosion prone area. And 15.995 percent area is reported as beach gaining area

It’s Not an End



Thoovappara Headland

National Centre for Earth Science Studies, INDIA