SHORELINE CHANGE ANALYSIS OF THE VIZHINJAM COAST USING BEACH PROFILES AND SATELLITE IMAGES

ANNUAL REPORT

(October 2024 to September 2025)

FOR

ADANI VIZHINJAM PORT PVT LIMITED

PREPARED BY

Coastal and Environmental Engineering Division

NATIONAL INSTITUTE OF OCEAN TECHNOLOGY

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Report Summary

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Project Shoreline change analysis of the Vizhinjam using beach profiles and satellite images		Project No.NIOT/CEE/1323			
1					
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Executive Summary

This report presents a study on shoreline change assessment along a 40-km stretch of the Vizhinjam coast from October 2024 to September 2025, utilising high-resolution satellite images (0.5m spatial resolution), field shoreline measurements, and field-measured beach profiles.

The shoreline change analysis has been carried out using multi-date satellite images and field shoreline data to estimate the rate of change in terms of the distance of the eroded or accreted coast. The rate of change was calculated using the cross-shore profile in terms of the volume of beach sediment.

The shoreline changes using satellite images from October 2024 to September 2025 show accretion at Edapadu to Paruthiyoor (CSP01-15), Adimalathura to Mullur (CSP35-36), Kovalam to Pannathura (CSP40-47), Punthura to Beemapally (CSP56-60), Valliyathura (CSP63-65), Shangumugham (CSP67-70), Kochuveli (CSP78), while erosion at Paruthiyoor to Adimalathura (CSP14-34), Punthura (CSP53-55), Beemapally (CSP61), Valliyathura (CSP66), Vettucaud to Thumba (CSP71-77, 79-81).

The shoreline changes using field-measured shoreline data from October 2024 to September 2025 shows accretion at Neerody (CSP11), Adimalathura to Mullur (CSP34-36), Kovalam (CSP43-45), Punthura (CSP56-58), Valliyathura (CSP63, 66), Shangumugham (CSP70-71), while erosion at Neerody (CSP10), Paruthiyoor to Poovar (CSP13-22), Adimalathura (CSP31-34), Kovalam (CSP42), Punthura (CSP53-55), Beemapally (CSP60-62), Valliyathura (CSP64-66), Shangumugham to Thumba (CSP68-69, 72-81)—no field data collected by survey agency from CSP01 to 09, 23 to CSP30 due to local protest.

From onshore beach profile analysis from October 2024 to September 2025, it was found that beaches exhibited accretion at Pozhiyoor (CSP10), Poovar south (CSP15,17), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP42,46), Panathura (CSP48), Punthura (CSP53), Valliyathura (CSP64A) and Shangumugham (CSP69) while erosion at Poovar south (CSP16), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP31-34), Mullur (CSP37), the port reclamation area (CSP40A), Kovalam (CSP43-45,46), Punthura (CSP54-55), Cheriyathura (CSP62), (CSP68), Shangumugham to Thumba (CSP70-81). No field data were collected by the AVPPL-appointed survey agency from CSP01 to CSP10 and from CSP23 to CSP30 due to local protests. Due to rough sea conditions, the offshore survey was also not carried out by the survey agency in any locations from September 2024 to November 2024, February 2025, and June 2025 to September 2025. As a result, the analysis of the offshore beach profile was not conducted to assess the overall volume change for this year.

The erosion and accretion spots identified from satellite images taken before and after 2015, using high-resolution satellite images, have also been compared. Long-term Shoreline trend analysis (200-2025) was also carried out for eight identified hotspot locations: Kochuveli, Valliyathura, Shangumugham, Punthura, Vizhinjam, Adimalathura, Poovar, and Edapadu. Monthly, seasonal, annual, and intra-annual shoreline changes were assessed from October 2024 to September 2025.

Shoreline change trends over the past two decades (2000-2025) were also evaluated using high-resolution satellite images. Erosion and accretion patterns were identified and compared with the field data and the previously published reports. Field data substantiated the satellite-based

observations, providing further validation. Climatic events, such as cyclones, swell surges, and early monsoon onset, significantly impacted shoreline stability, causing severe erosion and altering sediment dynamics. The Thiruvananthapuram coast experienced several significant climatic events from October 2024 to September 2025. In October 2024, January 2025, May 2025, and June 2025, a series of Kallakadal swell surge warnings were issued, resulting in rough sea conditions with wave heights reaching up to 3.5 meters in June. Cyclone Fengal affected the region from late November to early December 2024 with heavy rains and strong winds. Notably, the southwest monsoon arrived early in 2025, with the India Meteorological Department declaring its onset over Kerala, including Thiruvananthapuram, on May 24, eight days ahead of the usual onset date of June 1. This early monsoon arrival marked the earliest onset since 2009 and was influenced by favourable atmospheric and oceanic conditions. These events reflect a dynamic coastal climate influenced by monsoonal patterns, tropical cyclones, and ocean swell surges. Under normal conditions, the December-March period represents the fair-weather season, during which beach recovery and accretion typically dominate. However, the occurrence of Cyclone Fengal and recurrent Kallakadal events during this period disrupted the beach-building processes, resulting in net erosion. Consequently, a comparison with the previous year's fair-weather season indicates increased erosion along the coast.

Between October 2024 and September 2025, no dredging or breakwater construction took place in the Port area. Consequently, there were no significant human-induced changes (due to Port development) to sediment movement during this time, and the sediment distribution patterns primarily represent natural coastal processes. However, two groynes—one short groyne to the north of the port (Punthura) and two to the south (Paruthiyoor) –were newly installed. However, continuous monitoring is necessary to evaluate the scale of long-term effects on the coast.

1. INTRODUCTION

NIOT has been engaged by Adani Vizhinjam Port Private Limited (AVPPL) in the studies on shoreline change analysis along Vizhinjam coast using high resolution satellite images for the period October 2017 to September 2018 (SO No. 5700227001 dated 15/11/2017), October 2018-September 2019 (SO No. 5700262831 dated 07/03/2019), for the year October 2019 - September 2020 (SO No. 5700285305 dated 23/03/2020), for the year October 2020 - September 2021 (SO No. 5700289439 dated 28/09/2020), for the year October 2021 - September 2022 (SO No. 5702005927 dated 12/04/2022), for the year October 2022- September 2023 (SO No. 5702010119 dated 21/03/2023), and for the year for the year October 2023 - September 2024 (SO No. 5702015202 dated 08/04/2024). These reports are submitted by Adani Vizhinjam Port Private Limited (AVPPL) and Vizhinjam International Seaport Limited (VISL) for vetting by the NGT-appointed expert committee and shoreline monitoring cell. After incorporating the comments received from both committees, NIOT submitted the final study reports, which were forwarded by VISL to the Member Secretary of the NGT-appointed expert committee and uploaded to the Kerala Coastal Zone Management Authority (KCZMA) website.

Seven annual reports have been submitted between 2018 and 2024, incorporating high-resolution satellite imagery for shoreline change analysis covering the period from 2000 to 2024, both before and after the commencement of port construction. These reports also include assessments of beach volume changes from 2015 to 2024, along with evaluations of the impacts of extreme weather events and various coastal interventions.

Subsequently, with reference to the mail dated 07/02/2025, NIOT has received the work order SO No. 5702023390 dated 07/02/2025 to carry out the study on shoreline change analysis using beach profiles and high-resolution satellite images for the period from October 2024 to September 2025. Accordingly, NIOT has procured the high-resolution satellite data (20km on either side of Vizhinjam port/ whichever is available within 40km) through the Indian Space Promotion and Authorisation Centre (INSPACe) and Indian satellite images procured from the National Remote Sensing Centre (NRSC) and obtained field-measured data sets (beach profile) from AVPPL to study the shoreline changes analysis for a 40 km stretch along the Vizhinjam coast.

This document reports the analysis and observation of the study on shoreline change analysis carried out over a 40 km stretch, centred on Vizhinjam Port, using available high-resolution satellite images and beach profile data from October 2024 to September 2025.

2. OBJECTIVES

i. To assess the shoreline change over the 20 km coastline on either side of Vizhinjam port using satellite images and beach profile data from October 2024 to September 2025.

ii. To identify the erosion and accretion hotspots using high-resolution multispectral images acquired by remote sensing satellites and field-measured beach profile data from October 2024 to September 2025.

iii. Vetting of data and modelling reports

3. STUDY LOCATION

The study area, a 40km stretch along the southern Kerala coast (Figure 3.1), falls within the Thiruvananthapuram district of Kerala. It is bordered by Kollam District to the north, Kanyakumari District to the south, Tamil Nadu, and the Arabian Sea to the west, and is influenced by the Killi River, the main tributary of the Karamana River, and the Neyyar River (Poovar estuary). Geomorphologically, the south Kerala coast consists of coastal origin with younger coastal plains and a denudational origin with a pediment pediplain complex.

This study examines the impact of the Port construction on the Vizhinjam coastal morphology. Thus, the long-term shoreline changes resulting from the construction of Vizhinjam port facilities have been studied and reported in the 2018 Annual Report. Consequently, the annual monitoring and changes before and after 2015 have been documented. The development of a port involves various activities, including dredging, reclamation, and the construction of coastal structures such as breakwaters, groins, and jetties. Similarly, coastal protection and structures were introduced between 2010 and 2025 (Information on Coastal Infrastructures from the Kerala Irrigation Department), and these structures were identified using high-resolution satellite images, as listed in Table 3.1. These activities often modify the coastal morphology. Figure 3.2 depicts the percentage of natural and artificial coasts along the study area.

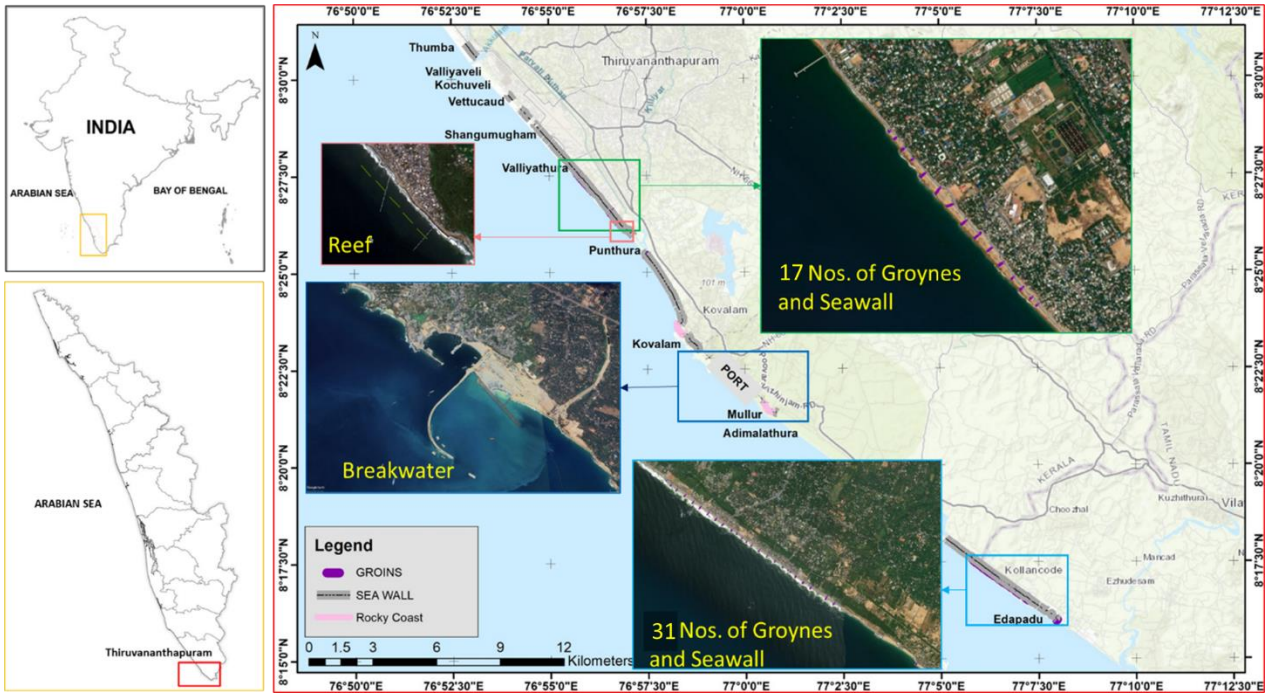

Figure 3.1 Location map depicting the coastal structures along the study area

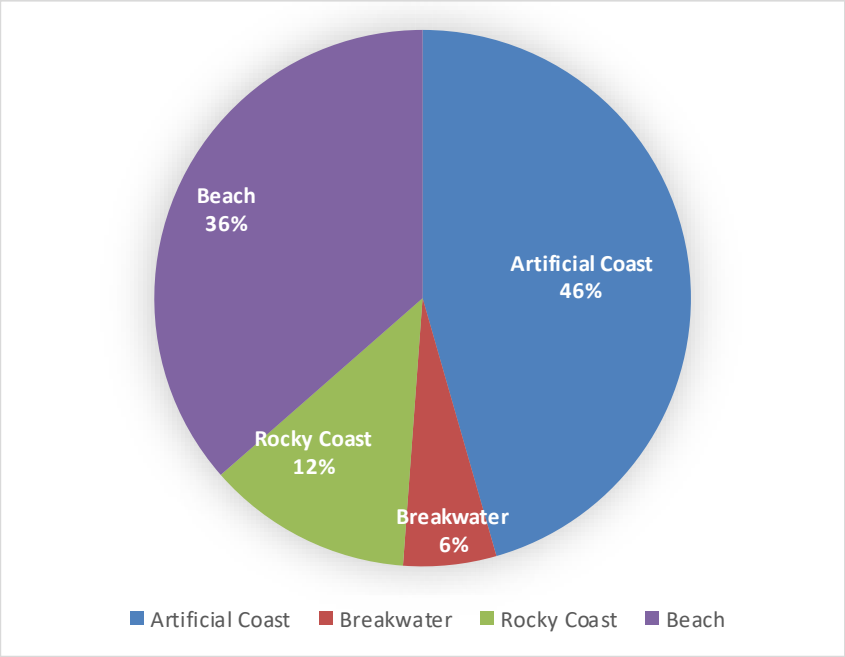

Figure 3.2 Pie Chart showing the percentage of natural and artificial coasts along the study area

The artificially modified coastline includes a 13 km-long seawall extending north of the port, with approximately 7.3 km reported as damaged (data sourced from the Kerala Irrigation Department) due to intense wave activity. Additionally, 29 groynes were constructed between 2020 and 2024, with two more groynes added in 2025 along the southern stretch of the Vizhinjam coast, extending into Tamil Nadu. The timeline of climatic and Port (Dredging and Reclamation activity and Breakwater construction) events along the Vizhinjam Coast is shown in Figure 3.3. Between October 2024 and September 2025, no dredging or breakwater construction took place in the Port area. Table 3.2 lists the natural and Port events from 2015 and the corresponding wave data from the Wave Rider Buoy. Cyclones Ockhi (December 2017) and Tauktae (May 2021), recurrent swell surges (Kallakadal), and enhanced monsoon activity have exerted significant impacts on the morphology of the Vizhinjam coast.

Table 3.1 Coastal structures along the study area (Source: Kerala Irrigation Department, High-resolution satellite images, field survey)

Year	Seawall (m)			Groynes (Nos.)			Geosynthetic Reef (m)	Port Breakwater (m)
	South	North	Total	South	North	Total		
2012	0	7185	7185	0	8	8	0	0
2015	340	8957	9297	0	8	8	0	0
2016	750	8480	9230	0	8	8	0	0
2017	1470	8480	9950	0	13	13	0	592
2018	1841	9870	11711	0	22	22	0	457
2019	3771	9870	13641	5	22	27	0	539
2020	3905	10110	14015	9	22	31	0	640
2021	4792	12801	17593	25	22	47	0	780
2022	5870	12801	18671	27	22	49	50	1134
2023	5830	14027	19857	29	22	51	50	1618
2024	5830	14377	20207	29	22	51	525	2975
2025	5830	14377	20207	31	24	55	525	2975

Table 3.2 Timeline of Natural and Port events along the Vizhinjam coast and corresponding wave measurements

Date	Month	Climatic events	Port activity	Wave observations captured in WRB
October 9-October 12	Oct-15	Deep Depression ARB03		
	Dec-15		Dredging &Reclamation (0.2Mm^3)	
	Apr-16		Breakwater construction initiated	
	May-16		Breakwater construction of 100m	
	Jun-16		Breakwater construction of 155m	
	Jul-16		Breakwater construction of 240m	
	Aug-16		Breakwater construction of 366m	
	Sep-16		Breakwater construction of 399m	
	Oct-16		Breakwater construction of 430m	
	Nov-16		Dredging (0.25Mm^3) BW 486m	
December 17-December 18	Dec-16	Depression ARB02	Dredging (0.25Mm^3) BW 537m	Maximum Hs-1.53m, Maximum Hmax-2.56m, Maximum Tp-18.18s
	Jan-17		Dredging (0.2Mm^3)	
	Feb-17		Reclamation (0.3Mm^3)	
	Mar-17		Jetty construction Dredging (0.2Mm3) Reclamation (0.3Mm3)	
	Apr-17		Dredging (0.2Mm^3) Reclamation (0.4Mm3)	
29th November-6th December	Dec-17	Cyclone Ockhi	Some portion of reclaimed areas washed away due to Cyclone Okhi, which passed the Kerala coast on 30.11.2017. The dredged material till 31.03.2019, amounting to 2.90 Mm^3 has been utilised for the reclamation of 0.36 Mm^3 area. BW 592m	Maximum Hs-4.05m, Maximum Hmax-7.29m, Maximum Tp-20s
	Jan-18		Backup yard and buildings	
March 13-March 14	Mar-18	Depression ARB01		Maximum Hs-1.62m, Maximum Hmax-6.2m, Maximum Tp-18.18s
6th October to 15th October	Oct-18	Cyclone Luban		Maximum Hs-2.17m, Maximum Hmax-3.62m, Maximum Tp-16.7s
November 10-November 19	Nov-18	Cyclone Gaja		Maximum Hs-1.19m, Maximum Hmax-2.21m, Maximum Tp-16.7s
	Dec-18		BW 592m	
June 10-17	Jun-19	Cycline Vayu		Maximum Hs-3.49m, Maximum Hmax-6.13m, Maximum Tp-16.7s
October 30-	Nov-19	Cyclone Maha		Maximum Hs-1.36m, Maximum Hmax-6.13m,

November 7				Maximum Tp-16.7s(No Data During Cyclone Time)
2nd December to 5th December	Nov-19	Deep Depression ARB07	No dredging and Reclamation	Maximum Hs-1.49m, Maximum Hmax-2.52m, Maximum Tp-18.2s
	Dec-19		Breakwater construction 668m	
16th to 22nd May 2020	May-20	Cyclone Amphan		Maximum Hs-2.55m, Maximum Hmax-4.99m, Maximum Tp-20s
31st May to 4th June 2020	Jun-20	Cyclone Nisarga		
17th to 19th June 2020	Jun-20	Monsoon		Maximum Hs-2.44m, Maximum Hmax-4.5m, Maximum Tp-20s
20th July 2020	Jul-20	Monsoon		Maximum Hs-3.15m, Maximum Hmax-6.28m, Maximum Tp-20s
8th August 2020	Aug-20	Monsoon		Maximum Hs-3.03m, Maximum Hmax-5.2m, Maximum Tp-16.67s
6th to 9th September 2020	Sep-20	The low-pressure area formed under the influence of cyclonic circulation		
20th to 22nd September 2020	Sep-20	Low-pressure area North East Bay of Bengal		Maximum Hs-3.98m, Maximum Hmax-8.84m, Maximum Tp-18.2s
13th to 14th October 2020	Oct-20	Deep depression over East Central Bay of Bengal		Maximum Hs-2.36m, Maximum Hmax-4.5m, Maximum Tp-20s
17th November 2020	Nov-20	Cyclone Gati	No dredging and Reclamation	Maximum Hs-1.68m, Maximum Hmax-2.92m, Maximum Tp-22.22s
	Feb-21		BW 774m	
	Jan-21		BW 850m	
14th May to 19th May 2021	May-21	Cyclone Tauktae		Maximum Hs-4.12m, Maximum Hmax-9.44m, Maximum Tp-18.2s
10th July 2021	Jul-21	Monsoon		Maximum Hs- 3.38m Maximum Hmax-5.74m Maximum Tp- 10.53s
26th July 2021	Jul-21	Monsson		Maximum Hs- 2.60m Maximum Hmax-4.43m Maximum Tp- 14.29s
3rd August 2021	Aug-21	Monsson		Maximum Hs- 2.41m Maximum Hmax-3.79m Maximum Tp- 16.67s
7th August 2021	Aug-21	Monsson	No dredging and Reclamation	Maximum Hs- 2.51m Maximum Hmax-4.37m Maximum Tp- 10.53s

26th to 28th September 2021	Sep-21	Cyclonic storm Gulab		Maximum Hs- 2.99m Maximum Hmax-5.86m Maximum Tp- 7.69s
15th to 17th October 2021	Oct-21	No associated extreme events in NIO		Maximum Hs- 3.62m Maximum Hmax-6.66m Maximum Tp- 7.69s
12th to 15th November 2021	Nov-21	Depression BoB 05		Maximum Hs- 2.87m Maximum Hmax-5.66m Maximum Tp- 10.0s
19th to 20th November 2021	Nov-21	Depression BoB 06	BW 940m	Maximum Hs- 1.86m Maximum Hmax-3.33m Maximum Tp- 6.67s
2nd to 6thDecember 2021	Dec-21	Cyclonic storm Jawad	BW 1138m	No Data
	Jan-22		BW 1247m	
	Feb-22		BW 1302m	
	Mar-22		BW1380m	
	Apr-22		BW 1450m	
14th to 15th May 2022	May-22	Severe cyclonic storm Asani		Maximum Hs- 3.03m Maximum Hmax-5.04m Maximum Tp- 8.33s
5th July 2022	Jul-24	Monsoon		Maximum Hs- 3.01m Maximum Hmax-5.26m Maximum Tp- 11.76s
1st August 2022	Aug-22	Monsoon		Maximum Hs- 3.51m Maximum Hmax-5.96m Maximum Tp- 9.09s
5th September 2022	Sep-22	No associated extreme events		Maximum Hs- 3.57m Maximum Hmax-6.87m Maximum Tp- 10.0s
3rd October 2022	Oct-22	No associated extreme events		Maximum Hs- 2.12 m Maximum Hmax-3.55 m Maximum Tp- 18.2s
5th November 2022	Nov-22	Depression BOB 08	No dredging and reclamation	Maximum Hs- 1.51 m Maximum Hmax-2.73 m Maximum Tp- 18.18s
11th December 2022	Dec-22	Severe Cyclonic Storm Mandous over the Bay of Bengal	Dredging works at Vizhinjam resumed in December 2022 and continued till May 2023, BW 1466m	Maximum Hs- 1.45 m Maximum Hmax-2.57 m Maximum Tp- 20.0 s
25th January 2023	Jan-23	No associated extreme events	0.03Mm^3 Reclaimed BW 1647m	Maximum Hs- 1.28 m Maximum Hmax-2.06 m Maximum Tp- 18.18 s
16th February 2023	Feb-23	No associated extreme events	0.23Mm^3 Reclaimed BW 1792m	Maximum Hs- 1.5 m Maximum Hmax-2.31 m Maximum Tp- 20.0 s
30th March 2023	Mar-23	No associated extreme events	0.12 Mm^3 Reclaimed BW 2020m	Maximum Hs- 1.23 m Maximum Hmax-2.59 m Maximum Tp- 20.0 s
	Apr-23		BW 2173m	
	May-23		BW 2220m	
13th June 2023	Jun-23	Extremely severe cyclonic storm Biparjoy over southeast Arabian sea	0.7893 Mm^3 Reclaimed	Maximum Hs- 2.49 m Maximum Hmax- 4.98 m Maximum Tp- 18.2 s

4th July 2023	Jul-23	No associated extreme events	No dredging and Reclamation / Breakwater Construction	Maximum Hs- 4.84 m Maximum Hmax-5.96m Maximum Tp- 25.0 s
6th August 2023	Aug-23	No associated extreme events		Maximum Hs- 2.97 m Maximum Hmax-5.42 m Maximum Tp- 18.18 s
30th September 2023	Sep-23	Depression over the east-central Arabian Sea		Maximum Hs- 2.29 m Maximum Hmax-3.03 m Maximum Tp- 20.0 s
	Oct-23	No associated extreme events	Dredging & Reclamation (D&R) (0.11983Mm^3)	Maximum Hs - 2.05 m Maximum Hmax-4.19 m Maximum Tp- 8.91 s
	Nov-23	No associated extreme events	D&R (0.19312Mm^3) BW 2349m	No WRB data
	Dec-23	No associated extreme events	D&R (0.2690Mm^3) BW 2560m	Maximum Hs - 1.39 m Maximum Hmax-2.57 m Maximum Tp- 20.0 s
	Jan-24	No associated extreme events	D&R (0.2213Mm^3) BW 2717m	Maximum Hs - 0.99 m Maximum Hmax-2.41 m Maximum Tp- 18.18 s
	Feb-24	No associated extreme events	D&R (0.3360Mm^3) BW 2850m	Maximum Hs - 1.38 m Maximum Hmax-2.49 m Maximum Tp- 18.18 s
	Mar-24	No associated extreme events	D&R (0.1529Mm^3) BW 2975m	Maximum Hs - 1.74 m Maximum Hmax-3.03 m Maximum Tp- 20.0 s
	Apr-24	No associated extreme events		Maximum Hs - 1.84 m Maximum Tp- 18.18 s
4-5 May 2024	May-24	INCOIS Warning on long-period swells combined with high tide conditions can cause coastal flooding in low-lying areas		
24th May 2024	Jun-24	Severe Cyclonic Storm Remal in the BoB		Maximum Hs - 3.35 m Maximum Tp- 22.22 s
	Jun-24	No associated extreme events		Maximum Hs - 2.74 m Maximum Tp- 20.00 s
	Jul-24	No associated extreme events		Maximum Hs - 2.78 m Maximum Tp- 21.35 s
21st August 2024	Aug-24	(Before the formation of) Cyclonic Storm Asna in the Arabian Sea		Maximum Hs - 3.30 m Maximum Tp- 18.18 s
	Sep-24	INCOIS Warning on High waves in the 2.3 - 2.4 meters range was forecasted from 17:30 hours on 31-08-2024 to 23:30 hours on 02-09-2024.	No Dredging or Reclamation / Break Water Construction	No WRB Data from 24th August 2024

15-16 October 2024	Oct-24	INCOIS Warning on Swell Surge (Kallakadal) Warning to South Kerala Coast for 15-16 October 2024.		Maximum Hs- 2.20 m Maximum Hmax-4.95 m (10-Oct-2024), 3.76 m (16-Oct-2024) Maximum Tp- 20.22 s
30-Nov-2024	Nov-24	Cyclone Fengal during 25 Nov 2024 – 4 Dec 2024		Maximum Hs- 1.38 m Maximum Hmax-1.85 m (14-Nov-2024), No Hmax data available during Fengal Maximum Tp- 18.18 s
02-Dec-2024	Dec-24	-		Maximum Hs- 1.87 m Maximum Hmax-3.08 m Maximum Tp- 22.22 s
20-Jan-2025	Jan-25	INCOIS Warning on Swell Surge (Kallakadal) Warning to South Kerala Coast for 14 January 2025.		Maximum Hs- 1.01 m Maximum Hmax-2.15 m Maximum Tp- 20.0 s
16-Feb-2025	Feb-25	-		Maximum Hs- 1.41 m Maximum Hmax-2.62 m Maximum Tp- 20.0 s
03-Mar-2025	Mar-25	-		Maximum Hs- 1.62 m Maximum Hmax-2.68 m Maximum Tp- 18.18 s
11-12, April 2025	Apr-25	No associated extreme events in NIO		Maximum Hs- 1.48 m Maximum Hmax-2.42 m Maximum Tp- 18.18 s
24-24 & 29-30, May 2025	May-25	Swell wave alert, Depression ARB01 (Invest 93A) & Deep Depression BOB 01		Maximum Hs- 3.18 m Maximum Hmax-5.33 m Maximum Tp- 20 s
15-Jun-2025	Jun-25	INCOIS Warning on Swell Surge (Kallakadal) Warning to Thiruvananthapuram coast & Monsson		Maximum Hs- 2.98 m Maximum Hmax-5.53 m Maximum Tp- 16.67 s
19-Jul-2025	Jul-25	Monsson		Maximum Hs- 2.94 m Maximum Hmax-5.12 m Maximum Tp- 16.67 s
05-Aug-2025	Aug-25	Monsson		Maximum Hs- 2.46 m Maximum Hmax-4.37 m Maximum Tp- 20 s
26-Sep-2025	Sep-25	No associated extreme events in NIO		Maximum Hs- 1.89 m Maximum Hmax-3.3 m Maximum Tp- 20 s

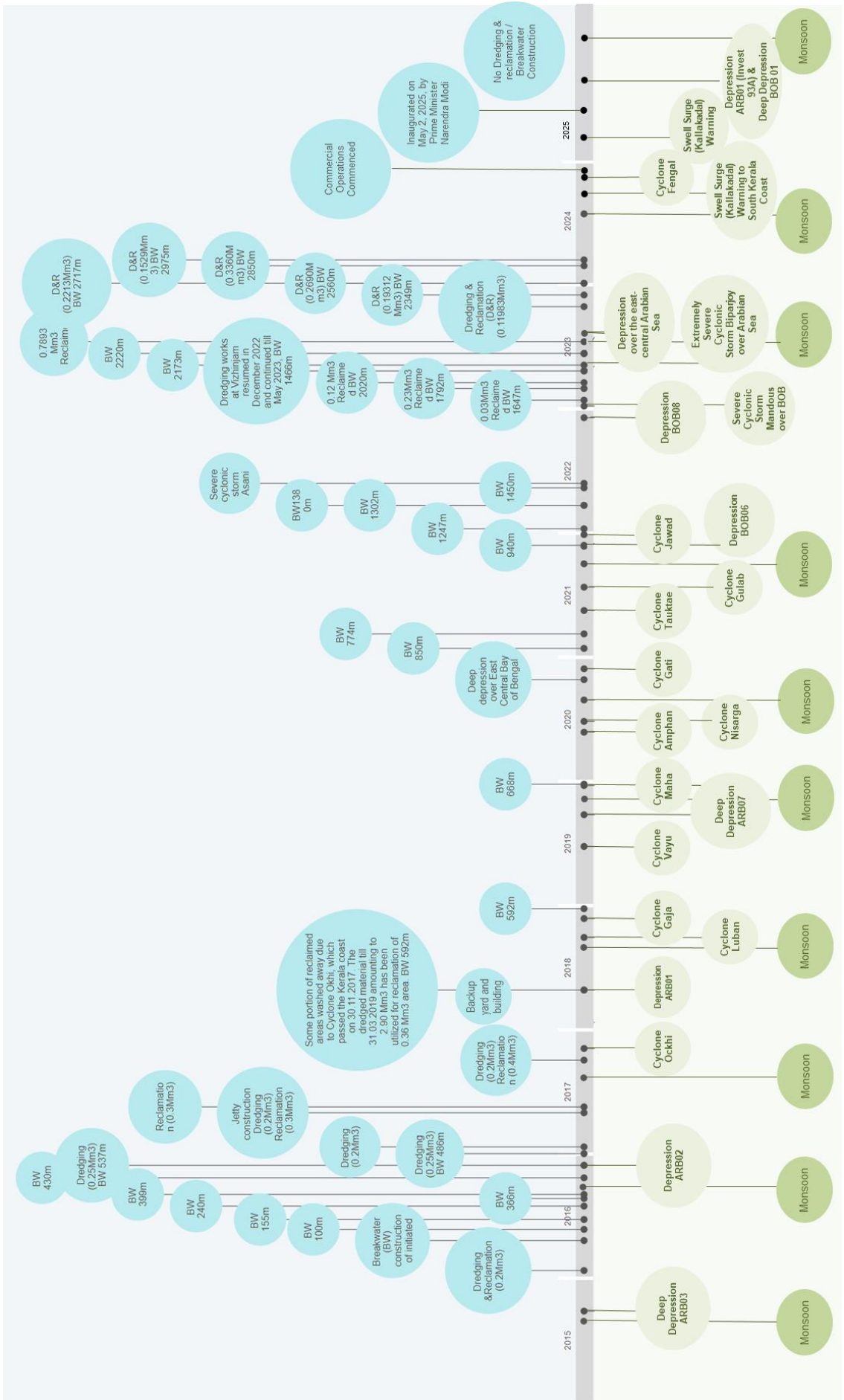

Figure 3.3 Timeline of Natural and Port events along the Vizhinjam coast

4. DATA & METHODS

4.1 Satellite images used

The input satellite images for the 20km stretch on either side of Vizhinjam Port, along with their corresponding tide, coverage, and resolution, are listed in Table 3.1. High-resolution satellite images with a resolution of less than 1m have been procured from vendors listed by the Indian National Space Promotion and Authorisation Centre (InSPACe) and the National Remote Sensing Centre, Department of Space, Government of India. Sentinel 2 MSI images from the European Space Agency and Resourcesat 2/2A Liss4 images from NRSC are acquired to study the monthly changes along the shoreline for a 40km stretch from October 2024 to September 2025.

Table 4.1. High-resolution satellite image data used for shoreline change analysis

Satellite	Date	Tide	Shoreline Coverage (Km)	Sensor Bands	Resolution (m)
World View2 / World View3	24-01-2012	0.125	30.1	(Multispectral)	0.5
	26-02-2015	0.289	29.9		
	10-02-2024	0.669	14.5		
	28-02-2024	0.486	16.5		
	14-09-2024	0.612	22.0		
	04-05-2024	0.861	22.0		
Kompsat3A	04-09-2024	0.391	40.0	(Multispectral)	0.5
	18-09-2024	0.592			
Satellogic	14-11-2024	0.644	40.0	(Multispectral)	0.7
	09-12-2024	0.494			
	05-01-2025	0.502			
	02-02-2025	0.323			
	03-03-2025	0.504			
	01-04-2025	-			
	10-05-2025	0.770			
	03-06-2025	-			
	05-07-2025	-			
	07-08-2025	0.810			
	10-09-2025	0.483			
Resourcesat2/ 2A	30-10-2023	0.750	40.0	LISS4	5
Sentinel 2	29-10-2024	-		MSI	10

4.2 Beach Profiles

Shoreline Change analysis using Cross Shore Profile (CSP) has been done as part of the Shoreline Monitoring Programme. CSP data is being collected monthly by the surveying agency engaged by AVPPL every month at 81 profile lines along a stretch of 40 km (from February 2015 to till date). The locations of the CSP lines are shown in Figure 4.1, and the corresponding landmarks and location names are given in Table 4.2.

Cross Shore Profile (CSP) surveys have been carried out as two components, Viz.:

(1) CSP Surveys (onshore) using RTK (Real Time Kinematic) GPS System landward up to 100m distance from HTL or +2m elevation w.r.t. HTL and

(2) CSP Surveys (offshore) using multi-beam echo sounder system to cover upto10m CD; collected monthly (4 CSP Lines (CSP-02 (Edapadu Beach), CSP-35 (Azhimala), CSP-64 (Valliyathura) and CSP-74 (Vettucaud)) up to a depth of 20 m in January, May, August and October as per the shoreline committee suggestion vide MoM of meeting dated 13th February 2019). The surveying agency combines, processes, and transfers these data sets to NIOT on a monthly basis.

Figure 4.1 Cross-Shore Profiles lines on either side of the Vizhinjam Port

4.3 Shoreline Monitoring Survey

The entire 41 km of shoreline was to be surveyed during the period October 2024 to September 2025. Local protests prevented access to several CSP locations between CSP-22 and CSP-30, resulting in no available data from CSP23-30. Additionally, rough sea conditions hindered offshore surveys at all locations from September 2024 to November 2024, as well as from February 2025 to June 2025 and from June 2025 to September 2025. The survey was carried out using the RTK system in GPS mode. This stretch extends from CSP-1 in the south (Eddapadu) to CSP-81 in the north (Thumba).

Table 4.2 Names of Landmark places and site conditions around each CSP line

CSP NOs.	Region	LANDMARK	LOCATION	SITE CONDITION
CSP-01	SOUTH OF PORT	CATHOLIC CRISMATIC PRAYER CENTER	EDAPPADU BEACH	Seawall
CSP-02				Beach
CSP-03				Seawall
CSP-04		ST.MARYS CHURCH	VALLAVILAY	Beach & Seawall
CSP-05				Beach & Seawall
CSP-06				Beach & Seawall
CSP-07		ST.NICOLAS CHURCH	NEERODY	Beach & Seawall
CSP-08				Beach & Seawall
CSP-09				Beach & Seawall
CSP-10		SREE BHADRAKALI TEMPLE	POZHIYOOR	Beach & Seawall
CSP-11				Seawall
CSP-12				Seawall
CSP-13		ST.MATHEWS CHURCH	PARUTHIYOOR	Seawall
CSP-14		CHURCH OF CRIST		Seawall
CSP-15		POOVAR ISLAND RESORT	POOVAR BEACH SOUTH	Beach
CSP-16				Beach
CSP-17				Beach
CSP-18		POZHIKARA BEACH	POOVAR	Beach
CSP-19				Beach
CSP-20		ST.ANTONYS CHAPEL	POOVAR BEACH NORTH	Beach
CSP-21				Beach
CSP-22		ST.ANTONYS CHURH	KARUMKULAM	Beach
CSP-23				Beach*
CSP-24				Beach*
CSP-25				Beach*
CSP-26				Beach*
CSP-27		GOTHAMBU ROAD	PULLUVILA	Beach*
CSP-28				Beach*
CSP-29				Beach*
CSP-30				Beach*
CSP-31		ADIMALATHURA CATHOLIC CHURCH	ADIMALATHURA	Beach
CSP-32				Beach
CSP-33				Beach
CSP-34				Beach
CSP-35		AZHIMALA TEMPLE	AZHIMALA	Rocky Area
CSP-35A				
CSP-36		NAGAR BHAGAVATHY TEMPLE	MULLUR	Beach
CSP-37				Beach & Seawall
CSP-38	PORT	ADANI RECLAMATION AREA	ADANI PORT OFFICE VIZHINJAM	Beach & Seawall
CSP-39				Port Construction
CSP-40				Port Construction
CSP-40A				Beach & Seawall

CSP-41	NORTH OF PORT	VIZHINJAM LIGHT HOUSE	KOVALAM	Beach & Seawall
CSP-42				Beach & Seawall
CSP-43				Beach & Seawall
CSP-44				Beach & Seawall
CSP-45				Beach & Seawall
CSP-46				Beach & Seawall
CSP-47		SAMUDRA BEACH PARK	KOVALAM (NORTH)	Seawall
CSP-48		MOSQUE	PANATHURA (SOUTH)	Seawall
CSP-49				Seawall
CSP-50		PANATHURA TEMPLE	PANATHURA (NORTH)	Seawall
CSP-51				Beach
CSP-52				Beach
CSP-53		PUNTHURA FISH MARKET	PUNTHURA	Beach & Estuary
CSP-54				Beach & Estuary
CSP-55				Beach & Estuary
CSP-56				Seawall
CSP-57				Beach & Seawall
CSP-58		BEEMA PALLY	BEEMA PALLY	Beach & Seawall
CSP-59				Beach & Seawall
CSP-60				Beach & Seawall
CSP-61		CHERIYATHURA SPORTS GROUND	CHERIYATHURA	Beach & Seawall
CSP-62				Beach & Seawall
CSP-63		VALLIYATHURA BRIDGE	VALLIYATHURA	Seawall
CSP-64				Seawall
CSP-64A				Beach
CSP-65				Beach & Seawall
CSP-66				Beach & Seawall
CSP-67				Beach & Seawall
CSP-68		SHANGUMUGHAM BEACH	SHANGUMUGHAM (SOUTH)	Beach & Seawall
CSP-69				Beach & Seawall
CSP-70		ST.PETERS CHURCH	SHANGUMUGHAM (NORTH)	Beach & Seawall
CSP-71				Beach & Seawall
CSP-72		VETTUCAUD CHURCH	VETTUCAUD	Beach & Seawall
CSP-73				Beach & Seawall
CSP-74				Beach
CSP-75		VELI CHILDRENS PARK	KOCHUVELI	Beach
CSP-76				Beach
CSP-77				Beach
CSP-78		ST.THOMAS CHURCH	VALIYA VELI	Beach & Seawall
CSP-79				Beach & Seawall
CSP-80		CHRISTIAN BROTHEREN CHURCH	THUMBA	Beach
CSP-81				Beach

* Inaccessible due to opposition from locals

4.4 Methodology

The methodology flowchart is shown in Figure 4.2. The shoreline change analysis has been carried out using multi-date satellite images to estimate the rate of change in terms of the distance of the eroded or accreted coast, and the rate of change was calculated using the cross-shore profile in terms of area and volume of beach sediment. The shoreline has been extracted from the satellite images after rectification and co-registration. The shoreline change rate between October 2024 and September 2025 has been analysed. Further, the trend has been compared with the beach profile data. Digital Shoreline Change Analysis System (DSAS) is a tool that works within the Geographic Information System (ArcGIS) software. DSAS computes the rate-of-change statistics for a time series of shoreline vector data. It is also helpful for computing the rates of change for other boundary change conditions that incorporate an identified feature position at discrete times. This method of integrating multi-date satellite images and beach profile data is a time-tested approach and has been used worldwide for similar studies on shoreline change (Theiler et al., 2017).

Similarly, the monthly beach profile data perpendicular to the 40 km Vizhinjam shoreline over the period from October 2024 to September 2025 was collected at intervals of 500m, using RTK or total station landward up to 100m distance from the HTL or +2m elevation w.r.t. the HTL and by using shallow draft boats, sledge and other suitable techniques seaward down to 10m CD. The shoreline change analysis using beach profile data has been carried out using SANDS software. The detailed methodology of the shoreline change analysis using satellite images and beach profile analysis has been provided in the Annual Reports of October 2017 to September 2018, October 2018 to September 2019, October 2019 to September 2020, October 2020 to September 2021, October 2021 to September 2022, October 2022 to September 2023 and October 2023 to September 2024, submitted to NGT Expert committees through VISL.

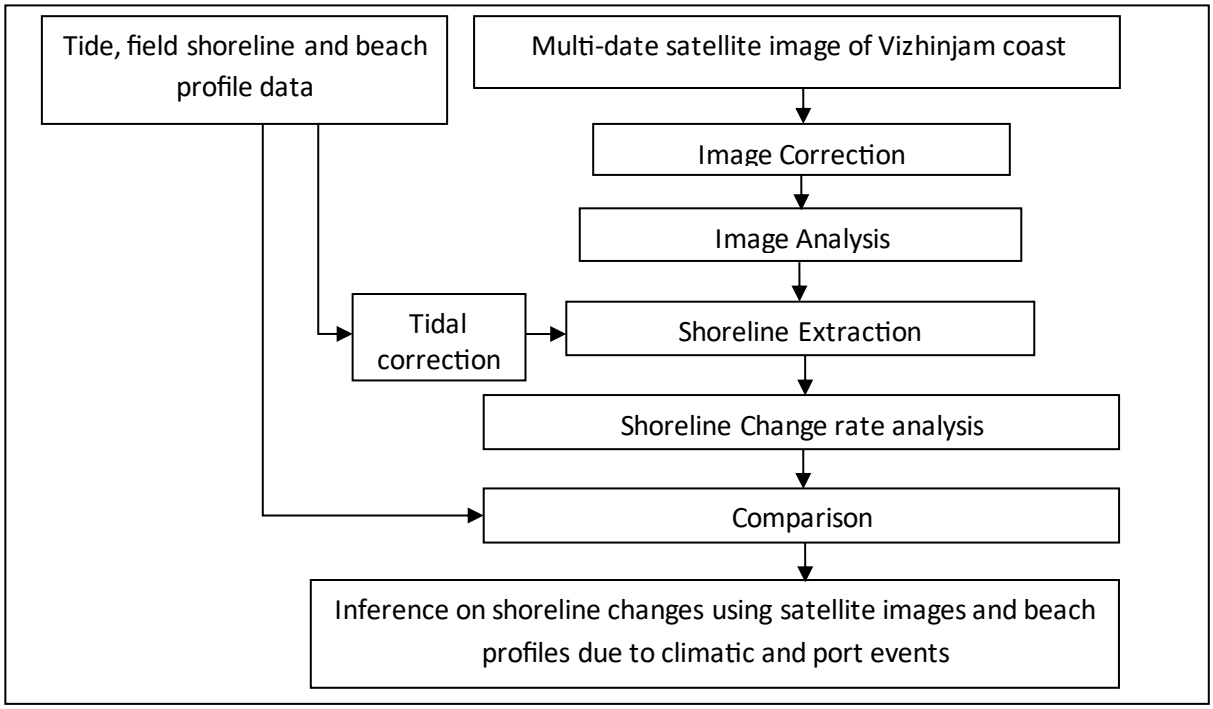

Figure 4.2 Flowchart of the methodology adopted

4.5 Shoreline change analysis from Satellite images and field data

Tide Correction

All shorelines derived from different satellites are normalised to a reference tidal datum of the mean high water level for each month. The tidal offset is estimated by calculating the vertical and horizontal displacement of the shoreline based on the tidal height at the time of image acquisition. The offset is adjusted with the shorelines, and corrected shorelines are used to estimate the shoreline change rates.

$$\Delta X = \frac{\Delta Z}{slope}$$

Where:

- ΔX: Horizontal shift of the shoreline
- ΔZ: Vertical tidal variation
- Slope: Shoreface gradient obtained from beach profile data.

Short-Term Shoreline Change Analysis

The end point rate (EPR) is estimated by dividing the distance of net shoreline movement by the time elapsed between the oldest and the most recent shoreline (Figure 4.3). The significant advantages of the EPR are the ease of computation and the minimal requirement of only two shoreline dates. The major disadvantage is that in cases where more data are available, the additional information is ignored.

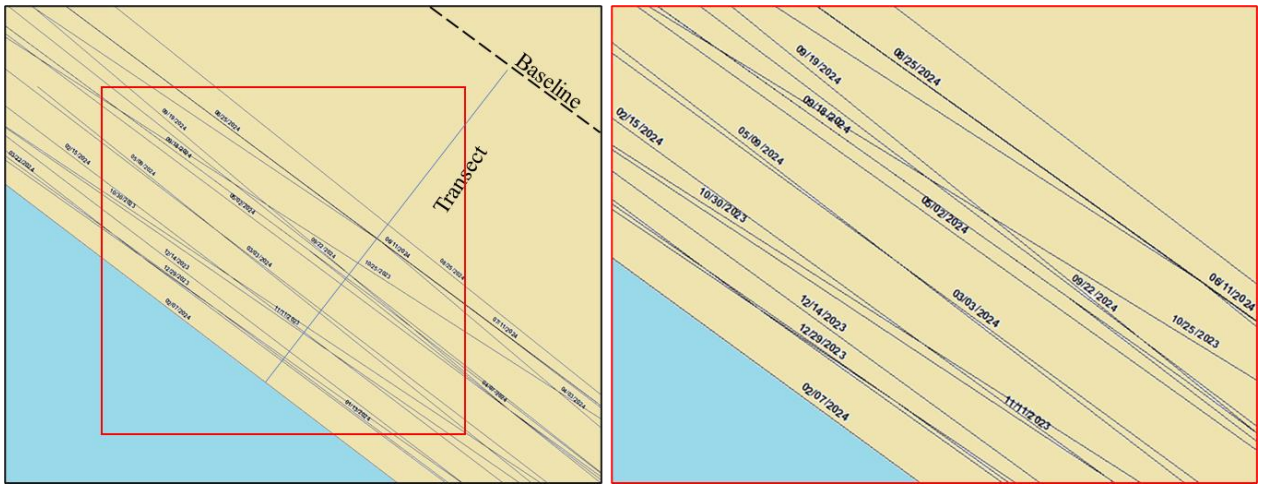

Figure 4.3 Estimation of Short-Term Shoreline Change (EPR)

Long-Term Shoreline Change Analysis

A linear regression rate-of-change (LRR) statistic is determined by fitting a least-squares regression line to all the shoreline points for a particular transect Figure 4.4. The regression line is placed so that the sum of the squared residuals (determined by squaring the offset distance of each data point from the regression line and adding the squared residuals together) is minimised. The linear regression rate is the slope of the line.

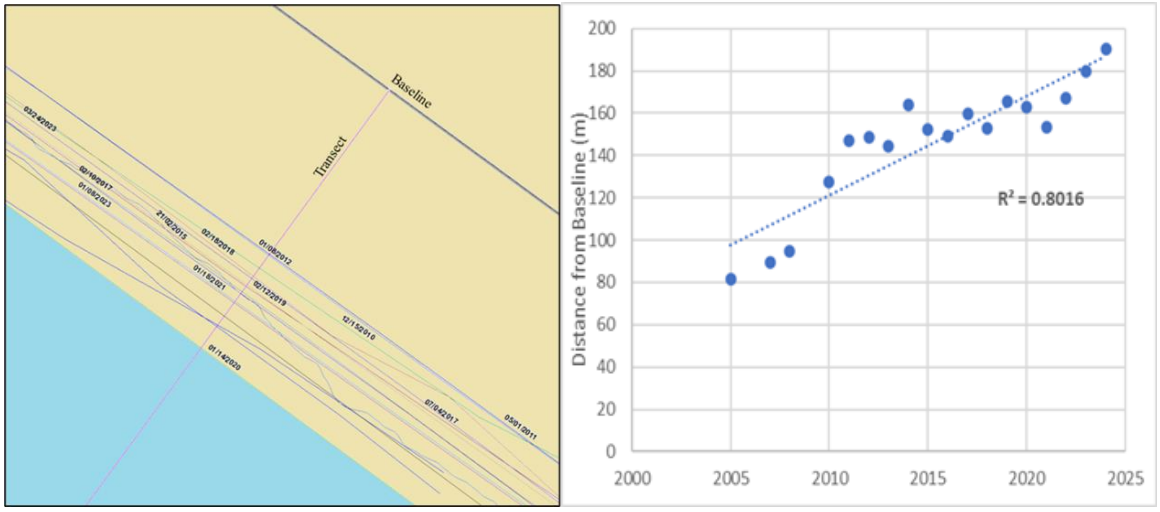

Figure 4.4 Estimation of Long-Term (LRR) Shoreline Change Analysis

The data received from the surveying agency was analysed by plotting each profile and by using SANDS software. This exercise aimed to establish a base data to compare profiles with surveyed data from different locations for different seasons. This data shall serve to assess the beach profile after the construction of the Port at Vizhinjam in the future. The difference, if any, shall be investigated further to understand the impact of the Port on the shoreline evolution. The profiles for different months were plotted location-wise. It is accepted that beach profiles can only be of actual use when surveys are carried out, starting at the same place and moving in the same direction (the Origin and Orientation of the profile). SANDS software stores the beach profile surveys to be viewed graphically and identifies and analyses the trends in beach levels at a location over time. The 'Beach Profile Graph' allows the user to plot and compare beach profiles from different/multiple locations.

During the analysis of cross-shore profiles, it was observed that some of the profiles appeared distorted, possibly due to some errors during the survey. These profiles are either discarded or manually corrected to the earlier profiles. The profiles corresponding to the Vizhinjam Port area are not considered and are mentioned as a development zone.

After qualitative and quantitative reprocessing for shoreline change assessment, the CSP data is directly imported to SANDS. The following flow chart (**Figure 4.5**) explains the process and workflow in SANDS.

Figure 4.5 Workflow in SANDS

4.6 Analysing Beach Profiles using SANDS

SANDS allows for any number of beach profile survey records to be stored at each profile location over a period. This database has been used to determine beach-level stability and long-term trends. The two main Beach Profile Analyses are Profile Analysis by Level and Profile Analysis by Chainage.

Profile Analysis by Level

Profile analysis 'by Level' analyses the changes in the chainage at which certain levels occur (**Figure 4.6**). In other words, this analysis looks at horizontal strips of the profile.

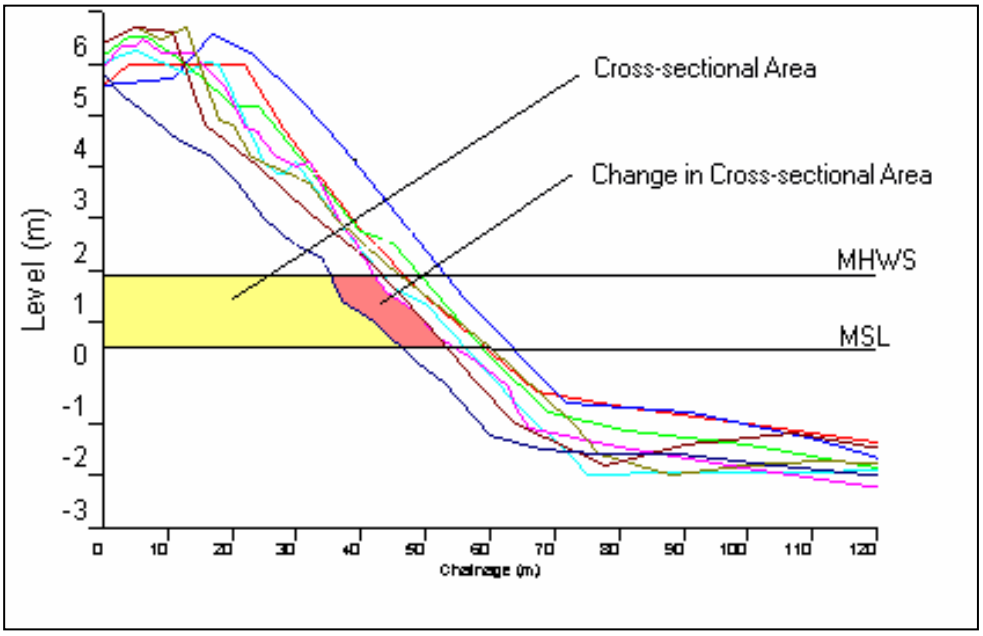

Figure 4.6 Profile Analysis by Level

Profile Analysis by Chainage

Profile analysis 'by Chainage' method analyses the changes in level at certain chainages. In other words, this analysis looks at vertical strips of the profile (**Figure 4.7**).

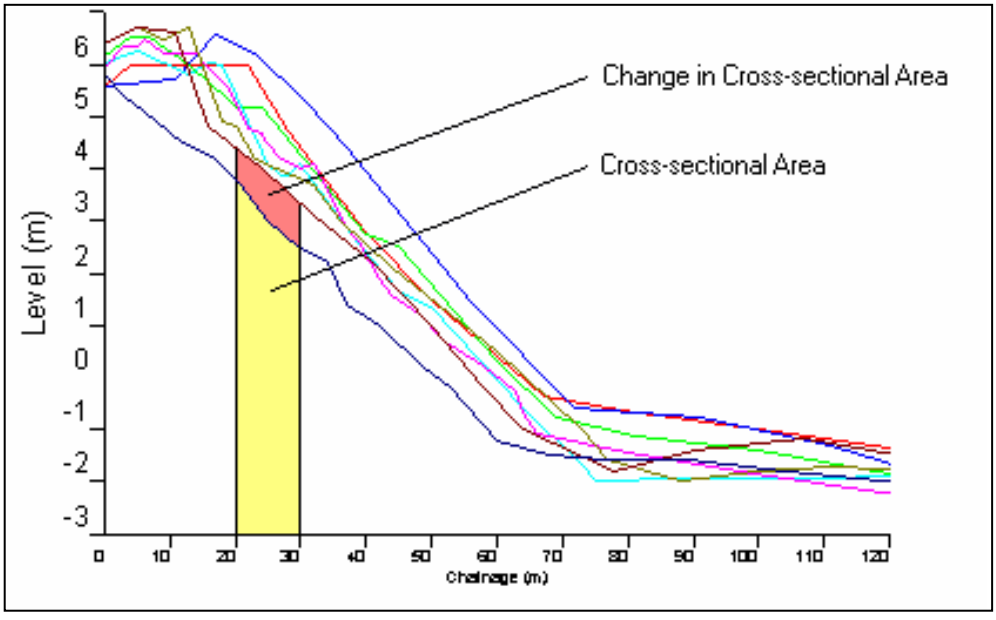

Figure 4.7 Profile Analysis by Chainage

SANDS estimates the profile changes and volumes of pre-defined areas based on the above methods. It also enables us to put all beach profile locations together and analyse the volumes of

these units. SANDS calculates the profile accretion/erosion by directly comparing profiles and displays the results within a GIS-style plan-view format to give striking visual results.

4.7 Vetting of Reports/ Data

Periodical (monthly, seasonal, and half-yearly) reports on field data quality checks and data on water quality, sediments, shoreline monitoring, etc., are scrutinised by NIOT. The Oceanographic and bathymetric data received from AVPPL and reviewed for the period from October 2024 to September 2025 are listed in Table 4.3. Sediment samples were collected seasonally at the cross-shore profile locations. Water quality (TSS, Salinity & Temperature carried out at 4 locations for February 2025, May& September 2025). Vetting of Reports on data analysis and model studies for Vizhinjam Port using data collected by AVPPL (October 2024 to September 2025) by ASSystems (previously LnTIEL) during December 2024, and vetting of monthly data reports on water quality, oceanographic, and bathymetric data collection by Shankar Surveys Private Ltd. (SSPL) for assessment of Shoreline changes has been completed till September 2025, and periodic review and suggestions are being provided to the survey agency appointed by AVPPL. After the periodic vetting, recommendations were provided to the surveyors, emphasising the imperative adherence to the Standard Operating Procedures (SOP) governing profile and Leo surveys. It is suggested that the monthly offshore profile survey be completed within two weeks, and the seasonal offshore surveys be completed within a month. The survey agency will conduct periodic quality checks of water samples in the testing laboratory for quality control (measurement uncertainty).

Table 4.3 Data Status October 2024 to September 2025

Sl no.	Parameters	Post Monsoon (Oct 2024 -Jan 2025)				Pre Monsoon (Feb 2025-May 2025)				SW Monsoon (Jun 2025- Sep 2025)			
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	August	Sept
1	Wave (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Tide (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓
3	Met (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	ADCP (4 locations) at 20 m water depth	×	×	×	×	×	×	×	×	×	×	×	×
5	Bathymetry	✓(jan)				✓(may)							
6	Beach Profile (81 locations at 500 m distance)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7	Water sample (TSS, Salinity and temp)	×				✓(feb)				✓(may,sep)			
8	Grain size(81 locations at 500 m distance)	✓(Oct)				✓(feb)				✓(jun,sep)			
9	LEO (81 locations at 500 m distance)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10	Shoreline monitoring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11	Photo documentation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12	Near Shore Survey	×	✓	✓	×	×	×	×	×	×	×	×	×
No data for CSP 1-10, 23-30, Offshore profile for November 2024, December 2024, January 2025, March 2025, April 2025, and May 2025, and Seabed Sample for April 2025													

4.8 The methodology adopted for verifying various monitored data

The calibrated pressure sensor was installed at Vizhinjam port for tide measurement. The Vizhinjam tide gauge data was connected to a benchmark near the jetty, and the data was observed with respect to the chart datum. NIOT has checked the consistency of the water level by installing a radar level sensor near the existing tide gauge. The periodic check by manual measurement logs is also verified, and the difference is matched well within the acceptable limit. The observed tide data are checked thoroughly, and flagged/suspicious data like spikes are removed.

The beach profile data quality check was carried out based on the quantity of the data received against the temporary benchmark and beach profile comparison with the earlier data sets. The data set has been discarded from the analysis based on the following criteria:
No simultaneous offshore profile data with onshore profile was observed with a contour less than +1 m.

1. More than 50% spatial profile deviation from the previous month's data with respect to x and y coordinates
2. A data set that has less than 4 data points
3. The cross-sectional profiles survey has been carried out using the RTK method. The NIOT team members visited the site during the RTK survey and checked the base station and rover setup during the survey. The consistency of position and level before starting the survey and after finishing the survey has been checked.

Initial data quality analysis has been done based on the above criteria. When two of the above points are noticed in all the profile data in a month, the data of that particular month is discarded. Sudden, unrealistic changes/spikes observed in the profile level that arise for some reason are carefully examined and removed before the analysis. Further, to normalise the gaps in a single profile, bilinear interpolation was carried out to fill the data gaps, and uniform 1-meter interval profile data was generated. The shoreline and nearshore data system (SANDS) that was used in the analysis has its own data quality procedure, which will not allow the system to proceed and analyse the data, but it ends up with an error. All profiles are manually checked before entering the data into SANDS.
The calibration of a multi-beam echo sounder is commonly referred to as a patch test. It is required to identify the offsets that would be applied to the data to compensate for any misalignment in the various sensors used. The offsets from the vessel reference point, DGPS antenna, and transducer were measured and entered into the acquisition software with an in-situ measurement of the sound velocity profiler. NIOT has instructed SSPL to carry out the crossline survey as per the IHO standards for multi-beam surveys. The NIOT team has checked the patch test and other offsets for the bathymetry survey.
The TSS data provided was analysed and verified using the protocol prescribed by the American Public Health Association (APHA) 21st Edition 2540 D and validated using available data. Turbidity was measured using a turbidity meter as per APHA protocol. The instrument was calibrated using formazin / factory-calibrated standard.
The Datawell DWR4 Wave Rider Buoy was deployed by INCOIS and AVPPL. The WRB was programmed to measure all the wave parameters and current speed and direction at the location at half-hourly intervals. The data is collected by INCOIS and sent to the AVPLL-appointed survey agency after quality check.
Grab samples analysis report checked whether i) Grain size analysis is carried out as per IS 2720 PART IV, ii) Grain size distribution chart and table are provided as per IS 2720 PART IV, Appendix A, iii) Soil classification is carried out as per IS 1498, and iv) D50 values and location are provided for each sample. Also, a duplicate set of a few samples is collected and analysed at the NIOT Geotechnical laboratory for cross-verification of the results submitted.

4.9 Wave Observations

Time series for the different wave parameters- Hs, Tp, and Dir, during the observation period from October 2024 to September 2025, are given in Figure 4.8. The dataset covers the period from

October 1, 2024, to September 30, 2025. There is a data gap from October 1, 2024, to October 8, 2024. During the fair-weather season, the sea state remains relatively calm, with an average Hs of 0.79 m. The maximum Hs of 1.87 m was observed on December 2, 2024. In contrast, the Hs during the monsoon seasons is higher, with an average of 1.67 m and a maximum of 2.98 m reported on June 15, 2025. The pre-monsoon season is characterized by moderate sea conditions, with an average Hs of 1.19 m, but the maximum of 3.18 m was observed on 30th May, 2025, due to a tropical disturbance designated as Invest 93A formed in the Arabian Sea near the west coast of India. The minimum Hs observed during the study period was 0.35 m on 8th January, 2025. The average Tp remains consistent around 12 seconds, with maximum Tp ranging from 20.00 s to 22.22 s during different seasons. Pre-monsoon season experiences long-period waves with a Tp of 22.22 s, followed by the monsoon season. The minimum Tp ranges between 3.03 s (during the Fair-weather season) and 5.0 s (during the monsoon season).

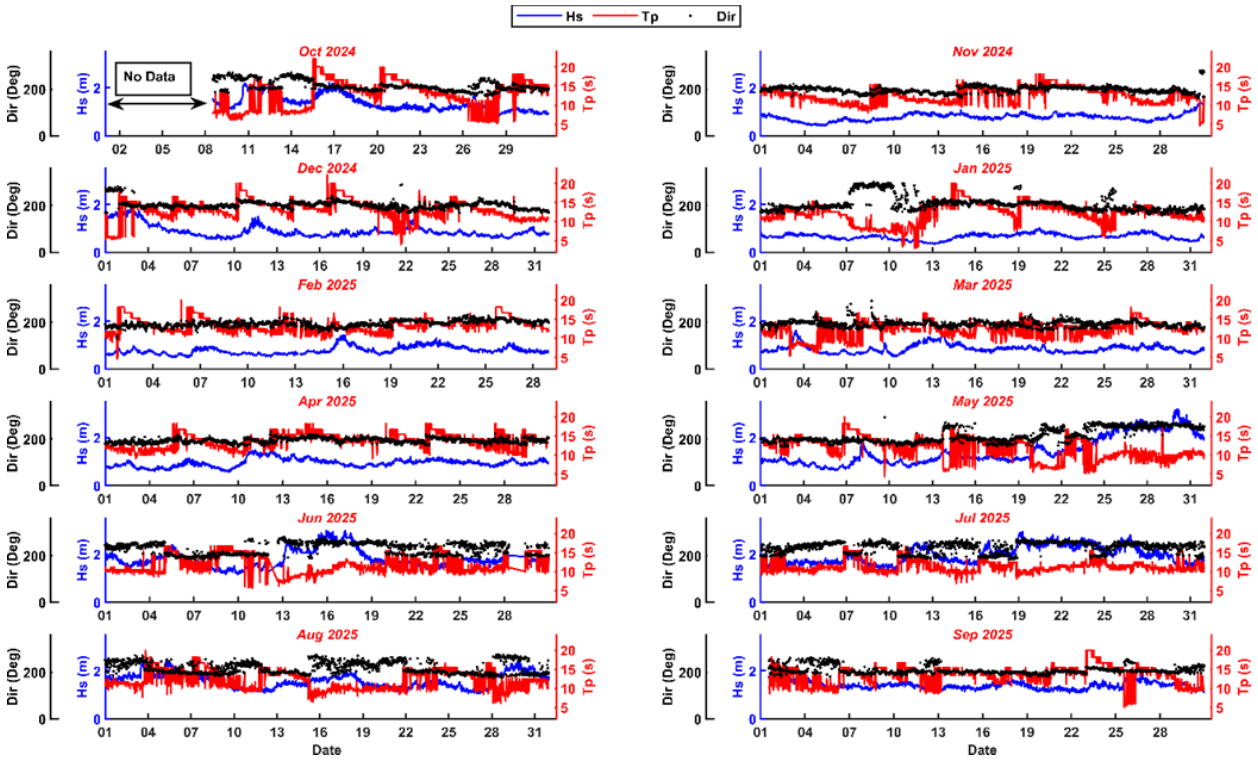

Figure 4.8 Wave observation from October 2024 to September 2025.

4.10 Tidal Observations

The Valeport Tidemaster Automatic Tide Gauge (ATG) was installed near the newly constructed berth inside the breakwater up to 14th May 2025 and then inside the Vizhinjam Fishinjam Harbour from 6th July 2025 onwards to measure the tides. The tide gauge is a pressure-sensor-based instrument that measures the water level due to changes in pressure on the sensor's surface. The sensor was installed in such a way that the zero of the sensor is always in water, irrespective of the phases of the tide. This was levelled to the local benchmark, situated on top of the jetty. The tide station was programmed to measure the tide at 6-minute intervals throughout the duration of the project. The tide is referenced to the Chart Datum (CD). The jetty top value was established at 3.687m above CD. The 'zero' of the sensor has been lowered to 1.355m below the jetty top,

corresponding to a correction factor of 2.332m. The tides observed are mixed semi-diurnal. The tide observation from October 2024 to September 2025 is presented.

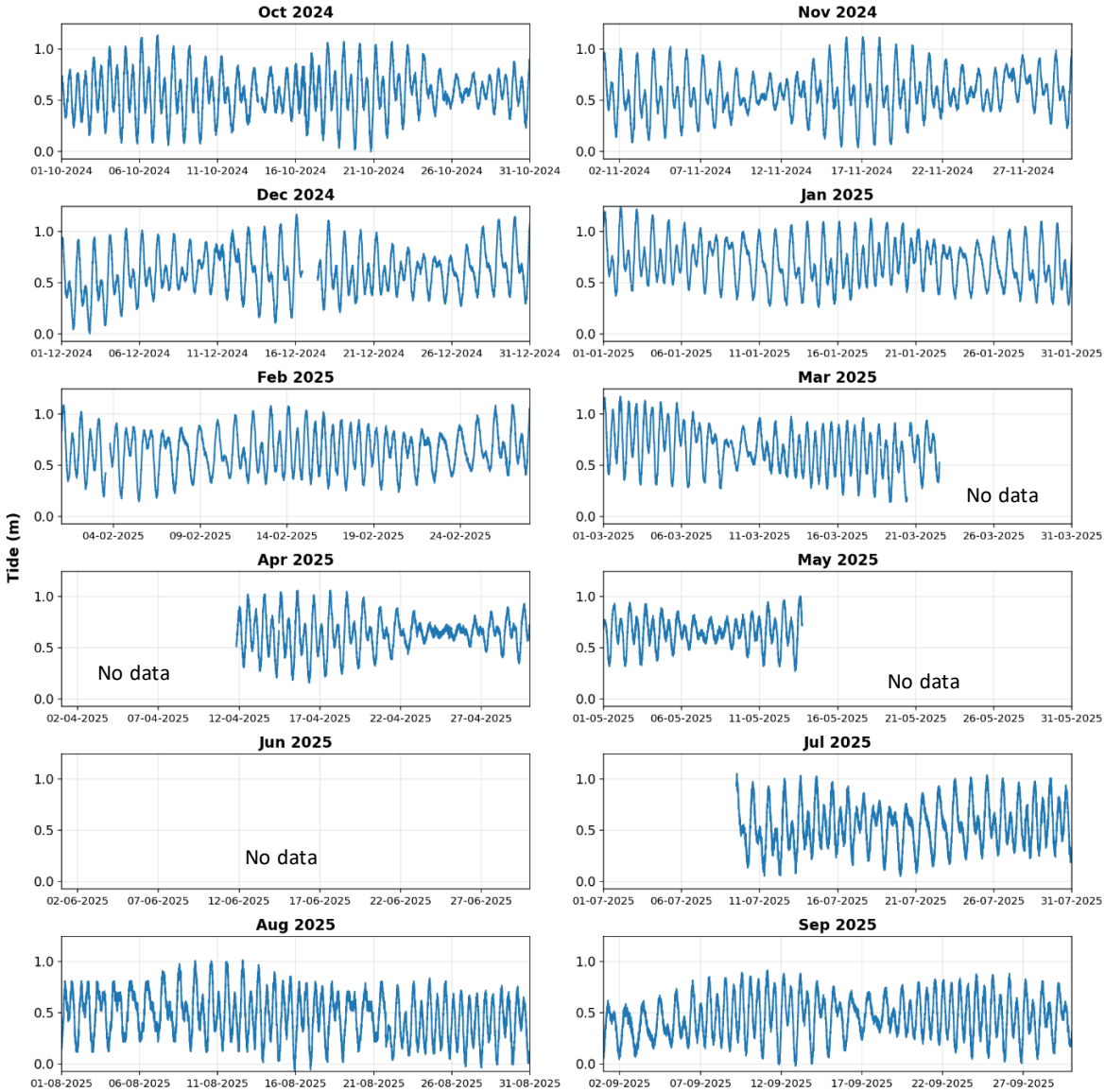

Figure 4.9 Tide observation from October 2024 to September 2025.

5. RESULTS OF THE ANALYSES

In the present study, the beach volume (monthly, seasonal, annual and intra-annual) change from the beach profile data (onshore and offshore data) is presented in section A.1 in detail and the shoreline rate of change statistics from a time series of multiple shoreline positions of a 40 km coastal stretch (20 km either side of Vizhinjam Port) has been taken into account for shoreline change estimation using satellite images (Section A.2) and field shoreline data (Section A.3). The shoreline change analysis (monthly, seasonal, annual and inter- and intra-annual) results from October 2024 to September 2025 have been examined. Based on the rate of change over the period being considered, areas of shoreline change have been categorised into five classes. They are high accretion (>5m/year), moderate accretion (5m to 1m/year), stable coast (1m to -1m/year), moderate erosion (-1m to -5m/year), and high erosion (<-5m/year).

The observations from the beach profile analysis done using SANDS for the entire 40 km stretch have been presented as monthly changes in the beach volume for a period from October 2024 to September 2025, and beach volume changes between October 2023-October 2024, February 2024- February 2025, May 2024-May 2025, and September 2024-September 2025 also have been worked out and presented in this report. Monthly beach volume changes have been assessed by comparing the month-to-month profiles in Section A.1. The erosion and accretion are highlighted with red and green colour fill in the charts for better understanding. The results shown in the charts are also presented in the tables.

The detailed summary of monthly, seasonal, annual, and intra-annual change results using beach profiles, satellite images, and field shoreline data is provided in Table 5.5.

The report summarises monthly onshore beach volume changes from October 2024 to September 2025, it was found that beaches exhibited accretion at Pozhiyoor (CSP10), Poovar south (CSP15,17), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP42,46), Panathura (CSP48), Punthura (CSP53), Valliyathura (CSP64A) and Shangumugham (CSP69) while erosion at Poovar south (CSP16), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP31-34), Mullur (CSP37), the port reclamation area (CSP40A), Kovalam (CSP43-45,46), Punthura (CSP54-55), Cheriyathura (CSP62), (CSP68), Shangumugham to Thumba (CSP70-81). There is no data from CSP01-10 and 23-30. Due to rough sea conditions, the offshore survey was not carried out in any locations from September 2024 to November 2024, February 2025, and June 2025 to September 2025. As a result, an analysis of the offshore beach profile was not conducted to assess the overall volume change for this year.

The shoreline changes using satellite images from October 2024 to September 2025 show accretion at Edapadu to Paruthiyoor (CSP01-15), Adimalathura to Mullur (CSP35-36), Kovalam to Pannathura (CSP40-47), Punthura to Beemapally (CSP56-60), Valliyathura (CSP63-65), Shangumugham (CSP67-70), Kochuveli (CSP78), while erosion at Paruthiyoor to Adimalathura (CSP14-34), Punthura (CSP53-55), Beemapally (CSP61), Valliyathura (CSP66), Vettucaud to Thumba (CSP71-77, 79-81).

The shoreline changes using field-measured shoreline data from October 2024 to September 2025 shows accretion at Neerody (CSP11), Adimalathura to Mullur (CSP34-36), Kovalam (CSP43-45), Punthura (CSP56-58), Valliyathura (CSP63, 66), Shangumugham (CSP70-71), while erosion at Neerody (CSP10), Paruthiyoor to Poovar (CSP13-22), Adimalathura (CSP31-34), Kovalam (CSP42), Punthura (CSP53-55), Beemapally (CSP60-62), Valliyathura (CSP64-66), Shangumugham to Thumba (CSP68-69, 72-81)—no field data collected by survey agency from CSP01 to10, 23 to CSP30 due to local protest.

The result from the 2012 to 2015 shoreline change analysis using high-resolution satellite images indicates erosion at Poovar (CSP17), Adimalathura (CSP32-33), Punthura (CSP53-55), Valliyathura (CSP66), and Vettucaud to Valiyaveli (CSP 75-81) while accretion at Poovar South (CSP14-15), Poovar North (CSP18-20), Karumkulam (CSP 22), Pullavila (CSP30), Karumkulam (CSP 25), Pullavila (CSP27), Shangumugham (CSP69). The comparison of the 2015 shoreline with 2025 using high-resolution satellite images shows erosion at Edapadu beach (CSP02,03), Paruthiyoor to Poovar (CSP14-21), Adimalathura (CSP34-35), Kovalam (CSP44), Punthura (CSP57), Valliyathura to Thumba (CSP64-81) while Vallavilay to Pozhiyoor (CSP04-10), Poovar to Adimalathura (CSP16-33), (CSP43-52), Beemapally (CSP58-60) shows stable and accretion at Edapadu beach (CSP01), Neerody (CSP09), Mullur (CSP36-37), Panathura north (CSP53), Cheriyathura (60-63). Figure 5.1 shows the shoreline change results from 2012 to 2015 and 2015 to 2025, indicating erosion and accretion spots identified from satellite images before and after

2015 using high-resolution satellite images. Figure 5.2 depicts the pie chart of artificial and natural coasts in 2015 and 2025. The shoreline change analysis carried out using satellite images and the beach profile data is shown in Figure 5.3, and the corresponding list of erosion, accretion, and stable spots is listed in Table 5.1.

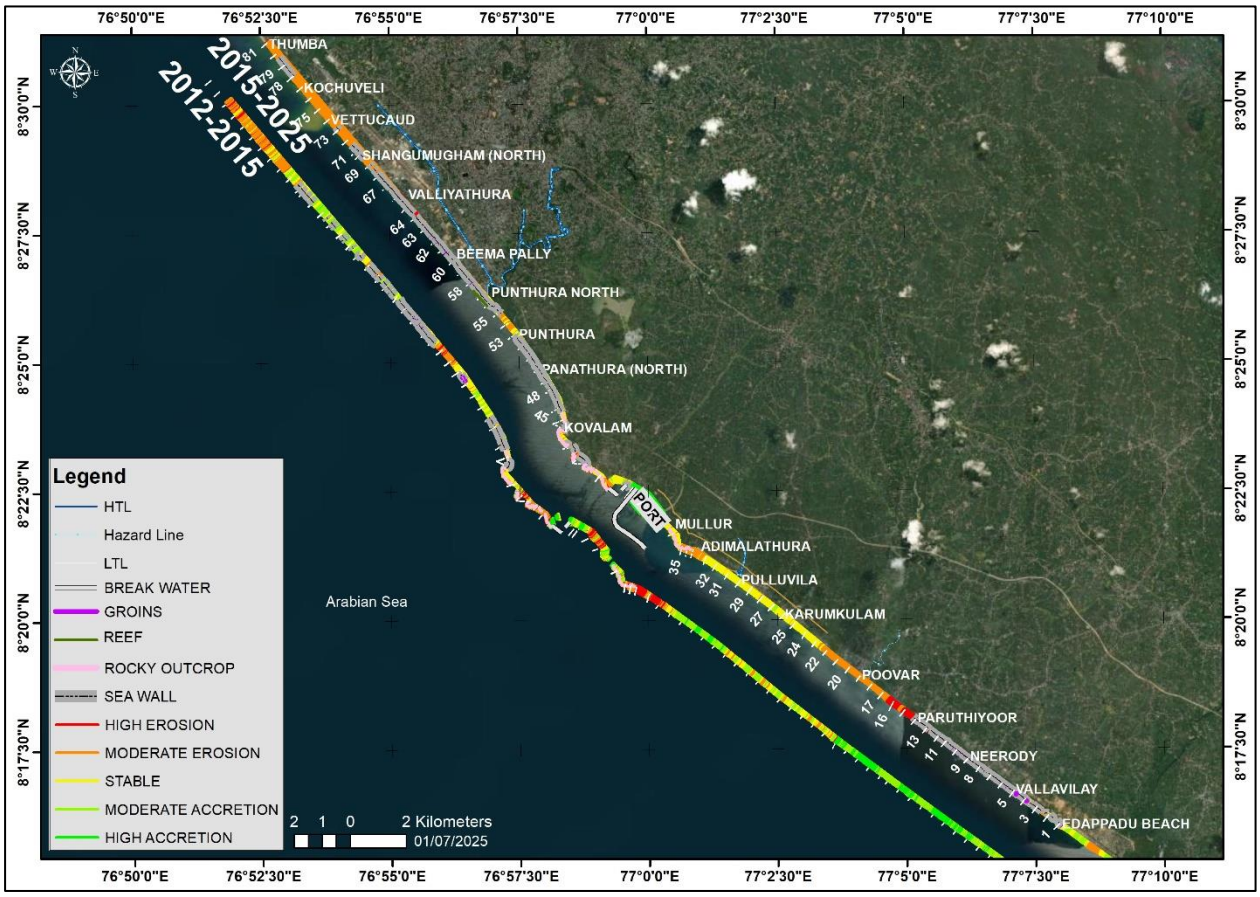

Figure 5.1 Shoreline Change Analysis for the period 2012 to 2015 and 2015 to 2025 using high-resolution satellite images

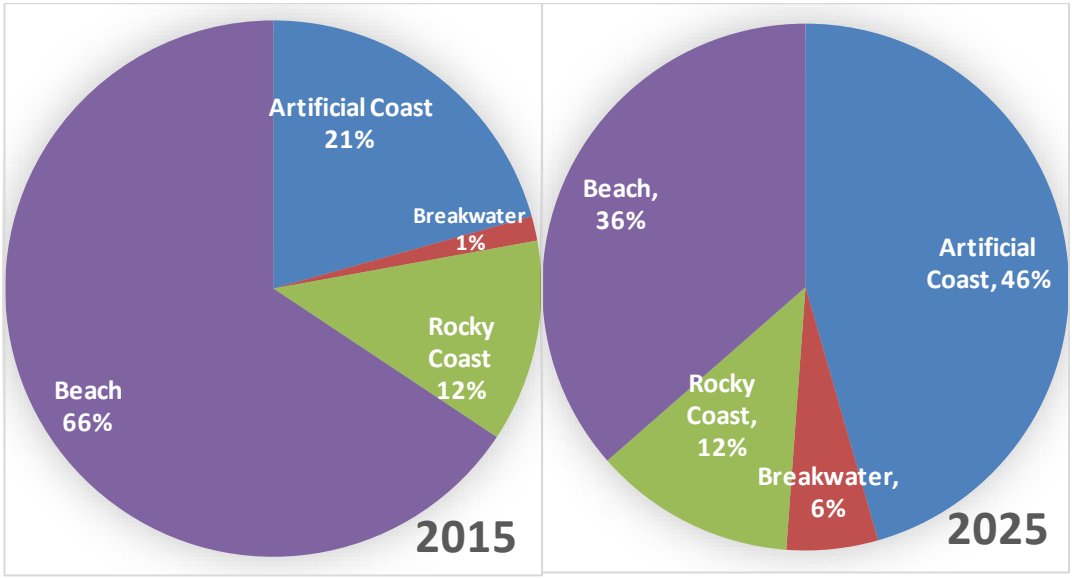

Figure 5.2 Pie chart showing artificial coast (seawall, groynes), rocky coast, breakwater, and beach in 2015 and 2025.

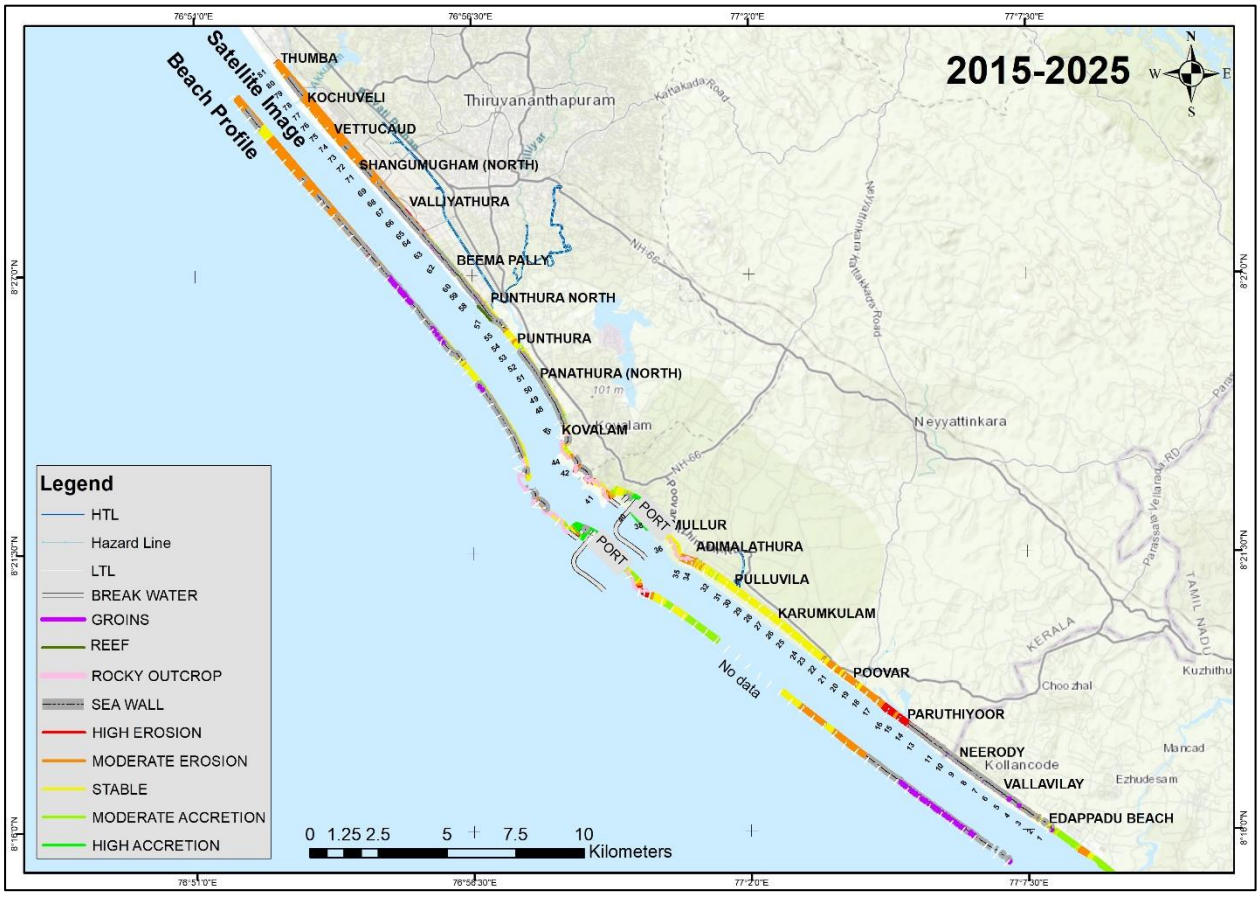

Figure 5.3 Shoreline Change Analysis for the period February 2015 to February 2025 using high-resolution satellite images and beach profile (onshore) data

Table 5.1. Erosion and accretion spots were identified from the beach profile (onshore) and satellite image analysis for the period February 2015 to February 2025.

	From Satellite image analysis	From Beach profile analysis-Onshore
Erosion spots	Edapadu beach (CSP02,03), Paruthiyoor to Poovar (CSP14-21), Adimalathura (CSP34-35), Kovalam (CSP44), Punthura (CSP57), Valliyathura to Thumba (CSP64-81)	No data from CSP01-10, 23-30, Pauthiyoor to Poovar (CSP11-16), Adimalathura (CSP34-35), Kovalam (CSP42), Valiyathura to Thumba (CSP63-76, 79-81)
Accretion spots	Edapadu beach (CSP01), Neerody (CSP09), Mullur (CSP36-37), Panathura north (CSP53), Cheriyathura (60-63)	Pulluvila to Adimalathura (CSP29-33), Mullur (CSP36-37), Panathura north (CSP53), Cheriyathura (CSP61-62)
Stable spots	Vallavilay to Pozhiyoor (CSP04-10), Poovar to Adimalathura (CSP16-33), (CSP43-52), Beemapally (CSP58-60)	Poovar to Karumkulam (CSP21-22, 31-32), Kovalam to Beemapally (CSP43-60), Kochuveli (CSP77-78)

The trend analysis from 2000 to 2025 was carried out for the erosion and accretion spots using high-resolution satellite images for the four accretion hotspots, such as Kochuveli, Vizhinjam, Adimalathura, Poovar, and four erosion hotspots, such as Shangumugam, Valliyathura, Punthura, and Edapadu. The erosion spots from shoreline change analysis have been compared for five-year periods (2000-2005, 2005-2010, 2010-2015, and 2015-2025) as shown in Table 5.2 and yearly erosion spots from 2018 to 2025 in Table 5.3. Historically, discrete locations such as

Kochuveli, Shangumugham, Valliyathura, Punthura, Pulluvila, and Poovar have consistently appeared as erosion hotspots across multiple five-year periods (2000-2020). During the most recent period (2020-2025), erosion is no longer confined to isolated pockets but has expanded into a continuous stretch from Thumba to Kochuveli, suggesting a shift from localized erosion to alongshore-distributed shoreline retreat. This spatial spreading corresponds with the implementation of shore protection measures at previously high-erosion sites such as Karumkulam-Edapadu, Shangumugham, and Punthura, which have effectively reduced localized high erosion. However, these protection structures have also altered shoreline dynamics, resulting in the redistribution of erosional stress to adjacent, unprotected shore segments. Consequently, areas like Valliyathura and Shangumugham, which earlier exhibited high erosion at specific points, now experience moderate erosion over longer stretches extending from Thumba to Kochuveli. This transition from concentrated high erosion zones to broader moderate erosion stretches highlights the combined influence of coastal interventions, changing hydrodynamic conditions, sediment inputs, and recent climatic extremes, including cyclonic activity, swell surge (Kallakadal) events, and disrupted fair-weather accretion cycles.

Table 5.2. Comparison of Erosion spots since 2000 using high-resolution satellite images

2000-2005	2005-2010	2010-2015	2015-2020	2020-2025
Kochuveli	-	Kochuveli	Kochuveli	Thumba to Kochuveli
Shangumugham	Valliyathura	Shangumugham	Shangumugham	Shangumugham
Valliyathura		Valliyathura	Valliyathura	Valliyathura
Punthura		Punthura	Punthura	Punthura
Pulluvila		Pannathura	Pullivila	-
		Poovar	Poovar	Poovar

Table 5.3. Comparison of Erosion spots from previous annual reports submitted since 2018

2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025
Kochuveli	Thumba to Vettucaud	Kochuveli Cheriyathura	Thumba to Kochuveli	Thumba to Kochuveli	Thumba to Kochuveli	Thumba to Vettucaud
Shangumugham	Shangumugham	Shangumugham	-	Shangumugham	Shangumugham	Shangumugham
Valliyathura	Valliyathura	Valliyathura	Valliyathura	-	Valliyathura	Valliyathura
Punthura	Punthura	Punthura	Punthura	-	Punthura	Punthura
Pulluvila to Edapadu	Karumkulam to Edapadu	Pulluvila	-	Poovar	Poovar	Poovar
			-	-	-	-

*Red colour indicates the places that are continuously appearing in erosion spots

A trend analysis was carried out for the hotspot locations along the coast from 2000 to 2025 using high-resolution satellite images, as shown in Figure 5.4. The hotspots are the locations that have been facing erosion or accretion consistently and severely for a long period. The trend indicates the retreating shoreline position from the baseline, clearly showing the impact of Cyclone Ockhi (December 2017) and Cyclone Tacuktae (May 2021) along the coast. The effect of the climatic events has significantly increased along the Kerala coast. Notably, during Cyclone Ockhi, high erosion occurred along the south Kerala coastline, and the original profile of the coast has not recovered. The Thiruvananthapuram coast experienced several significant climatic events from October 2024 to September 2025. In October 2024, January 2025, May 2025, and June 2025, a series of Kallakadal swell surge warnings were issued by the Indian National Centre for Ocean Information Services (INCOIS), causing rough sea conditions with wave heights reaching up to 3.5 meters during June. Cyclone Fengal affected the region from late November to early December 2024 with heavy rains and strong winds. Notably, the southwest monsoon arrived early in 2025, with the India Meteorological Department declaring its onset over Kerala, including Thiruvananthapuram, on May 24, eight days ahead of the usual June 1 date. This early monsoon arrival marked the earliest onset since 2009 and was influenced by favorable atmospheric and oceanic conditions. These events reflect a dynamic coastal climate influenced by monsoonal patterns, tropical cyclones, and ocean swell surges.

Increasing cyclone intensity in the Arabian Sea—rising by about 40% during the pre-monsoon season and 20% during the post-monsoon season over the last four decades—combined with warmer sea surface temperatures and higher ocean heat content, has strengthened storm-driven wave and surge conditions along the Thiruvananthapuram coast. These enhanced atmospheric-oceanic forcings contribute to more frequent episodic erosion, greater cross-shore sediment loss during cyclone and monsoon peaks, and the accelerated reshaping of beaches such as Shangumugham, Valliyathura, and Poovar. As a result, recent shoreline change patterns increasingly reflect the influence of extreme events over gradual seasonal processes, amplifying coastal vulnerability. (Dhara et al., 2025).

Erosion trends across specific coastal areas, including Shangumugham, Valliyathura, Kochuveli, and Poovar, reflected seasonal patterns. High erosion occurred during the northeast monsoon (October-March) due to stronger waves and winds, with recovery observed during the calmer months (April-June). Shangumugham and Valliyathura experienced peak erosion in December and January, stabilizing during the post-monsoon period. Kochuveli faced erosion in January and February, followed by slower rates in March, while Poovar showed significant erosion in December and January, recovering partially by June. These patterns underscore the vulnerability of the Thiruvananthapuram coast to monsoon-driven erosion and the importance of protective measures to mitigate damage.

As regards the net littoral drift along the Kerala coast, it is known that the net littoral drift is towards the North direction (Sheela Nair et al. 2015), with erosion of beaches taking place during Monsoon periods, followed by accretion during pre- and post-SW monsoon months. With specific reference to the southern shore of the Vizhinjam region, sand is transported, mainly in the breaker zone, from south to north during most of the year. However, sand transport also occurs from north to south in the monsoon season. Thus, it is a fact that sediment transport will occur in both directions along the Vizhinjam coast.

Furthermore, no dredging or breakwater construction occurred in the Port area from October 2024 to September 2025. Consequently, there were no significant human-induced changes (due to Port development) in sediment movement in the port area during this time, and the sediment distribution patterns primarily reflect natural coastal processes. However, two groynes—one short groyne to the north of the port near Poonthura and two to the south near Paruthiyoor were newly installed.

In summary, the Thiruvananthapuram coast exhibits dynamic shoreline changes driven by seasonal variations in currents, waves, and wind patterns. Monsoon-induced high-energy conditions contribute to erosion and sediment redistribution, while calmer post-monsoon periods promote partial recovery. Sediment composition, rainfall, and erosion trends reinforce the seasonal impact on shoreline stability. The findings underscore the importance of continuous monitoring, effective sediment management, and robust erosion control strategies to protect the coast against long-term environmental changes.

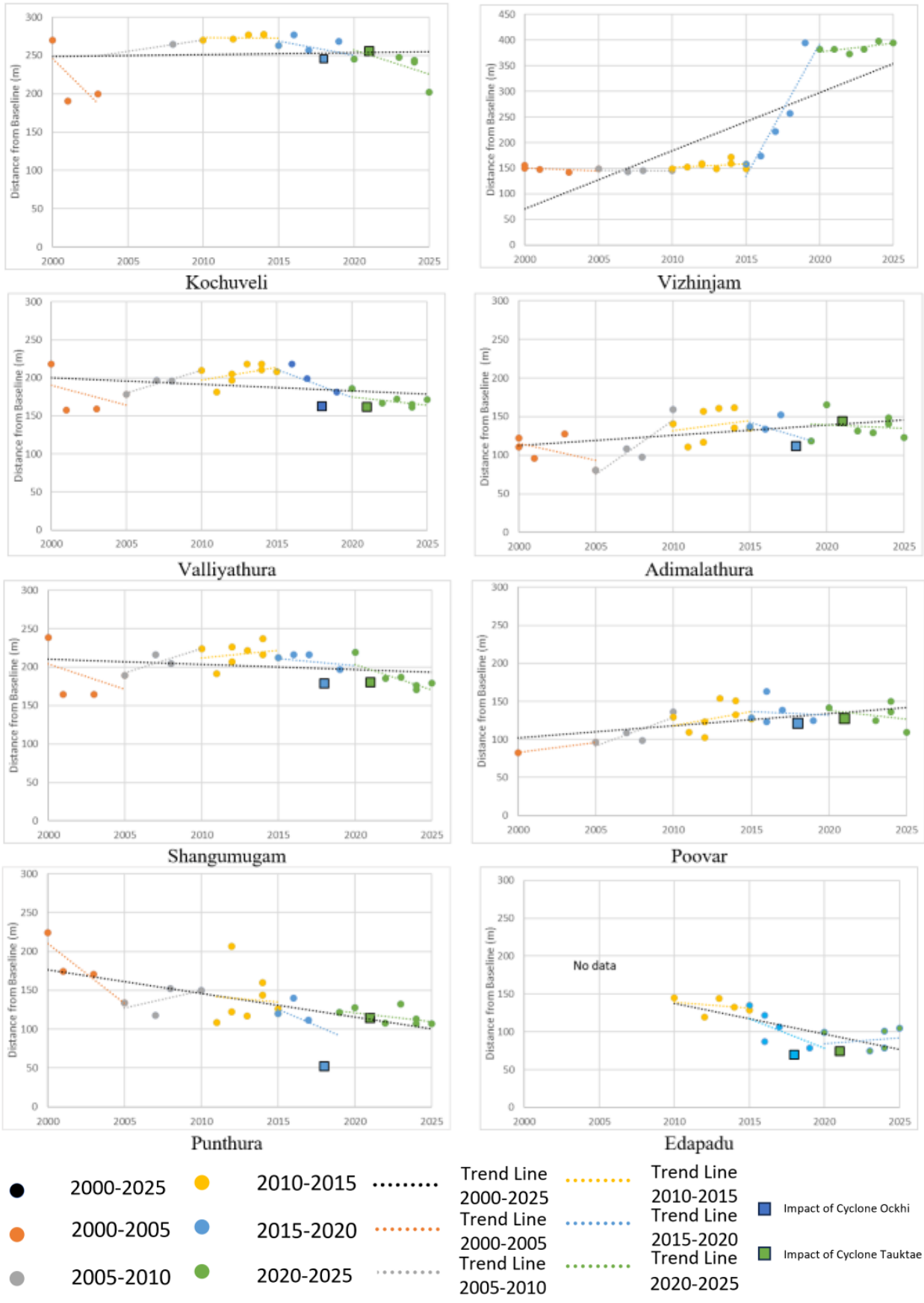

Figure 5.4 Trend analysis of shoreline change distance from baseline from 2000 to 2025, and trends before and after 2015

Validation and Comparison

The shorelines were validated by comparing shorelines derived from February 2025 satellite data with those obtained from available beach profile measurements and field-collected shoreline data (33 profiles out of 81). The beach profile data, collected at 500m intervals, and field shoreline data, collected using the Digital Global Positioning System (DGPS), are used for validation. The Shorelines derived from the satellite image for February 2025 are compared with the shoreline derived from field data and the corresponding tide level of the beach profile data, as shown in Figure 5.5. The regression coefficient (R2) of 0.95 is achieved when compared with the shoreline derived from the beach profile data, whereas 0.98 is achieved with the field shoreline data. This comparison evaluates the accuracy of capturing shoreline dynamics.

Several institutes and organisations have conducted shoreline change analysis studies along the Thiruvananthapuram coast, utilising satellite imagery and tools such as the Digital Shoreline Analysis System (DSAS), as listed in Table 5.4. SAC (2014) analysed High Water Line (HWL) data from 1989-1991 and 2004-2006, while SAC (2021) reported 2004-2006 and 2014-2016, incorporating field observations for accuracy. INCOIS (2012) utilised Landsat TM and IRS P6 LISS III imagery (1992-2011) to estimate shoreline change rates, categorising changes as ranging from high erosion (<-5m/year) to high accretion (>5m/year). NCSCM (2010) conducted a 38-year study (1972-2010) and categorised the shoreline into eight classes, including erosion, accretion, stability, and artificial coasts. NCCR (2016, updated in 2022) extended the analysis period (1990-2018) using multiple satellite datasets and classified changes into high, moderate, and low erosion/accretion zones. NIOT's present study provides a comprehensive assessment from 2000 to 2025, leveraging high-resolution imagery (1m to 5m) and focusing on both long-term and short-term shoreline variations.

Key findings indicate zones of high erosion predominantly at Valliyathura, Shangumugham, Punthura, Poovar, and Edapadu. Historical records (Table 5.4) show erosion hotspots at Valliyathura and Punthura during different periods, with consistent vulnerability observed. In contrast, areas such as Poovar, Vizhinjam Port region, Adimalathura, Karumkulam, and Kochuthura were identified as high accretion zones, indicating sediment deposition and shoreline growth. These studies highlight the dynamic nature of the Thiruvananthapuram coast, underscoring the need for ongoing monitoring and targeted coastal management strategies to mitigate erosion and stabilise vulnerable areas.

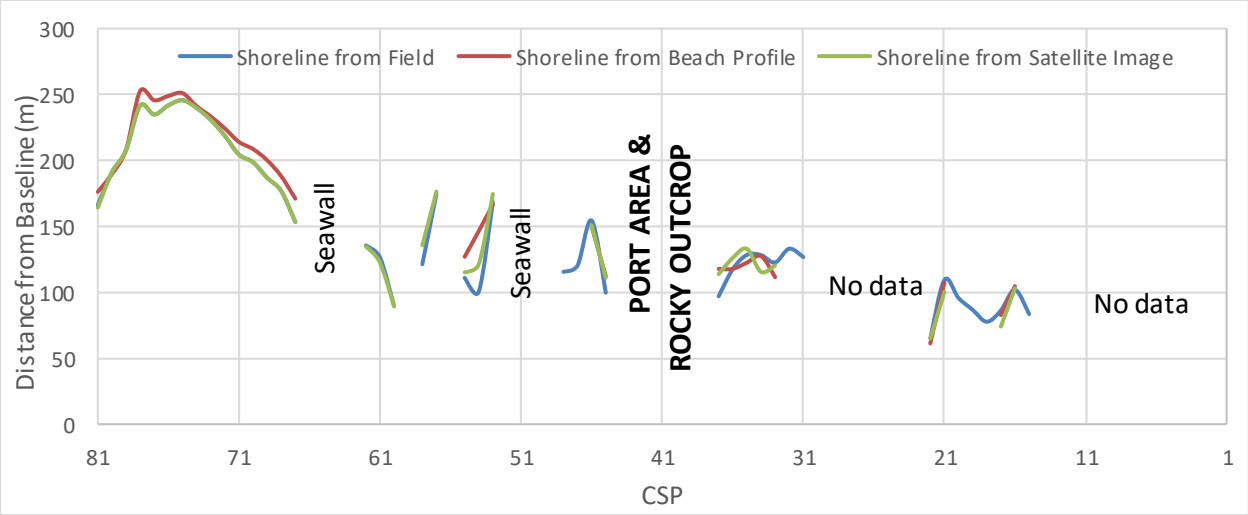

Figure 5.5 Comparison of shoreline changes estimated from the satellite images, beach profiles and field data at 500m intervals.

Table 5.4 Comparison of Erosion spots from previously published reports

Institute/ Organisation	SAC (2014) Updated (2021)	INCOIS and L&T (2012)	NCSCM (2010)	NCCR (2016) Updated (2022)	NIOT (present study)
Shoreline Change Analysis studies	• HWL of 1989-91 and HWL of 2004-2006 (2014 report), HWL of 2004-06 and HWL of 2014-2016 (2021 report) have been considered to derive the areas under erosion and accretion. • Field checks were carried out, and corrections were incorporated based on field observations.	• Landsat TM and IRS P6 LISS III over the period from 1992 to 2011 have been considered. • Shoreline change rates were estimated during the period of 1992-2011 using the DSAS tool.	• Over the period of 38 years from 1972 to 2010. • USGS Digital Shoreline Analysis System (DSAS) software in ArcGIS.	• Landsat TM, ETM+, IRS P5 PAN, IRS P6 LISS III, and Resoursesat LISS IV over the period from 1990-2018 have been used. • Shoreline change rates were estimated during the period of 1990-2018 using the DSAS tool.	• For long-term changes, from 2000 to 2024, using high resolution (5m, 2.5, and 1m), from 2012 to 2024, using satellite images of less than 1m (from 1973 to 2024 Landsat/ Sentinel images) • USGS Digital Shoreline Analysis System (DSAS) software in ArcGIS.
Analysis of Results (Quantitative/ Qualitative)	Hotspots were identified based on the magnitude of shoreline dynamics. Recent satellite images (2011-2012) were acquired and analysed.	The change rates were classified as : High erosion (<-5m/year), Low erosion (-2--5m/year), no change (erosion and accretion up to 2m/year), low accretion (2-5m/year) and high accretion (>5m/year)	The results were categorised into eight classes of zones of erosion/accretion, such as: High accretion, medium accretion, low accretion, stable coast, low erosion, medium erosion, high erosion, and artificial coast.	The change rate was categorised as follows: High erosion (<-5.0) Moderate Erosion (-5.0 to -3.0) Low Erosion (-3.0 to -0.5) Stable coast (-0.5 to 0.5) Low Accretion (0.2 to 3.0) Moderate Accretion (3.0 to 5.0) High Accretion (>5.0)	The change rates were classified as: High accretion (>5m/year), moderate accretion (5-1m/year), stable coast (1 to -1m/year), moderate erosion (-1 to -5m/year), and high erosion (<-5m/year).
Zones of High Erosion	Shangumugam, Valliathura, Thirvallam	Between Valliathura and Punthura- a stretch of 5 Kms. (Muthala Pozhi) **1992-1997**- Narakattara (Killi) **1997-2001**- Valliyathura **2001-2006**-Between Narakattara and Kovalam **2006-2011**- Narakattara (Killi)	Valliyathura beach	Punthura, Valliyathura	Valliyathura, Shangumugham, Punthura, Poovar, and Edapadu
Zones of High Accretion	Puliyakudi, Karumkulam, Poovar	Poovar, Kovalam, Adimalathura,	Poovar	Karumkulam, Kochuthura	Vizhinjam Port region, Adimalathura, and Poovar

Table 5.5. Erosion and Accretion spots identified from Satellite images, Beach profile analysis (onshore), and Field Shoreline during each month and season from October 2024 to September 2025

Month Year	Erosion/ Accretion	From Satellite image analysis	From Beach profile analysis-Onshore	From Field Shoreline analysis
October 2024	Erosion spots	Edappadu beach (CSP01), Mullur (CSP37), Kovalam (CSP41-42), Punthura (CSP52-53), Valliyathura to Thumba (CSP66-81)	Poovar North (CSP21), Adimalathura (CSP34), port reclamation area (CSP40A), Kovalam (CSP42), the stretch from Kovalam to Panathura (CSP47-48), Punthura (CSP53), Cheriyathura (CSP62), ValliyathuraShangumugham (CSP67-70), andVettucaud to Thumba (CSP73-81)	Poovar Beach (CSP16-18), Pulluvila (CSP 31), Punthura (CSP53-54), Valliyathura to Thumba (CSP67-81).
	Accretion spots	Edapadu to Vallavilay (CSP02-05), Neerody (CSP07), Poovar North to Karumkulam (CSP18-26), Adimalathura (CSP32-34), Kovalam (CSP42-44), Punthura to Valliyathura (CSP54-65).	Poovar south to north (CSP15-20), between Karumkulam (CSP22), Adimalathura (CSP31-33), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP43-46), Punthura (CSP54-55), Beemapally (CSP60) and from Shangumugham to Vettucaud (CSP71-72)	Poovar beach (CSP15), Adimalathura (CSP32-34)
November 2024	Erosion spots	Edapadu to Neerody (CSP01-09), Poovar (CSP16), Kovalam (CSP41-44), Punthura (CSP53), Valiyathura (CSP63)	Pozhiyoor (CSP10), Poovar South (CSP15-16), Poovar (CSP18-19), Adimalathura (CSP31-32), Mullur (CSP36-37), Port reclamation area (CSP40A), Kovalam (CSP 44,47), Punthura (CSP53), Beemapally (CSP60) and Thumba (CSP81)	Poovar (CSP15)
	Accretion spots	Poovar to Adimalathura (CSP17-34), Punthura (CSP54-58), Beemapally (CSP59-60), Valliyathura to Thumba (CSP64-81).	Poovar South (CSP17), Poovar Northto Karumkulam (CSP20-22),Adimalathura to Azhimala (CSP33-35), Kovalam (CSP42-43,45-46), Panathura South (CSP48), Punthura (CSP54-55), Cheriyathura(CSP62), Valliyathura (CSP64A), Valliyathura to Thumba (CSP67-80)	Poovar to Karumkulam (CSP16-22), Adimalathura toAzhimala(CSP 31-35), Kovalam to Thumba (CSP45-81).

December 2024	Erosion	Paruthiyoor (CSP14), Punthura (CSP53), Beemapally (CSP60), Valliyathura (CSP64).	Poovar South (CSP16),Poovar north (CSP21), Adimalathura (CSP31), Azhimala (CSP35), Mullur (CSP37), the port reclamation area (CSP40A),Punthura (CSP55), Cheriyathura (CSP62), Shangumugham to Vettucaud (CSP68-73),Kochuveli (CSP76-77) and Valiyaveli to Thumba (CSP79-80)	Poovar (CSP15), Pulluvila (CSP 31), Punthura (CSP53-54), Valliyathura (CSP64-67)
	Accretion spots	Edapadu to Neerody (CSP01-11), Poovar (CSP15-18), Adimalathura (CSP33-35), Punthura (CSP56-58), (CSP78).Shangumugham (CSP68-71), Vettucaud (CSP72) Kochuveli (CSP74-75), Thumba (CSP78)	Pozhiyoor (CSP10), Poovar South (CSP15), from Poovar South to north (CSP17-20), Karumkulam (CSP22), Adimalathura (CSP31-33-34), Azhimala to Mullur (CSP35A-36), Kovalam (CSP42,44,46-47), Panathura (CSP48), Punthura (CSP53-54), Cheriyathura (CSP60-61), Valliyathura (CSP64A,67) and Vettucaud to Kochuveli (CSP74-75), as well as Thumba (CSP81)	Poovar (CSP16-17), Adimalathura (CSP34), Kovalam (CSP42-43), Shangumugham to Thumba (CSP69-80).
January 2025	Erosion spots	Poovar (CSP16), Pulluvila (CSP30-32), Mullur (CSP37), Beemapally to Cheriyathura (CSP59-61), Valliyathura (CSP63-65).	Area from Poovar South to Poovar (CSP15-18), Adimalathura (CSP32), Mullur (CSP37), Kovalam (CSP44), Punthura (CSP53, 55), Beemapally (CSP60),Vettucaud (CSP73-74), Valiyaveli (CSP78) and Thumba (CSP81)	Poovar (CSP14)
	Accretion spots	Edapadu (CSP01-04), Pulluvila(CSP28-29), Adimalathura (CSP32-35), Pannathura (CSP48-52), Punthura (CSP53-58), Shangumugham (CSP71), Vettucaud (CSP74-75).	Pozhiyoor (CSP10), Poovar South (CSP15), Poovar to Karumkulam (CSP19-22), Adimalathura (CSP31), the stretch from Adimalathura to Mullur (CSP33-36), the Port reclamation area (CSP40A), the section from Kovalam (CSP42-43), Kovalam toPanathura (CSP45-48), Punthura (CSP54), Cheriyathura (CSP61-62), and the area from Valiyathura (CSP64A), Valliyathura to Vettucaud (CSP67-72), Kochuveli (CSP75-77) and Valiyaveli to Thumba (CSP79-80)	Poovar (CSP16), Adimalathura (CSP32-34), Kovalam (CSP44-46), Punthura (CSP53-58), Vettucaud to Thumba (CSP73-80).
February 2025	Erosion spots	Edapadu (CSP01), Poovar (CSP14-15,17-21), Punthura (CSP53), Cheriyathura (CSP61), Valliyathura	Pozhiyoor (CSP10), Poovar south(CSP15), Poovar (CSP19), between Adimalathura and Azhimala (CSP33-35), Mullur (CSP36-37), Kovalam (CSP45,47), Punthura (CSP53-55),	Poovar (CSP15, 18-21), Punthura (CSP53), Cheriyathura (CSP61-62), Valliyathura (CSP66),

		(CSP63,66), Vettucaud (CSP73), Valliyaveli (CSP79), Thumba (CSP80).	Cheriyathura (CSP62), Valiyathura (CSP64A), from Valiyathura to Shangumugham (CSP66-68),Kochuveli (CSP75-76) and Thumba (CSP80	Kochuveli (CSP77), Thumba (CSP80).
	Accretion spots	Vallavilay (CSP03-05), Karumkulam (CSP22-24), Adimalathura (CSP33-35), Kovalam (CSP41-43), Pannathura to Punthura (CSP48-52,56-57).	At Poovar South to Poovar (CSP16-18), Poovar north to Karumkulam (CSP20-22), Adimalathura (CSP31-32), Azhimala (CSP35A), the port reclamation area (CSP40A), from Kovalam (CSP42-44,46), Panathura (CSP48), from Beemapally to Cheriyathura (CSP60-61), between Shangumugham and Vettucaud (CSP69-74), Kochuveli to Valiyaveli (CSP77-79) and Thumba (CSP81)	Poovar (CSP16), Adimalathurato Azhimala (CSP33-35), Kovalam (CSP42-43), Punthura (CSP54-56).
March 2025	Erosion spots	Edapadu to Vallavilay (CSP01-03), Neerody to Paruthiyoor (CSP08-09, 11-15), Poovar (CSP18-19), Kaurmkulam to Pulluvila (CSP23-30), Mullur (CSP36-37), Kovalam (CSP40-45), Pannathura (CSP50-51), Punthura (CSP52-55), Beemapally (CSP60), Valliyathura (CSP63-66), Shangumugham to Thumba (CSP67-81)	Poovar South (CSP15), Poovar south to north (CSP17-21), Adimalathura (CSP31-32), Azhimala (CSP35),Kovalam (CSP42-44),Kovalam to Panathura (CSP46-48), Cheriyathura (CSP61), Valiyathura (CSP64A,67), Shangumugham (CSP69,71), Vettucaud (CSP74), Kochuveli to Valiyaveli (CSP77-79) and Thumba (CSP81)	Poovar (CSP15-17), Punthura (CSP53-55), Beemapally (CSP61), Valliyathura (CSP62, 67), Shangumugham (CSP68-70), Thumba (CSP78-81).
	Accretion spots	Vallavilay (CSP05), Neerody (CSP07), Poovar (CSP17,20), Adimalathura (CSP30-35), Pannathura (CSP48), Punthura (CSP56-58), Beemapally (CSP61), Valliyathura (CSP63-66)	Pozhiyoor (CSP10), Karumkulam (CSP22), Adimalathura (CSP33-34), Azhimala-Mullur (CSP35A-37), Port reclamation area (CSP40A), Kovalam (CSP45), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham (CSP68, 70), Vettucaud (CSP72-73), Kochuveli (CSP75-76), and Thumba (CSP80).	Adimalathura (CSP31-34), Punthura (CSP58)
April 2025	Erosion spots	Paruthiyoor (CSP14-16), Puuluvia to Adimalathura (CSP28-33), Kovalam (CSP43-44), Pannathura (CSP47-53), Valliyathura (CSP63-65)	Pozhiyoor (CSP10), from Poovar South to Poovar (CSP17-18),Poovar north (CSP20), Adimalathura (CSP32), Port reclamation (CSP40A), Kovalam (CSP45), Beemapally to Cheriyathura (CSP60-61), Valliyathura (CSP64A), Shangumughamto Kochuveli (CSP69-76) and Valiyaveli (CSP79)	Neerody (CSP10), Poovar (CSP14-18), Adimalathura (CSP31-33), Punthura (CSP53-54), Shangumugham (CSP67)

	Accretion spots	Edapadu to Paruthiyoor (CSP01-13), Poovar (CSP16-27), Kovalam (CSP40-42), Pannathura (CSP45-46), Punthura (CSP54-57), Beemapally (CSP58-62), Valliyathura to Thumba (CSP66-81)	Poovar South (CSP15), Poovar (CSP19), Poovar north to Karumkulam (CSP21-22), Adimalathura (CSP31),Adimalathura to Mullur (CSP33-37), Kovalam (CSP42-44),Kovalam to Panathura (CSP46-48),Punthura (CSP53-55), Cheriyathura (CSP62), Shangumugham (CSP68), Kochuveli to Valiyaveli (CSP77-78) and Thumba (CSP81)	Mullur to Adimalathura (CSP33-36), Kovalam (CSP41-45), Shangumugham to Thumba (CSP69-81)
May 2025	Erosion spots	Paruthiyoor to Poovar (CSP11-18), Karumkulam (CSP24-25), Kovalam (CSP41, 45), Pannathura (CSP46, 48), Punthura (CSP53-54), Valliyathura (CSP63-64), Shangumugham (CSP66-70)	Pozhiyoor (CSP10), Poovar South to Karumkulam (CS17-P22), AdimalathuratoAzhimala (CSP34-35A), Mullur (CSP37), Port area (CSP40A), Kovalam (CSP42), Panathura (CSP48), Punthura (CSP53-55), Shangumugham (CSP69,71), and Thumba (CSP80-81).	Paruthiyoor to Poovar (CSP15-22), Kovalam (CSP42-45), Punthura (CSP53-55), Thumba (CSP80-81)
	Accretion spots	Edapadu to Neerody (CSP01-10), Karumkulam to Adimalathura (CSP26-36), Kovalam (CP42-44), Pannathura (CSP49-52), Punthura to Beemapally (CSP55-58, 61-62), Vettacud to Thumba (CSP70-81)	Poovar South (CSP15), Adimalathura (CSP31-33), Mullur (CSP36), Kovalam (CSP43-47), Cheriyathura (CSP62),Valliyathura (CSP64A), Shangumugham South (CSP68,70), and from Vettucaud to Valiyaveli (CSP72-79)	Neerody (CSP10) Paruthiyoor (CSP14), Adimalathura (CSP32-35)
June 2025	Erosion spots	Edapadu to Neerody (CSP02-10), Poovar to Adimalthura (CSP16-35), Kovalam to Pannathura (CSP43-50), Punthura to Valliyathura (CSP54-64), Shangumugham to Thumba (CSP59-81)	Pozhiyoor (CSP10), Poovar south (CSP15), the area from Poovar north to Karumkulam (CSP21-22), Adimalathura (CSP31,33-34), Mullur (CSP37), Kovalam (CSP42), Kovalam to Panathura (CSP47-48), Valiyathura (CSP64A), Shangumugham south (CSP68), and (CSP80-81).	Poovar (CSP15-16, 18-22), Adimalathura (CSP31-34), Kovalam (CSP42-45)
	Accretion spots	Edapadu (CSP01), Paruthiyoor (CSP11-15), Mullur (CSP36), Kovalam (CSP40-42), Punthura (CSP51-53), Valliyathura (CSP65-68)	Poovar south to north (CSP17-20), Adimalathura (CSP32), Azhimala (CSP35), Mullur (CSP36), Port area (CSP40A) and Kovalam (CSP45)	Paruthiyoor (CSP14), Poovar (CSP 17)
July 2025	Erosion spots	Paruthiyoor (CSP11-13), Karumkulam (CSP25), Pulluvila (CSP28), Adimalathura (CSP32-35), Kovalam (CSP42-44), Punthura (CSP55),	At Karumkulam (CSP22), Adimalathurato Azhimala (CSP32-35), Mullur (CSP36), Reclamation area (CSP40A), Kovalam (CSP42,45), Kovalam to Panathura (CSP47-	Poovar (CSP17), Adimalathura (CSP33-34)

		Beemapally (CSP61), Valliyathura to Shangumugham (CSP68-73), Kochuveli (CSP77-78)	48), Shangumugham (CSP68) and Thumba (CSP81)	
	Accretion spots	Edapadu to Paruthiyoor (CSP01-10), Poovar (CSP14-24), Pulluvila (CSP29-31), Kovalam to Punthura (CSP41, 45-52, 54), Punthura North (CSP57-60), Valliyathura (CSP64-66), Vettucaud (CSP74-76), Thumba (CSP79-81)	Pozhiyoor (CSP10), stretching from Poovar south to north (CSP15-21), Adimalathura (CSP31), Mullur (CSP37), Valliyathura (CSP64A) and Thumba (CSP80)	Paruthiyoor (CSP13-16), Poovar (CSP18-22). Kovalam (42-45), Thumba (CSP80-81)
August 2025	Erosion spots	Edapadu (CSP02), Poovar to Adimalathura (CSP17-35), Kovalam (CSP45), Punthura North (CSP54-57), Valliyathura (CSP68), Shangumugham (CSP70), Vettucaud (CSP71, 74), Kochuveli (CSP75-76), Thumba (CSP80-81)	Poovar to Karumkulam (CSP18-22), in Adimalathura to Azhimala (CSP31-35), Kovalam (CSP42),Kovalam to Panathura (CSP44-48), Shangumugham (CSP68,70), Kochuveli (CSP76) and Valiyaveli (CSP79)	Poovar (CSP20-21), Adimalathura (CSP32-34), Kovalam (CSP45), Veetuacud to Kochuveli (CSP73-77)
	Accretion spots	Edapadu (CSP01), Paruthiyoor (CSP11-15),	Pozhiyoor (CSP10), the southern region of Poovar (CSP15,16), Mullur (CSP36-37), Port reclamation area (CSP40A), Cheriyathura (CSP62), Valliyathura (CSP64A), Shangumugham (CSP69,71), Vettucaud (CSP74), Kochuveli to Valiyaveli (CSP77-78) and Thumba (CSP80)	Neerody (CSP10), Paruthiyoor (CSP13-17)
September 2025	Erosion spots	Edapadu (CSP01), Poovar (CSP18), Karumkulam (CSP23), Mullur (CSP36), Punthura (CSP53)	Poovar south (CSP15),Poovar north to Karumkulam (CSP20-22), Adimalathura (CSP31-32), Azhimala (CSP35), Port area (CSP40A), Kovalam (CSP45), Valiyathura (CSP67) and Shangumugham (CSP71)	Neerody (CSP10-11), Paruthiyoor (CSP14), Poovar (CSP16, 19), Adimalathura (CSP32)
	Accretion spots	Edapadu (CSP02), Paruthiyoor (CSP 14-16), Poovar (CSP21), Karumukulam to Adimalathura (CSP24-33), Kovalam to Pannathura (CSP43-50), Punthura to Thumba (CSP54-81)	Southern Poovar(CSP16-18), Adimalathura (CSP33-34), Mullur (CSP36-37), Kovalam (CSP42,44),Kovalam to Panathura (CSP46-48), Cheriyathura (CSP62),Valliyathura (CSP64A), Shangumugham (CSP69-70), Vettucaud (CSP72-74) and Kochuveli andThumba (CSP76-80)	Poovar (CSP17-18, 20-22), Adimlathura (CSP31,33-34), Kovalam (CSP42-45), Valliyathura (CSP62-64), Shangumugham to Thumba (CSP71-81)

Post-monsoon (October 2024-November 2024)	Erosion spots	Edapadu to Neerody (CSP01-09), Poovar (CSP16), Kovalam (CSP41-44), Punthura (CSP53), Valiyathura (CSP63)	Pozhiyoor (CSP10), Poovar south (CSP15-16), Poovar (CSP18-19), Adimalathura (CSP31-32), Mullur (CSP36-37), Port reclamation area (CSP40A), Kovalam (CSP44,47), Punthura (CSP53), Beemapally (CSP60), Thumba (CSP81)	Poovar (CSP15)
	Accretion spots	Poovar to Adimalathura (CSP17-34), Punthura (CSP54-58), Beemapally (CSP59-60), Valliyathura to Thumba (CSP64-81).	Poovar South (CSP17), Poovar north toKarumkulam (CSP20-22), Adimalathura to Azhimala (CSP33-35), Kovalam (CSP42-43,45-46), Panathura (CSP48), Punthura (CSP54-55), Cheriyathura (CSP62), Valiyathura (CSP64A), Shangumugham to Thumba (CSP68-80)	Poovar to Karumkulam (CSP16-22), Adimalathura to Azhimala (CSP 31-35), Kovalam to Thumba (CSP45-81).
Fairweather (Dec 2024 to March 2025)	Erosion spots	Poovar (CSP13-21), Punthura (CSP 53-54), Valliyathura to Thumba (CSP64-81)	Poovar South (CSP15,17),Adimalathura (CSP31-32), Mullur (CSP36-37), Kovalam (CSP44,47), Punthura (CSP53-55), Cheriyathura (CSP61),Valiyathura (CSP64A), Vettucaud (CSP73-74), Valiyaveli (CSP78) and Thumba (CSP81)	Poovar (CSP15-20), Punthura (CSP54), Shangumugham (CSP67-71), Thumba (CSP79-81).
	Accretion spots	Edapadu (CSP02), Neerody (CSP09), Adimalathura (CSP32-35), (CSP53).	Pozhiyoor (CSP10),Poovar to Karumkulam (CSP18-22), Adimalathura to Azhimala(CSP33-35A), Port reclamation area (CSP40A), Kovalam (CSP42-43,45-46), Panathura (CSP48), Punthura (CSP57), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham to Vettucaud (CSP68-72), Kochuveli (CSP75-77), Valiyaveli to Thumba (CSP79-80)	Adimalathura (CSP31-35), Mullur (CSP37), Punthura (CSP56-58).
Pre-Monsoon (April 2025-May 2025)	Erosion spots	Paruthiyoor to Poovar (CSP11-18), Karumkulam (CSP24-25), Kovalam (CSP41, 45), Pannathura (CSP46, 48), Punthura (CSP53-54), Valliyathura (CSP63-64), Shangumugham (CSP66-70)	Pozhiyoor (CSP10), Poovarsouth to Karumkulam (CSP17-22), Adimalathura to Azhimala (CSP34-35A), Mullur (CSP37), Port area (CSP40A), Kovalam (CSP42),Panathura (CSP48), Punthura (CSP53-55,57), Shangumugham(CSP69-71), and Thumba (CSP80-81)	Paruthiyoor to Poovar (CSP15-22), Kovalam (CSP42-45), Punthura (CSP53-55), Thumba (CSP80-81)

	Accretion spots	Edapadu to Neerody (CSP01-10), Karumkulam to Adimalathura (CSP26-36), Kovalam (CP42-44), Pannathura (CSP49-52), Punthura to Beemapally (CSP55-58, 61-62), Vettacud to Thumba (CSP70-81)	Poovar South (CSP15), Adimalathura (CSP31-33),Mullur (CSP36), Kovalam (CSP43-47), Cheriyathura (CSP62), Valliyathura (CSP64A),Shangumugham South (CSP68,70), Vettucaud to Valiyaveli (CSP72-79)	Neerody (CSP10) Paruthiyoor (CSP14), Adimalathura (CSP32-35)
Monsoon (June 2025-September 2025)	Erosion spots	Edapadu (CSP01), Poovar (CSP21), Karumkulam (CSP24-26), Pulluvila (CSP28-29), Adimalathura (CSP32-36), Kovalam (CS45), Punthura (CSP53), Valliyathura (CSP67)	Poovar south (CSP17), Poovar-Karumkulam(CSP19-22),Adimalathura to Azhimala (CSP31-35),Mullur (CSP36),the port reclamation area (CSP40A),Kovalam (CSP42,45,47), Panathura (CSP48), Shangumugham(CSP68), Kochuveli (CSP76), andThumba (CSP81)	Adimalathura (CSP32-34)
	Accretion spots	Edapadu to Poovar (CSP02-20, 22-24), Adimalathura (CSP30-31), Kovalam to Pannathura (CSP41-50), Punthura to Valliyathura (CSP54-66), Shangumugham to Thumba (CSP68-81)	Pozhiyoor(CSP10),Poovar south (CSP15-16),Mullur(CSP37),Valliyathura (CSP64A) and Thumba (CSP80)	Paruthiyoor to Poovar (CSP11-21), Kovalam (CSP42-45), Valliyathura to Thumba (CSP62-81)
Overall change (October 2024-September 2025)	Erosion spots	Edapadu (CSP01), Paruthiyoor to Adimalathura (CSP14-34), Punthura (CSP53-55), Beemapally (CSP61), Valliyathura (CSP66), Vettucaud to Thumba (CSP71-77, 79-81)	Poovar south (CSP16), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP31-34), Mullur (CSP37), the port reclamation area (CSP40A), Kovalam (CSP43-45,46), Punthura (CSP54-55),Cheriyathura (CSP62), Shangumugham (CSP68), Shangumugham to Thumba (CSP70-81)	Neerody (CSP10), Paruthiyoor to Poovar (CSP13-22), Adimalathura (CSP31-34), Kovalam (CSP42), Punthura (CSP53-55), Beemapally (CSP60-62), Valliyathura (CSP64-66), Shangumugham to Thumba (CSP68-69, 72-81)
	Accretion spots	Edapadu to Paruthiyoor (CSP02-15) Adimalathura to Mullur (CSP35-36), Kovalam to Pannathura (CSP40-47), Punthura to Beemapally (CSP56-60), Valliyathura (CSP63-65), Shangumugham (CSP67-70), Kochuveli (CSP78)	Pozhiyoor (CSP10),Poovar south (CSP15,17), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP42,46), Panathura (CSP48), Punthura (CSP53), Valliyathura (CSP64A) and Shangumugham (CSP69)	Neerody (CSP11), Adimalathura to Mullur (CSP34-36), Kovalam (CSP43-45), Punthura (CSP56-58), Valliyathura (CSP63, 66), Shangumugham (CSP70-71)
	Erosion spots	Poovar to Karumkulam (CSP14-24), Adimalathura (CSP33-35), Mullur	Poovar south to Karumkulam (CSP17-22), Adimalathura (CSP34), Mullur (36-37), Kovalam	Poovar (CSP16-22), Adimalathura (CSP34-36),

October 2023-October 2024		(CSP37), Kovalam (CSP41), Punthura (CSP55-56), Valliyathura (CSP66-68), Shangumugham (CSP70-72), and Vettucaud to Thumba (CSP 73-80)	(CSP42-43 and 45-46), Panathura (CSP48), Punthura (CSP54-55), Beemapally (CSP60), Cheriyathura (CSP62), Shanghaimugham (CSP68) and Kochuveli (CSP77)	Punthura (CSP53-55), Shangumugham to Thumba (CSP67-81)
	Accretion spots	Edapadu Beach to Paruthiyoor (CSP01-10), Karumkulam (CSP 24-29), Adimalathura (CSP32), Kovalam to Panathura North (CSP42-51), Punthura (CSP57-61), Valliyathura (CSP65), Shangumugham (CSP69) and Vettucaud (CSP72).	Pozhiyoor (CSP10), Poovar South (CSP15), Port reclamation area (CSP40A), Kovalam (CSP44 and 47), Punthura (CSP53), Valiyathura (CSP64A), ShangumughamKochuveli (CSP69-76) and Valiyaveli to Thumba (CSP78-81)	Poovar (CSP15), Punthura (CSP53) and Valliyathura (CSP78)
February 2024-February 2025	Erosion spots	Edapadu Beach (CSP01-13), Poovar to Mullur (CSP16-35), Pannathura (CSP 45-48), Punthura (CSP 53-56), Beemapally to Valliyathura (CSP59-68), Shangumugham to Thumba (CSP71-81).	Poovar South (CSP15), Poovar to Poovar North (CSP18-20), Karumkulam(CSP22), Adimalathura (CSP31), Azhimala to Mullur (CSP35A-37), Kovalam (CSP44), Beemapally (CSP58 and 60) and Cheriyathura (CSP62)	Poovar (CSP16-22), Adimalathura to Mullur (CSP32-37), Punthura (CSP54), and Valliyathura to Thumba (CSP66-78).
	Accretion spots	Poovar (CSP14-15), Kovalam (CSP43-44), Pannathura (CSP48-50), Punthura (CSP56-58) and Shangumugham (CSP69)	Pozhiyoor (CSP10), Poovar south (CSP16-17), Poovar north (CSP21), Adimalathura (CSP32-34), Port reclamation area (CSP40A), Kovalam (CSP42-43), Kovalam to Panathura (CSP45-48), Punthura (CSP54-55 and 57), Cheriyathura (CSP61), Valiyathur (CSP64A) and Valiyathura to Thumba (CSP67-81)	Poovar (CSP14-15), Punthura (CSP53, 55-58), Thumba (CSP68-79-80)
May 2024-May 2025	Erosion spots	Poovar (CSP19-22), Karumkulam (CSP25, 27), Mullur (CSP35-36), Kovalam (CSP41-42), Punthura (CSP53-54), Beemapally (CSP58-60), Valliyathura (CSP63-64)	Pozhiyoor (CSP10),Poovar South (CSP15), Poovarto Karumkulam(CSP18-22),Mullur (CSP36-37), port reclamation area (CSP40A), Panathura (CSP48), Punthura (CSP53-55,57), Cheriyathura (CSP62),Valiyathura(CSP64A), Shangumugham to Vettucaud (CSP69-72) and Valiyaveli to Thumba (CSP79-81)	Poovar (CSP16-17), Punthuta (CSP53-55), Thumba (CSP80-81)
	Accretion spots	Edapadu to Paruthiyoor (CSP01-18), Pulluvila to Adimalathura (CSP28-34), Kovalam to Pannathura (CSP43-52), Punthura (CSP55-57), Valliyathura to Thumba (CSP67-81)	Poovar south (CSP17), Adimalathura (CSP31,33-34), Kovalam (CSP42-46), Shangumugham (CSP68), Vettucaud to Valiyaveli (CSP73-78)	Paruthiyoor (CSP14-15), Adimalathuta (CSP31-35), Kovalam (CSP42-45)

September 2024-September 2025	Erosion spots	Edapadu (CSP02), Paruthiyoor to Adimalathura (CSP14-34), Punthura (CSP53-55), Beemapally to Thumba (CSP60-81)	Poovar south (CSP16), Poovar toKarumkulam (CSP18-22),Adimalathura (CSP31-34),Mullur (CSP37),port reclamation area (CSP40A), Kovalam (CSP42-45,47), Punthura (CSP54),Cheriyathura (CSP62) and Shangumugham to Thumba (CSP68-81)	Paruthiyoor to Poovar (CSP 14-22), Adimalathura (CSP31-36), Kovalam (CSP42-43), Punthura (CSP54-55), Valliyathura (CSP64), Shangumugham to Thumba (CSP68-69, 72-81)
	Accretion spots	Edapadu (CSP01), Vallavilay to Paruthiyoor (CSP03-13) Adimalathura to Mullur (CSP35-36), Kovalam to Pannathura (CSP40-47), Punthura (CSP56-58)	Poovar south (CSP15,17),Azhimala (CSP35), Mullur (CSP36),Kovalam (CSP46) and Punthura (CSP53,55)	Kovalam (CSP45), Punthura (CSP53), Shangumugham (CSP70-71)

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6. SUMMARY AND CONCLUSIONS

A detailed analysis of the 40km coastal stretch (20km on either side of the Port) and a comprehensive study of the factors mentioned above were carried out and presented in this report to understand the consequences of the Port's construction on the shoreline change. Pre- and post-port construction dates have also been considered in the analysis.

This report uses beach profile data to discuss the monthly shoreline changes (in terms of distance eroded/accreted) using satellite images and the monthly shoreline changes (in terms of volume). From onshore beach profile analysis from October 2024 to September 2025, it was found that beaches exhibited accretion at Pozhiyoor (CSP10), Poovar south (CSP15,17), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP42,46), Panathura (CSP48), Punthura (CSP53), Valliyathura (CSP64A) and Shangumugham (CSP69) while erosion at Poovar south (CSP16), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP31-34), Mullur (CSP37), the port reclamation area (CSP40A), Kovalam (CSP43-45,46), Punthura (CSP54-55), Cheriyathura (CSP62), (CSP68), Shangumugham to Thumba (CSP70-81). No field data were collected by the AVPPL-appointed survey agency from CSP01 to CSP10 and from CSP23 to CSP30 due to local protests. Due to rough sea conditions, the offshore survey was not carried out by the survey agency in any locations from September 2024 to November 2024, February 2025, and June 2025 to September 2025. As a result, the analysis of the offshore beach profile was not conducted to assess the overall volume change for this year.

The shoreline changes using satellite images from October 2024 to September 2025 show accretion at Edapadu to Paruthiyoor (CSP01-15), Adimalathura to Mullur (CSP35-36), Kovalam to Pannathura (CSP40-47), Punthura to Beemapally (CSP56-60), Valliyathura (CSP63-65), Shangumugham (CSP67-70), Kochuveli (CSP78), while erosion at Paruthiyoor to Adimalathura (CSP14-34), Punthura (CSP53-55), Beemapally (CSP61), Valliyathura (CSP66), Vettucaud to Thumba (CSP71-77, 79-81).

This study analysed shoreline changes along a 40 km stretch (20 km on either side of Vizhinjam Port) using beach profile data, satellite images, and field shoreline data. Monthly, seasonal, annual, and intra-annual shoreline changes were assessed from October 2024 to September 2025. Shoreline change trends over the past two decades (2000-2025) were also evaluated using high-resolution satellite images. Erosion and accretion patterns were identified and classified into five categories: high accretion, moderate accretion, stable, moderate erosion, and high erosion. Field data corroborated the satellite-based observations, providing further validation.

The erosion and accretion spots identified from satellite images taken before and after 2015, using high-resolution satellite images, have also been compared. Long-term Shoreline trend analysis (200-2025) was also carried out for eight identified hotspot locations: Kochuveli, Valliyathura, Shangumugham, Punthura, Vizhinjam, Adimalathura, Poovar, and Edapadu. Monthly, seasonal, annual, and intra-annual shoreline changes were assessed from October 2024 to September 2025.

Shoreline change trends over the past two decades (2000-2025) were also evaluated using high-resolution satellite images. Erosion and accretion patterns were identified and compared with the field data and the previously published reports. Field data substantiated the satellite-based observations, providing further validation. Climatic events, such as cyclones, swell surges, and early monsoon onset, significantly impacted shoreline stability, causing severe erosion and altering sediment dynamics. The Thiruvananthapuram coast experienced several significant climatic events

from October 2024 to September 2025. In October 2024, January 2025, May 2025, and June 2025, a series of Kallakadal swell surge warnings were issued, resulting in rough sea conditions with wave heights reaching up to 3.5 meters in June. Cyclone Fengal affected the region from late November to early December 2024 with heavy rains and strong winds. Notably, the southwest monsoon arrived early in 2025, with the India Meteorological Department declaring its onset over Kerala, including Thiruvananthapuram, on May 24, eight days ahead of the usual onset date of June 1. This early monsoon arrival marked the earliest onset since 2009 and was influenced by favourable atmospheric and oceanic conditions. These events reflect a dynamic coastal climate influenced by monsoonal patterns, tropical cyclones, and ocean swell surges. Under normal conditions, the December-March period represents the fair-weather season, during which beach recovery and accretion typically dominate. However, the occurrence of Cyclone Fengal and recurrent Kallakadal events during this period disrupted the beach-building processes, resulting in net erosion. Consequently, a comparison with the previous year's fair-weather season indicates increased erosion along the coast.

Between October 2024 and September 2025, no dredging or breakwater construction took place in the Port area. Consequently, there were no significant human-induced changes (due to Port development) to sediment movement during this time, and the sediment distribution patterns primarily represent natural coastal processes. However, two groynes—one short groyne to the north of the port (Punthura) and two to the south (Paruthiyoor)—were newly installed. However, continuous monitoring is necessary to evaluate the scale of long-term effects on the coast.

Table 6.1. **Summary and significant findings of the Annual reports submitted**

Reports	Period	Significant finding
Annual Report 2018	October 2017 to September 2018	• The shoreline change analysis, using available high-resolution satellite images, was carried out for the period 2000-2018, with annual variations for the years 2015-2016, 2016-2017, and 2017-2018. • Erosion spots are located at Valliyathura, Punthura, and Neerody, leading to Edapadu beach. Table 5.2 indicates that these sites were facing erosion even before the start of port activities. • The study has been compared with other available data and reports (NCCR, NCSCM, SAC), which indicate that these sites along the Vizhinjam coast have undergone erosion for a considerable period.
Annual Report 2019	October 2018 to September 2019	• The overall shoreline shows accretion at a few transects of Cheriyathura and Mullur. It is stable at Pannathura and Adimalathura, whereas erosion is noticed at Kochuveli, Shangumugam, Valliyathura, Punthura, Pulluvila, and Edapadu Beach. • The overall beach volume change shows net accretion at CSP 22-23 (Karumkulam), CSP 32-33 (Adimalathura), CSP 35-38 (Mullur), CSP 61 (Cheriyathura), and net erosion at other locations. • It was noted that the spots of erosion, such as Valliyathura, Shangumugham, and Punthura, remained the same before and after the commencement of the Port in December 2015 (Table 5.2).
Annual Report 2020	October 2019 to September 2020	• Thumba to Valliyathura, Punthura, and Edapadu have been identified as zones of erosion, whereas Kovalam, Poovar, and Karumkulam regions are identified as zones of accretion.

		• The spots of erosion, such as Valliyathura, Shangumugham, and Punthura, remained the same before and after the commencement of the Port (December 2015). However, spots such as Thumba to Vettucaud to the north of Valliyathura show erosion.
Annual Report 2021	October 2020 to September 2021	• From shoreline change analysis using satellite images, erosion is observed at Kochuveli, Shangumugham, Valliyathura, Cheriyathura, Punthura, Mullur, Pulluvila, while accretion is noted at Thumba, Vettucaud, and Shangumugham, as well as at Adimalathura, Karumkulam, Poovar, and Edapadu beach. • From beach volume change analysis, erosion is observed at Thumba, Vettucaud to Kochuveli, Valliyathura, Pannathura to Punthura, Kovalam, Mullur, Pulluvila to Adimalathura, Karumkulam, and Poovar, while accretions are noted at Edapadu Beach, Poovar, Karumkulam to Pulluvila, Adimalathura, Shangumugham, and Valiyaveli. • It is inferred that the spots of erosion, such as Valliyathura, Shangumugham, and Punthura, remained the same before and after the commencement of the Port in December 2015 (Table 6.4). • A trend analysis comparison of beach volume change (onshore) and shoreline change using satellite images (February to February) from 2015 to 2021 is presented in the report. It was noticed that high erosion occurred during the Ockhi cyclone along the Thiruvananthapuram coast, and the original profile has not recovered.
Annual Report 2022	October 2021 to September 2022	• From shoreline change analysis using satellite images, erosion is noticed at Adimalathura (CSP 35), Mullur (CSP 37), Punthura (CSP 51-53), Valliyathura (CSP 64,66), Thumba to Kochuveli (CSP 75-81), while accretion is noticed at Adimalathura to Poovar (CSP 22-34) and Shangumugam (CSP 69-71). • From beach profile analysis for October 2021 to September 2022, it is erosion at Poovar (CSP15,17), Pulluvila (CSP27,30), Adimalathura (CSP31,33), Kovalam (CSP42-43), Pannathura to Punthura (CSP51-53), and Valliyathura (CSP66) and Vettucaud (CSP73), and accretion at most of the locations, such as Pulluvila to Poovar (CSP 17-29) and Thumba to Shangumugam (CSP 69-72).
Annual Report 2023	October 2022 to September 2023	• The shoreline changes using satellite images shown erosion at Poovar (CSP15), Pulluavila (CSP27), Karumkulam (CSP24), Mullur (CSP36-37), Punthura (CSP56), Valiyathura (CSP65), Shangumugham (CSP69), and Thumba (CSP80); while accretion at Edapadu beach (CSP02), Poovar (CSP16-18), Karumkulam (CSP25-26), Adimalathura (CSP31-34), Kovalam (CSP43), Punthura (CSP57), Shangumugham north (CSP70), Vettucaud (CSP73), Kochuveli (CSP75), Valliyaveli (CSP76-79). • From beach profile analysis, erosion was observed at Shangumugham South (CSP69), Vettucaud (CSP74), and Kochuveli to Valiyaveli (CSP76-78), which were identified as erosion spots. The beach experienced accretion at Edappadu

		Beach (CSP02), Kovalam (CSP42, 43), Panathura North (CSP52), Shangumugham North (CSP70-71), Vettucaud (CSP73), Kochuveli (CSP75), and Thumba (CSP80-81).
Annual Report 2024	October 2023 to September 2024	• The shoreline changes, as observed using satellite images, field-measured shorelines, and onshore beach profiles, from October 2023 to September 2024, have been analysed. Shoreline analysis before and after Port development (2012-2015 and 2015-2025) using high-resolution images has been analysed and reported. • The shoreline changes using satellite images from October 2023 to 2024 shows accretion at Edapadu beach (CSP01, 03), Poovar (CSP16), Karumkulam (CSP25), Adimalathura (CSP32), Mullur (CSP36), Kovalam (CSP44-45), Punthura (CSP53-54, 57), Shangumugham (CSP68-69), Vettucaud (CSP73), Kochuveli (CSP77) and Valliyaveli (CSP78) while erosion at Pozhiyoor (CSP11-12), Poovar (CSP15, 18, 20-21), Karumkulam (CSP23-24), Pulluvila (CSP30), Adimalathura (CSP31, 33,34), Mullur (CSP37), Kovalam (CSP42, 47), Pannathura (CSP50-52), Punthura (CSP55-56), Valiyathura (CSP63, 65-67), Shangumugham (CSP70-71), Vettucaud (CSP72) and Thumba (CSP80-81). • From onshore beach profile analysis from October 2023 to September 2024, it was found that beaches exhibited accretion at Poovar south (CSP17), Mullur (CSP36), the port reclamation area (CSP40A), Kovalam (CSP44), Punthura (CSP53), Cheriyathura (CSP62), from Shangumugham south to north (CSP68-71), between Vettucaud and Kochuveli (CSP74-76), at Valiyaveli (CSP78), and in Thumba (CSP80-81) while erosion at Poovar south (CSP15), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP34), Mullur (CSP37), Kovalam (CSP42-43, 45-46), Punthura (CSP54), Beemapally (CSP60), Vettucaud (CSP72-73), Kochuveli (CSP77), and Valiyaveli (CSP79). No field data was collected by the AVPPL-appointed survey agency from CSP23 to CSP30 due to local protests.

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RESEARCH

Long-term shoreline dynamics of South Kerala Coast using satellite images

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Abstract
The shoreline experiences significant changes due to human activities and natural processes, resulting in erosion and accretion. Studying the morphology of shorelines is crucial for identifying the causes and impacts of coastal processes along the coast, which helps protect the ecosystem and facilitate future development. This study comprehensively analyses shoreline changes along the Kerala coast from 2000 to 2024, revealing substantial shifts due to frequent cyclones and other natural events. Key findings include significant erosion at Shangumugam, Valliyathura, Punthura, and Edapadu beaches and notable accretion at Thumba, Kochuveli, Vizhinjam, Adimalathura, Pullavila, Karumkulam, and Poovar. The study employs a novel trend analysis approach to evaluate the localized impact of cyclonic events on various coastal locations. Trend analysis from 2000 to 2024, using high-resolution satellite images, identified consistent erosion patterns, particularly after Cyclone Ockhi in 2017 and Cyclone Tauktae in 2021, which caused significant, unrecovered erosion along the Vizhinjam coastline. Regression analysis validates the findings with a high correlation ($R^2 = 0.872$ against beach profile data and $R^2 = 0.96$ against field data). It is observed that the frequency of cyclonic activity has increased in recent times along the Kerala Coast. The study accentuates Kerala's increasing vulnerability to natural disasters and the necessity of advanced monitoring techniques for effective coastal management.

Keywords Shoreline changes · Erosion · Accretion · Cyclones

Introduction

Coastal regions are highly dynamic, influenced by natural processes, anthropogenic activities, and climate variations. Understanding shoreline dynamics is crucial for effective coastal management and sustainable development (Douglas & Crowell, 2000). Regular shoreline monitoring identifies natural changes and human impacts, aiding in the formulation of management strategies.

This study examines the decadal evolution of the south Kerala coast using high-resolution satellite imagery and Digital Shoreline Analysis Systems (DSAS). Remote sensing over a 20-year period reveals complex coastal morphology changes, including abrupt shifts caused by extreme events like cyclones and flooding.

Coastal erosion results from hydraulic action, abrasion, attrition, and corrosion by sea waves (Bird, 2008). Factors like rising sea levels, storm surges, wave action, sediment disruption, and sand mining exacerbate erosion and flooding (Acharjee & Shariot-Ullah, 2021). In India, wave action, reduced sediment supply, tectonics, and human activities are primary drivers of erosion (Sudha et al., 2015).

Littoral processes involving waves, currents, and sediment transport shape the coastline and influence erosion and deposition (Kaliraj et al., 2017). On the south Kerala coast, coastal currents and sediment transport significantly impact morphology. Human interventions like port construction or groins can disrupt sediment dynamics, leading to localized accretion or erosion, necessitating regular monitoring to maintain coastal equilibrium (Stive et al., 2002; Pandian et al., 2004).

The south Kerala coast, characterized by longshore sediment transport, has experienced significant morphological changes due to the construction of Vizhinjam Port. This

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ANNEXURE

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A. DETAILED RESULTS OF THE ANALYSES

In the present study, the shoreline rate of change statistics from a time series of multiple shoreline positions of a 40 km coastal stretch (20 km either side of Vizhinjam Port) have been taken into account for shoreline change estimation using satellite images. The result of the shoreline change analysis carried out from October 2024 to September 2025has been examined.

Based on the rate of change over the period being considered, areas of shoreline change have been categorized into five classes. They are high accretion (>5m/year), moderate accretion (5m to 1m/year), stable coast (1m to -1m/year), moderate erosion (-1m to -5m/year), and high erosion (<-5m/year).

The observations from the beach profile analysis done using SANDS for the entire 40 km stretch have been presented as monthly changes in the beach volume for a period from October 2024 to September 2025, and beach volume changes between October 2023-October 2024, February 2024- February 2025, May 2024-May 2025, and September 2024- September 2025 have also been worked out and presented in this report. Monthly beach volume changes have been assessed by comparing the month-to-month profiles in **Section A.1**. The erosion and accretion are highlighted with red and green colourfill in the charts for better understanding. The results shown in the charts are also presented in the tables.

A.1 Results of Beach Profile Analysis

The data for the beach profile includes profiles from both the onshore and offshore areas. Onshore surveys at CSP1-10 and CSP23-30 were not conducted from September 2024 to September 2025. There were no offshore surveys from September 2024 to November 2024, February 2025, and June 2025 to September 2025 at any locations because of adverse weather conditions.

A.1.1 Monthly Beach Volume variations for October 2024 to September 2025 for the onshore profiles

This report contains the monthly beach volume changes from October 2024 to September 2025 and has been represented graphically in **Figures A.1 to A.12** and **Table A.1.**

In September 2024, no onshore surveys were conducted at CSP10, CSP11, CSP35A, CSP41, and CSP64A. In October 2024, surveys were not done at CSP16 and

CSP35A. During March 2024, CSP16 had no survey, and in May 2025, CSP60 had no data. In June 2025, no surveys occurred at CSP35A, CSP41, CSP43, CSP53-55, CSP60, CSP67, CSP72, and CSP73. Similarly, in July 2025, surveys were not conducted at CSP35A, CSP41, CSP43, CSP53-55, CSP60, CSP67, and CSP73. In August 2025, no data were available for CSP35A, CSP41, CSP43, CSP53-55, CSP60, and CSP67, and in September 2025, data were missing for CSP35A, CSP41, CSP60, and CSP67.

A shorter survey distance was recorded at CSP46 in June 2025; CSP57 in October 2024; CSP58, CSP60, and CSP61 from May to September 2025; CSP66 in September-October 2024, December 2024, and March-September 2025; CSP67 in April 2025; CSP69 in June 2025; CSP70 in June 2025; CSP72 in June 2025; CSP73 in June-July 2025; CSP75 in June and August 2025; and CSP81 in August 2025.

In October 2024, beach accretion was noted in Poovar south to north (CSP15-20), between Karumkulam (CSP22), Adimalathura (CSP31-33), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP43-46), Punthura (CSP54-55), Beemapally (CSP60), and from Shangumugham to Vettucaud (CSP71-72). Meanwhile, beach erosion was recorded at several locations, including Poovar North (CSP21), Adimalathura (CSP34), port reclamation area (CSP40A), Kovalam (CSP42), the stretch from Kovalam to Panathura (CSP47-48), Punthura (CSP53), Cheriyathura (CSP62), ValliyathuraShangumugham (CSP67-70), and Vettucaud to Thumba (CSP73-81) in the same month.

Accretion occurred in November 2024 at the following sites: Poovar South (CSP17), Poovar North to Karumkulam (CSP20-22), Adimalathura to Azhimala (CSP33-35), Kovalam (CSP42-43,45-46), Panathura South (CSP48), Punthura (CSP54-55), Cheriyathura(CSP62), Valliyathura (CSP64A), Valliyathura to Thumba (CSP67-80). Erosion was detected in November 2024 at locations including Pozhiyoor (CSP10), Poovar South (CSP15-16), Poovar (CSP18-19), Adimalathura (CSP31-32), Mullur (CSP36-37), Port reclamation area (CSP40A), Kovalam (CSP 44,47), Punthura (CSP53), Beemapally (CSP60), and Thumba (CSP81).

In December 2024, the beaches at Pozhiyoor (CSP10), Poovar South (CSP15), from Poovar South to the north (CSP17-20), Karumkulam (CSP22), Adimalathura (CSP31-33-34), Azhimala to Mullur (CSP35A-36), Kovalam (CSP42,44,46-47), Panathura (CSP48), Punthura (CSP53-54), Cheriyathura (CSP60-61), Valliyathura (CSP64A,67), and Vettucaud to Kochuveli (CSP74-75), as well as Thumba (CSP81), experienced

accretion. In contrast, erosion was noted at Poovar South (CSP16), Poovar North (CSP21), Adimalathura (CSP31), Azhimala (CSP35), Mullur (CSP37), the port reclamation area (CSP40A), Punthura (CSP55), Cheriyathura (CSP62), Shangumugham to Vettucaud (CSP68-73), Kochuveli (CSP76-77), and Valiyaveli to Thumba (CSP79-80) during December 2024.

In January 2025, the following areas experienced accretion: Pozhiyoor (CSP10), Poovar South (CSP15), Poovar to Karumkulam (CSP19-22), Adimalathura (CSP31), the stretch from Adimalathura to Mullur (CSP33-36), the Port reclamation area (CSP40A), the section from Kovalam (CSP42-43), Kovalam toPanathura (CSP45-48), Punthura (CSP54), Cheriyathura (CSP61-62), and the area from Valiyathura (CSP64A), Valliyathura to Vettucaud (CSP67-72), Kochuveli (CSP75-77) and Valiyaveli to Thumba (CSP79-80). The locations noted for experiencing erosion in January 2025 include the area from Poovar South to Poovar (CSP15-18), Adimalathura (CSP32), Mullur (CSP37), Kovalam (CSP44), Punthura (CSP53, 55), Beemapally (CSP60), Vettucaud (CSP73-74), Valiyaveli (CSP78), and Thumba (CSP81).

At Poovar South to Poovar (CSP16-18), Poovar north to Karumkulam (CSP20-22), Adimalathura (CSP31-32), Azhimala (CSP35A), the port reclamation area (CSP40A), from Kovalam (CSP42-44,46), Panathura (CSP48), from Beemapally to Cheriyathura (CSP60-61), between Shangumugham and Vettucaud (CSP69-74), Kochuveli to Valiyaveli (CSP77-79), and Thumba (CSP81)—accretion was noted in February 2025. Conversely, erosion was recorded in February 2025 at several locations, including Pozhiyoor (CSP10), Poovar south(CSP15), Poovar (CSP19), between Adimalathura and Azhimala (CSP33-35), Mullur (CSP36-37), Kovalam (CSP45,47), Punthura (CSP53-55), Cheriyathura (CSP62), Valiyathura (CSP64A), from Valiyathura to Shangumugham (CSP66-68), Kochuveli (CSP75-76), and Thumba (CSP80).

In March 2025, accretion was noted at Pozhiyoor (CSP10), Karumkulam (CSP22), Adimalathura (CSP33-34), Azhimala-Mullur (CSP35A-37), Port reclamation area (CSP40A), Kovalam (CSP45), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham (CSP68, 70), Vettucaud (CSP72-73), Kochuveli (CSP75-76), and Thumba (CSP80). Poovar South (CSP15), Poovar south to north (CSP17-21), Adimalathura (CSP31-32), Azhimala (CSP35), Kovalam (CSP42-44), Kovalam to Panathura (CSP46-48), Cheriyathura (CSP61), Valiyathura (CSP64A,67),

Shangumugham (CSP69,71), Vettucaud (CSP74), Kochuveli to Valiyaveli (CSP77-79), and Thumba (CSP81) are among the locations where erosion has been seen in March 2025.

In April 2025, accretion was noted at Poovar South (CSP15), Poovar (CSP19), Poovar north to Karumkulam (CSP21-22), Adimalathura (CSP31), Adimalathura to Mullur (CSP33-37), Kovalam (CSP42-44), Kovalam to Panathura (CSP46-48), Punthura (CSP53-55), Cheriyathura (CSP62), Shangumugham (CSP68), Kochuveli to Valiyaveli (CSP77-78), and Thumba (CSP81). Erosion was recorded at Pozhiyoor (CSP10), from Poovar South to Poovar (CSP17-18), Poovar North (CSP20), Adimalathura (CSP32), Port reclamation (CSP40A), Kovalam (CSP45), Beemapally to Cheriyathura (CSP60-61), Valliyathura (CSP64A), Shangumugham to Kochuveli (CSP69-76), and Valiyaveli (CSP79).

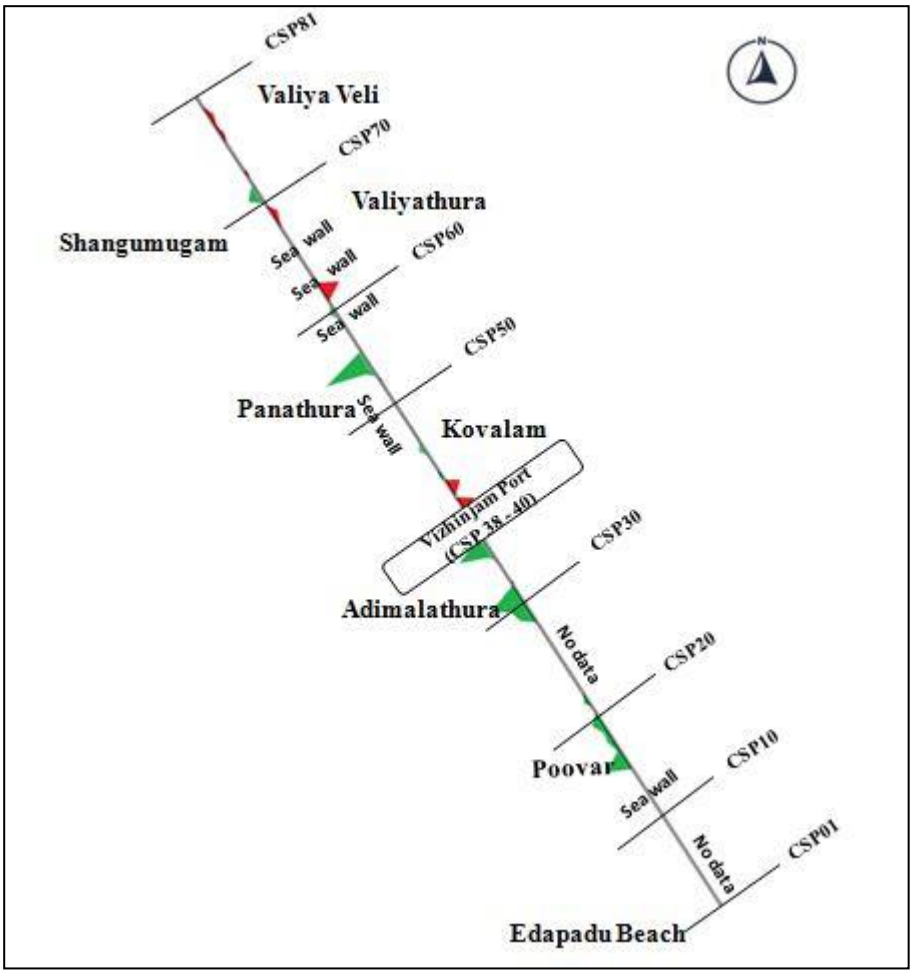
In May 2025, CSP16 found erroneous. Accretion was noted at Poovar South (CSP15), Adimalathura (CSP31-33), Mullur (CSP36), Kovalam (CSP43-47), Cheriyathura (CSP62), Valliyathura (CSP64A), Shangumugham South (CSP68,70), and from Vettucaud to Valiyaveli (CSP72-79). Erosion was recorded at Pozhiyoor (CSP10), Poovar South to Karumkulam (CS17-P22), AdimalathuratoAzhimala (CSP34-35A), Mullur (CSP37), Reclamation area (CSP40A), Kovalam (CSP42), Panathura (CSP48), Punthura (CSP53-55), Shangumugham (CSP69,71), and Thumba (CSP80-81).

In June 2025, accretion was observed from Poovar south to north (CSP17-20), Adimalathura (CSP32), Azhimala (CSP35), Mullur (CSP36), Port reclamation area (CSP40A), and Kovalam (CSP45). Erosion was detected at Pozhiyoor (CSP10), Poovar south (CSP15), the area from Poovar north to Karumkulam (CSP21-22), Adimalathura (CSP31,33-34), Mullur (CSP37), Kovalam (CSP42), Kovalam to Panathura (CSP47-48), Valiyathura (CSP64A), Shangumugham south (CSP68), and (CSP80-81).

Accretion was recorded at Pozhiyoor (CSP10), stretching from Poovar south to north (CSP15-21), Adimalathura (CSP31), Mullur (CSP37), Valliyathura (CSP64A), and Thumba (CSP80) during July 2025. Erosion occurred at Karumkulam (CSP22), Adimalathurato Azhimala (CSP32-35), Mullur (CSP36), Reclamation area (CSP40A), Kovalam (CSP42,45), Kovalam to Panathura (CSP47-48), Shangumugham (CSP68), and Thumba (CSP81) during July 2025.

Accretion was observed in Pozhiyoor (CSP10), the southern region of Poovar (CSP15,16), Mullur (CSP36-37), Port reclamation area (CSP40A), Cheriyathura (CSP62), Valliyathura (CSP64A), Shangumugham (CSP69,71), Vettucaud (CSP74), Kochuveli to Valiyaveli (CSP77-78), and Thumba (CSP80). Erosion was detected from Poovar to Karumkulam (CSP18-22), in Adimalathura to Azhimala (CSP31-35), Kovalam (CSP42), Kovalam to Panathura (CSP44-48), Shangumugham (CSP68,70), Kochuveli (CSP76), and Valiyaveli (CSP79) in August 2025.

Erosion has been noted in southern Poovar south (CSP15), Poovar north to Karumkulam (CSP20-22), Adimalathura (CSP31-32), Azhimala (CSP35), Port reclamation area (CSP40A), Kovalam (CSP45), Valiyathura (CSP67) and Shangumugham (CSP71), whereas accretion has been reported at southern Poovar(CSP16-18), Adimalathura (CSP33-34), Mullur (CSP36-37), Kovalam (CSP42,44), Kovalam to Panathura (CSP46-48), Cheriyathura (CSP62), Valliyathura (CSP64A), Shangumugham (CSP69-70), Vettucaud (CSP72-74) and Kochuveli andThumba (CSP76-80) in September 2025.



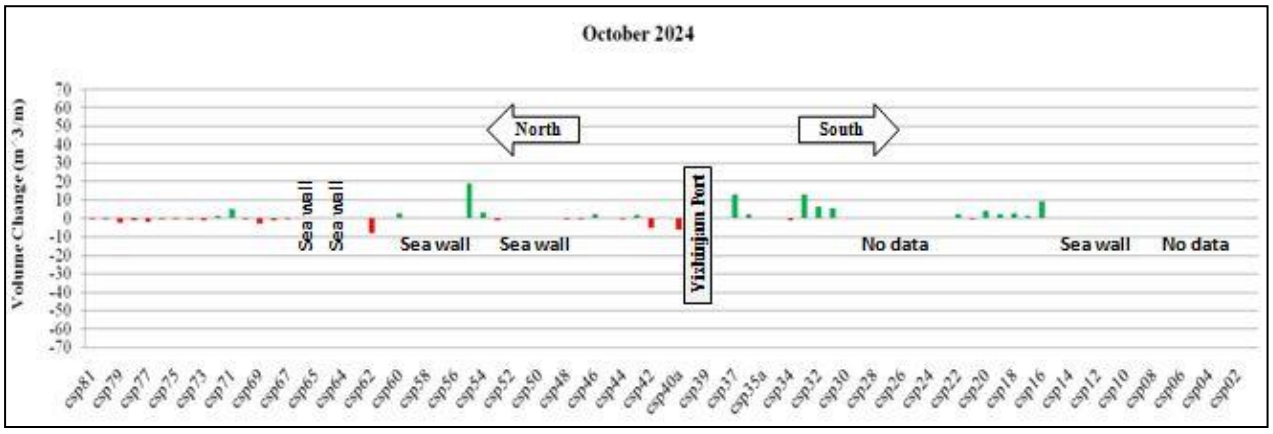
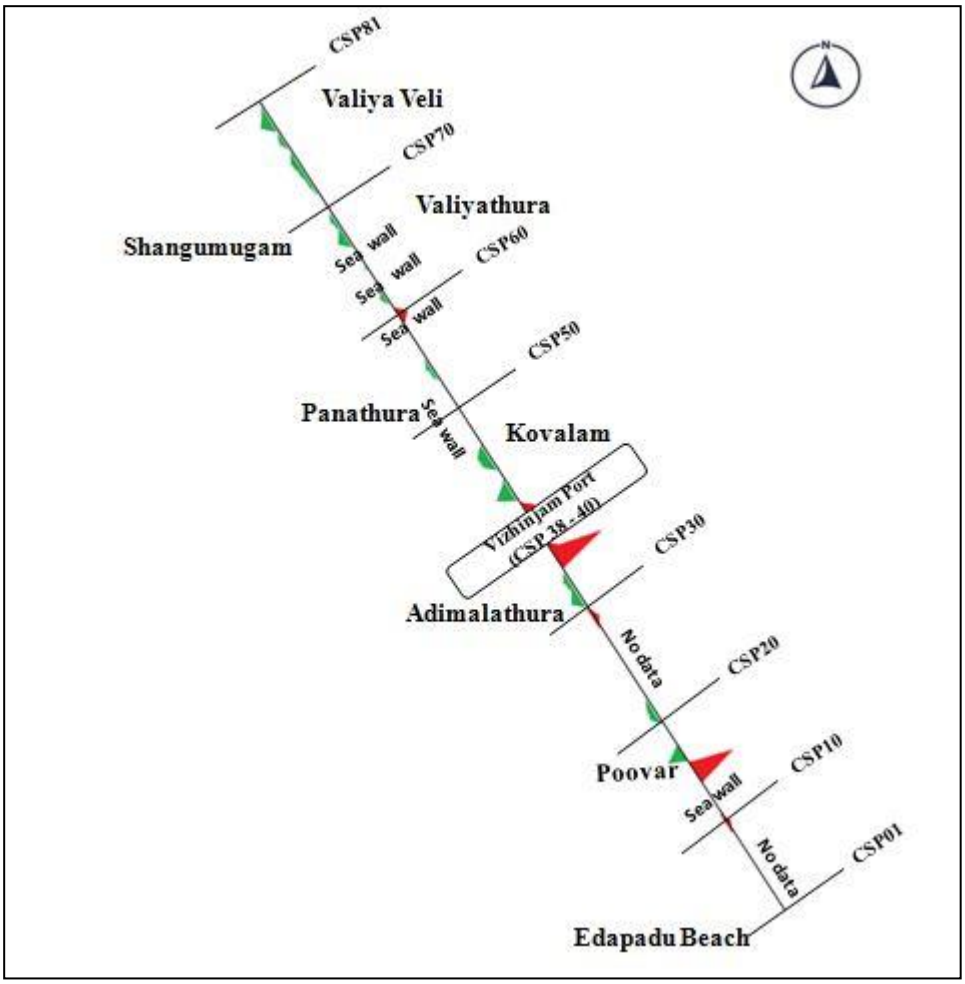


Figure A.1 Monthly Beach Volume Changes in October 2024 in m3/m (onshore)



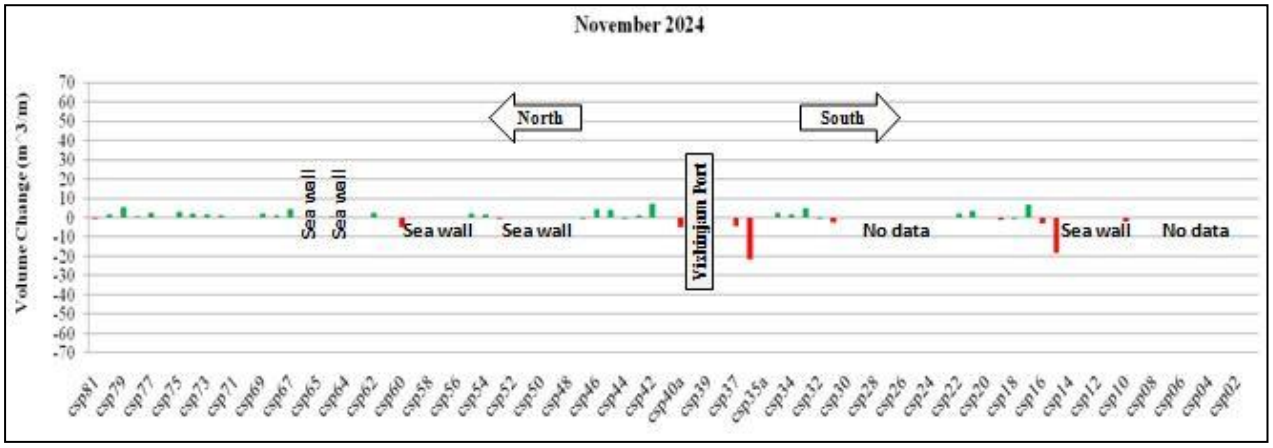
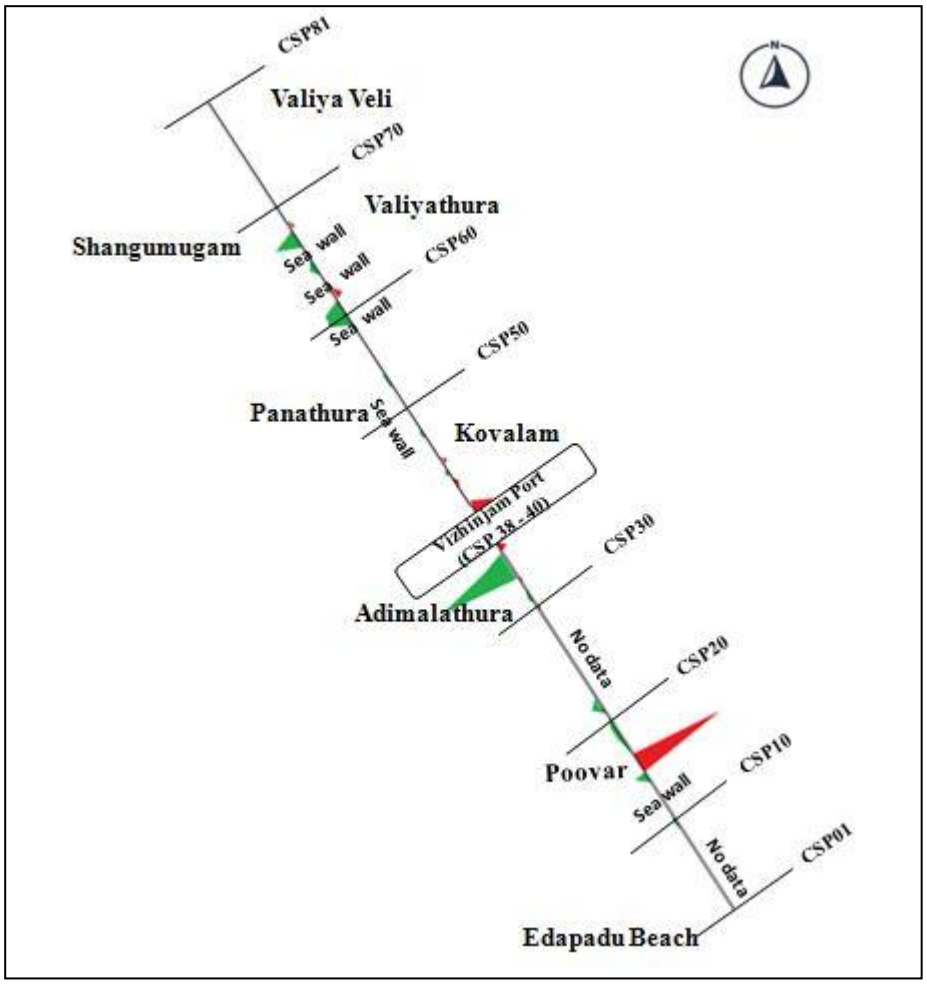


Figure A.2 Monthly Beach Volume Changes in November 2024 in m3/m (onshore)



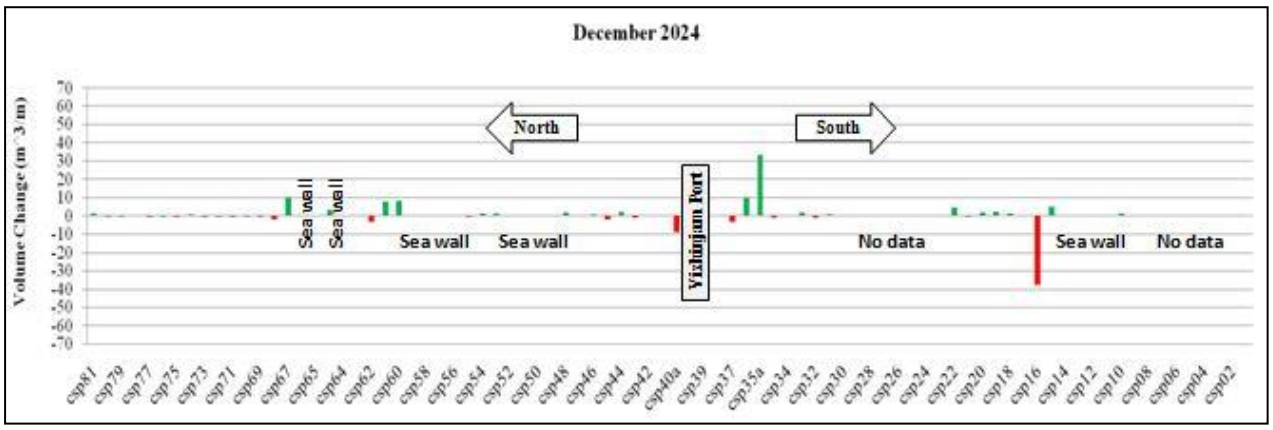
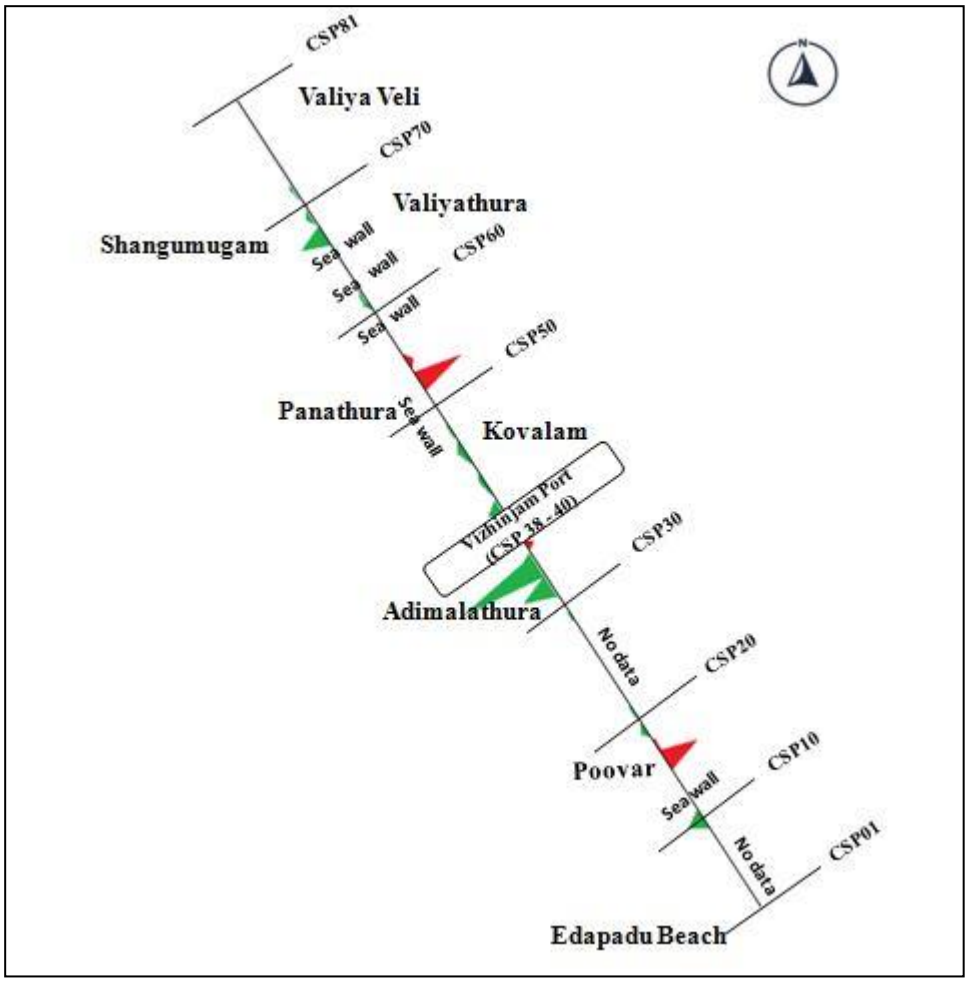


Figure A.3 Monthly Beach Volume Changes in December 2024 in m3/m (onshore)



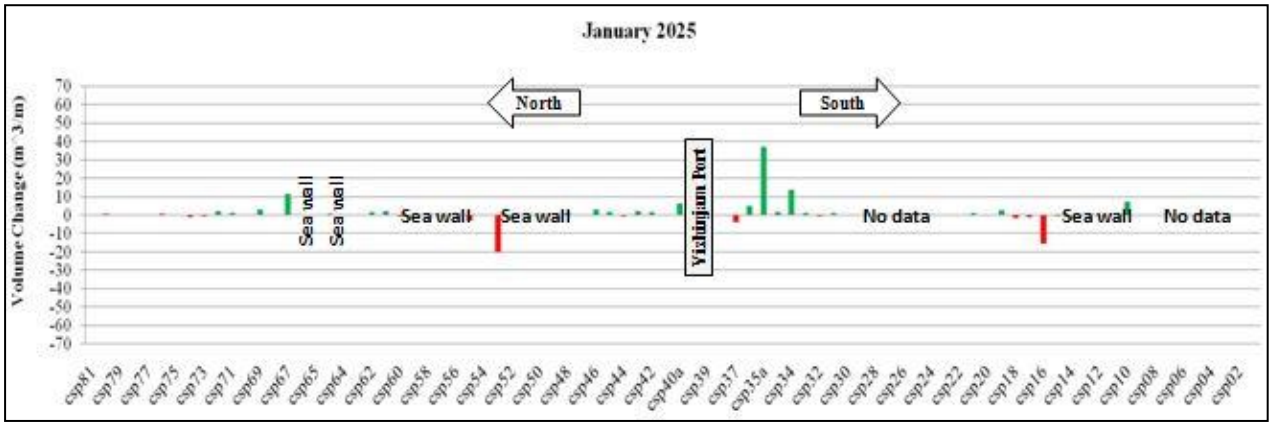
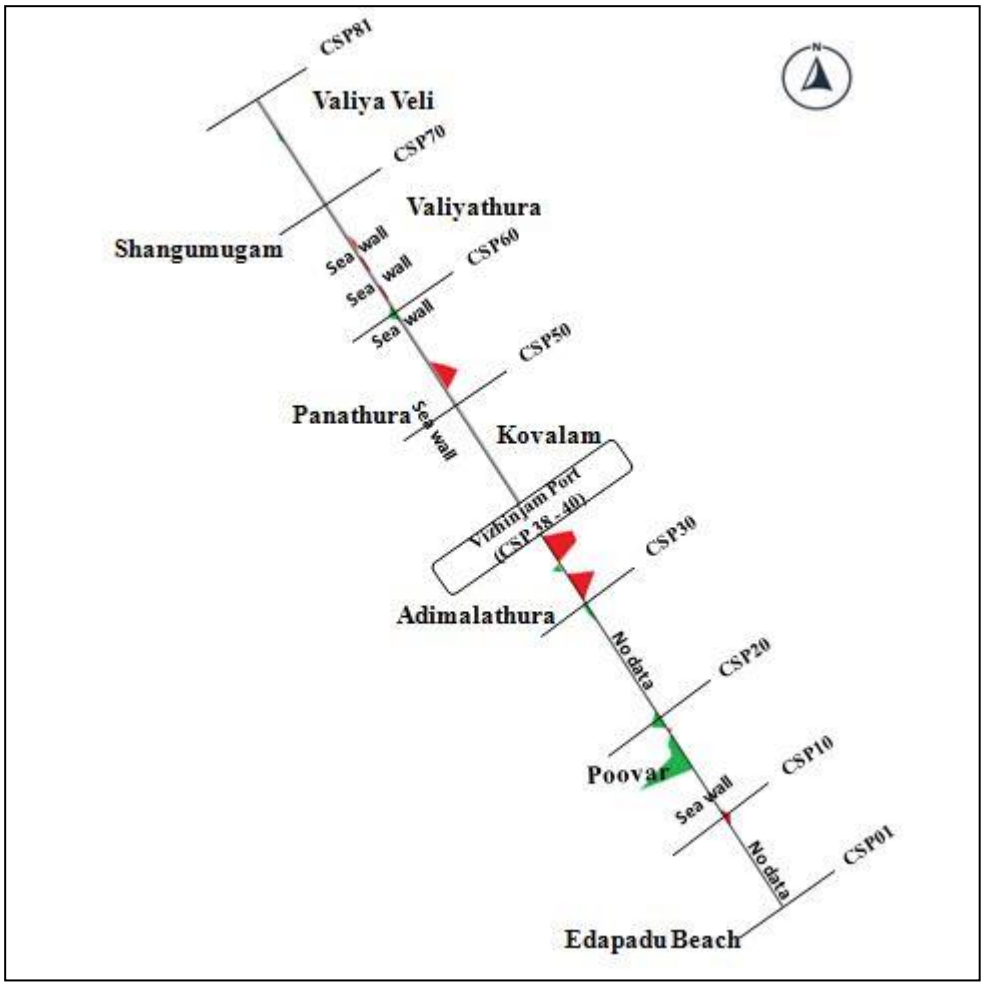


Figure A.4 Monthly Beach Volume Changes in January 2025 in m3/m (onshore)



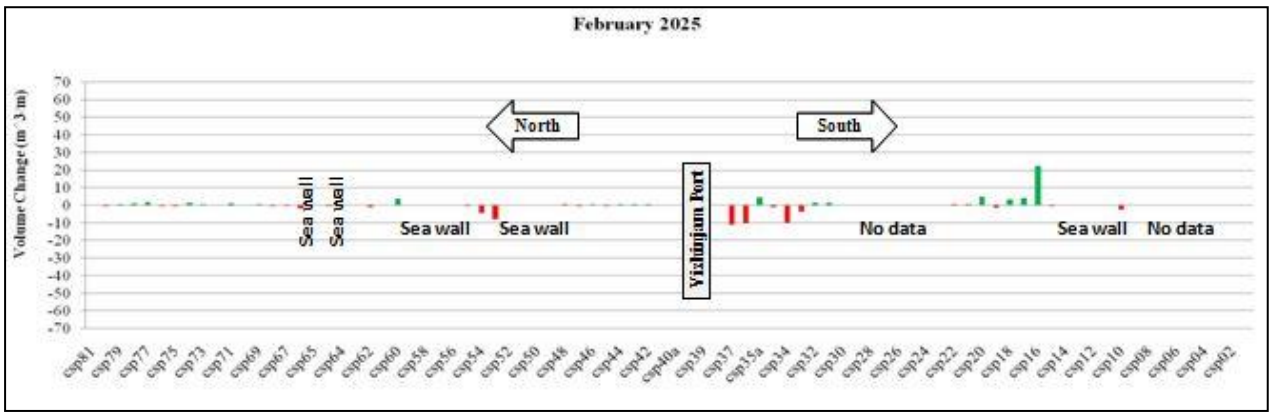
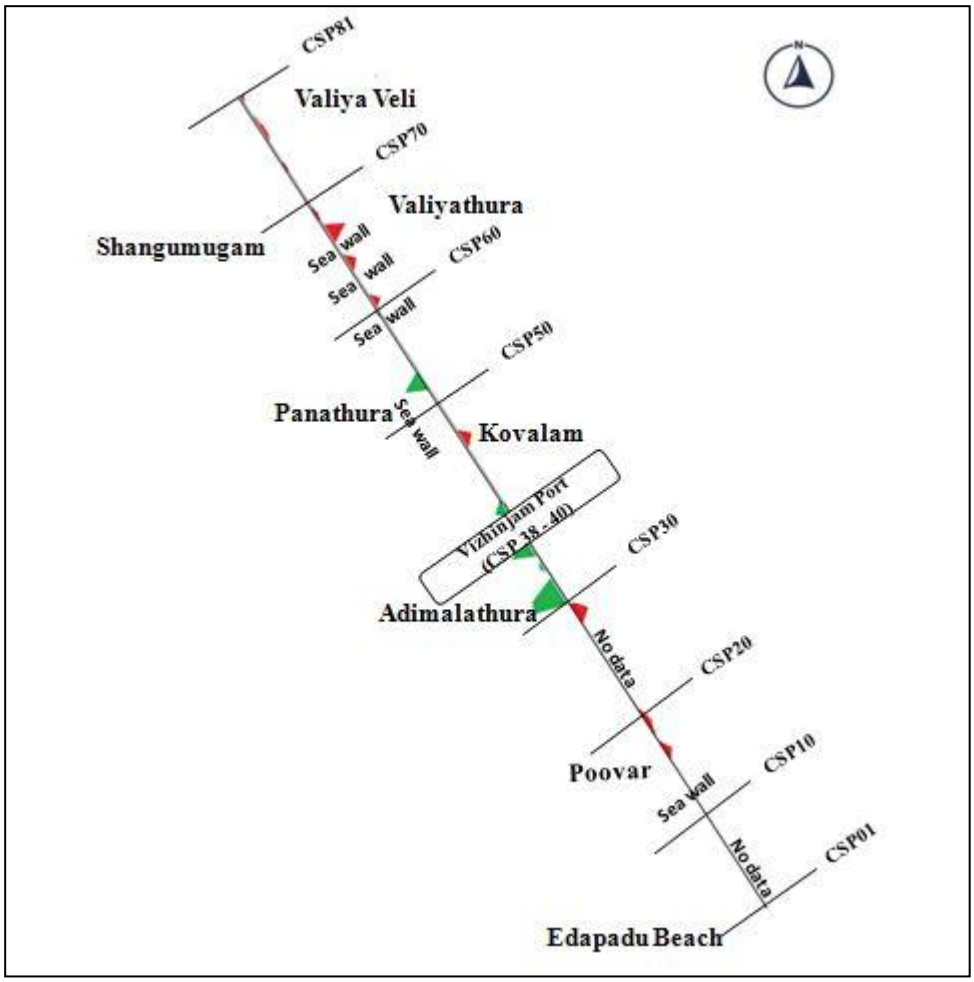


Figure A.5 Monthly Beach Volume Changes February 2025 in m^3/m (onshore)



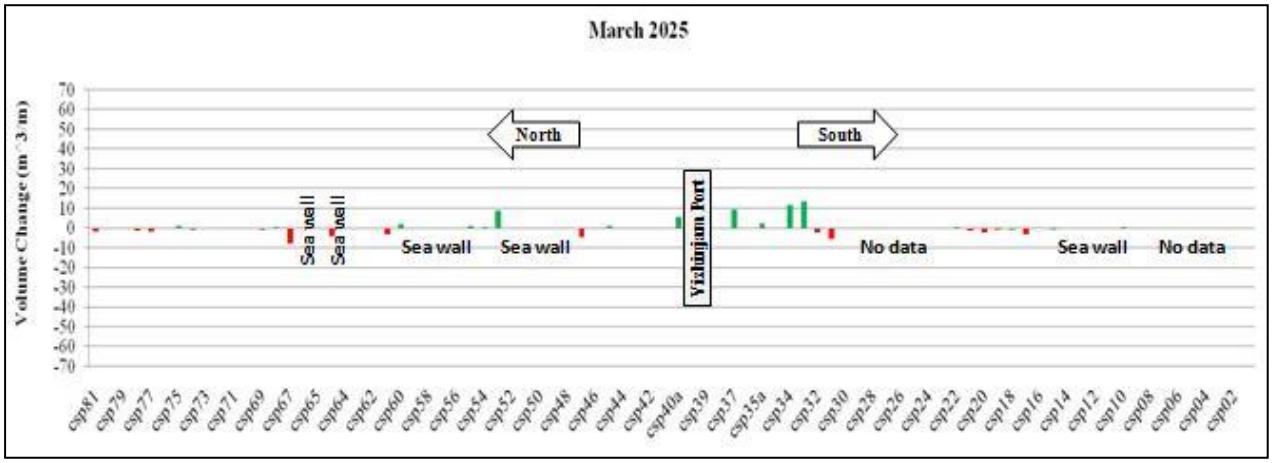
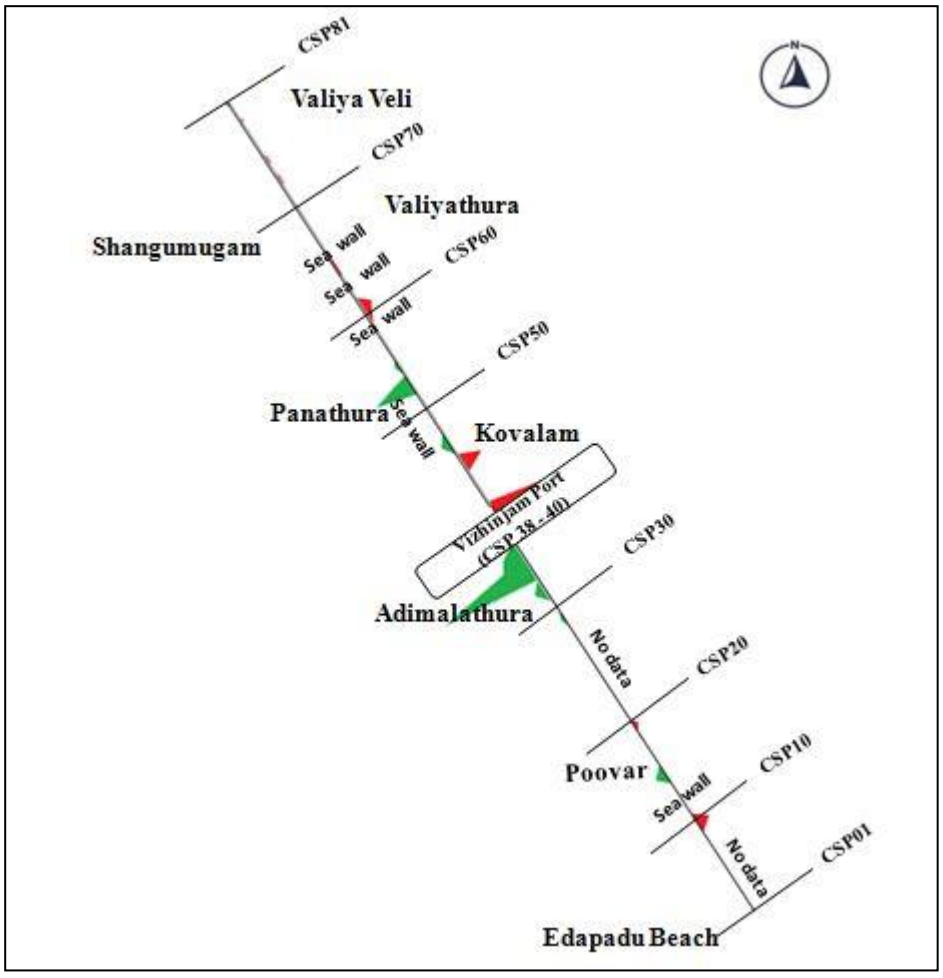


Figure A.6 Monthly Beach Volume Changes in March 2025 in m^3/m (onshore)



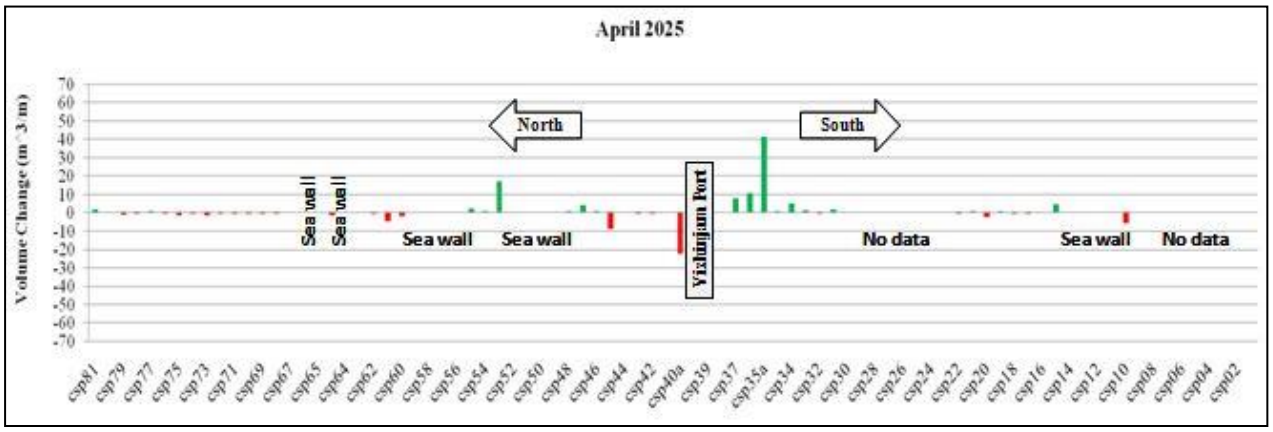
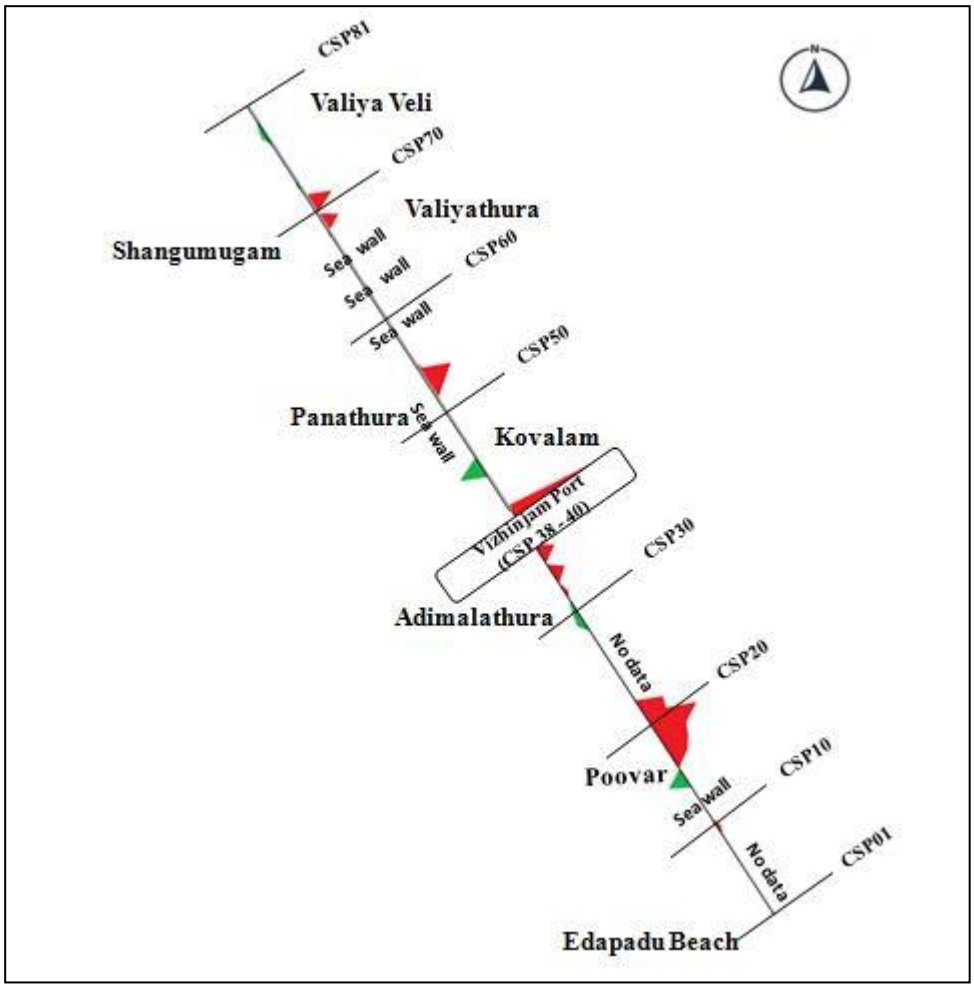


Figure A.7 Monthly Beach Volume Changes in April 2025 in m^3/m (onshore)



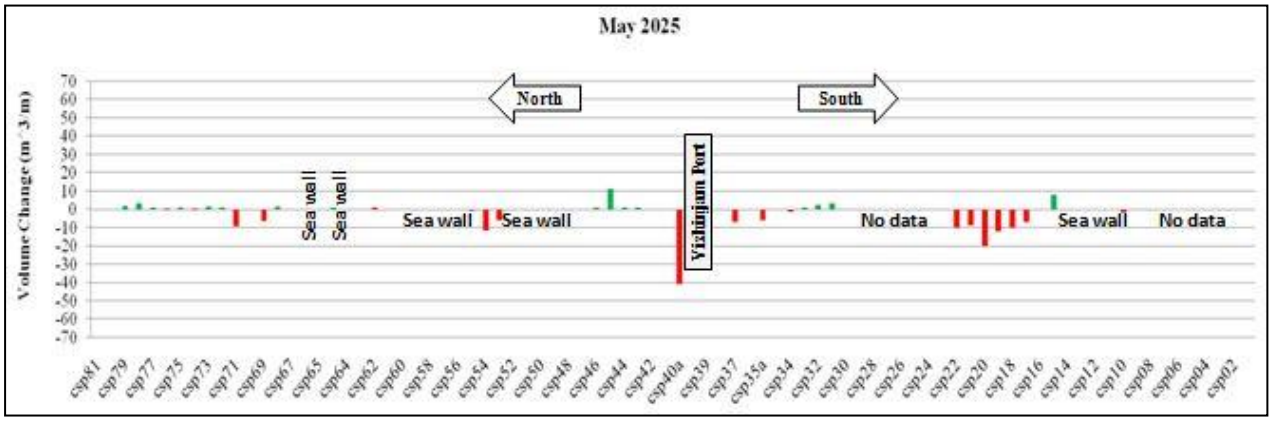
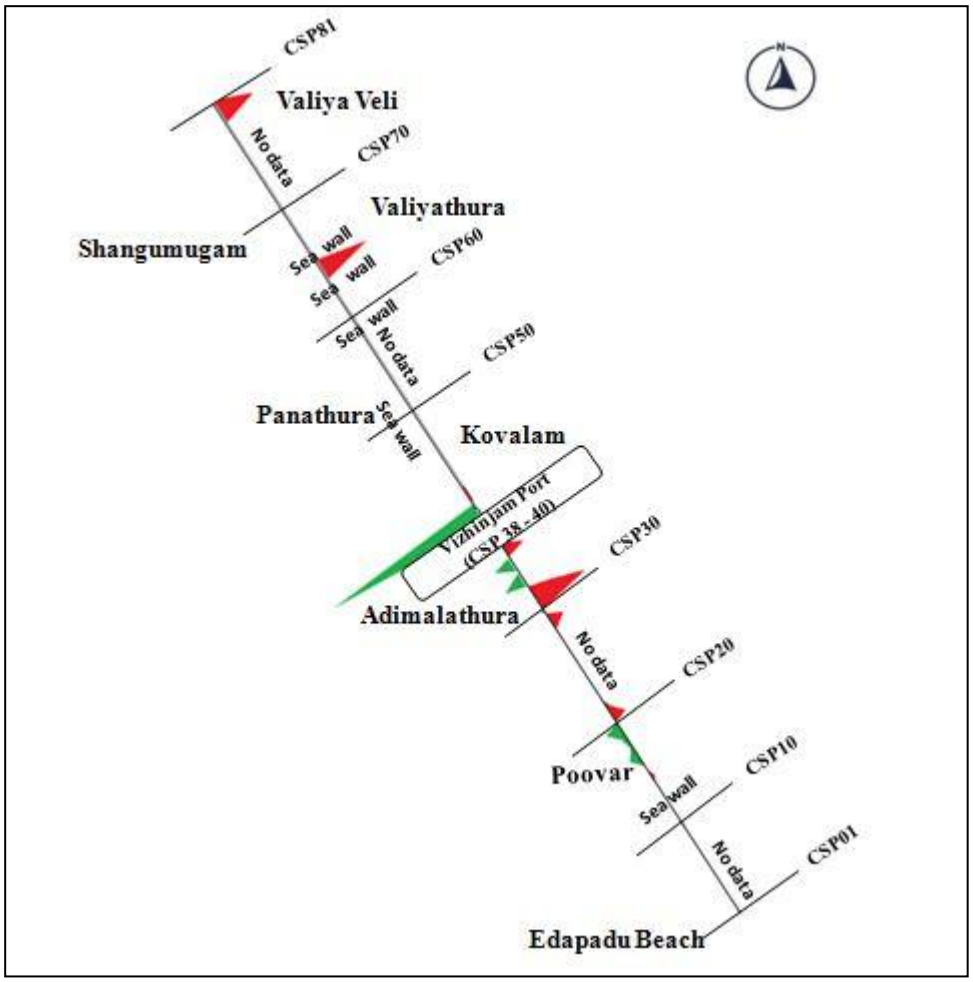


Figure A.8 Monthly Beach Volume Changes in May 2025 in m^3/m (onshore)



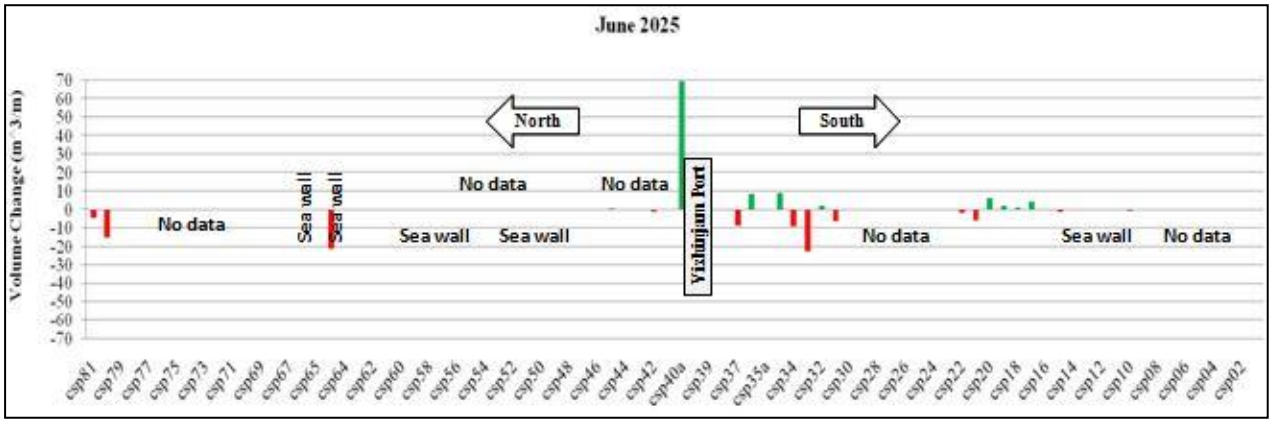
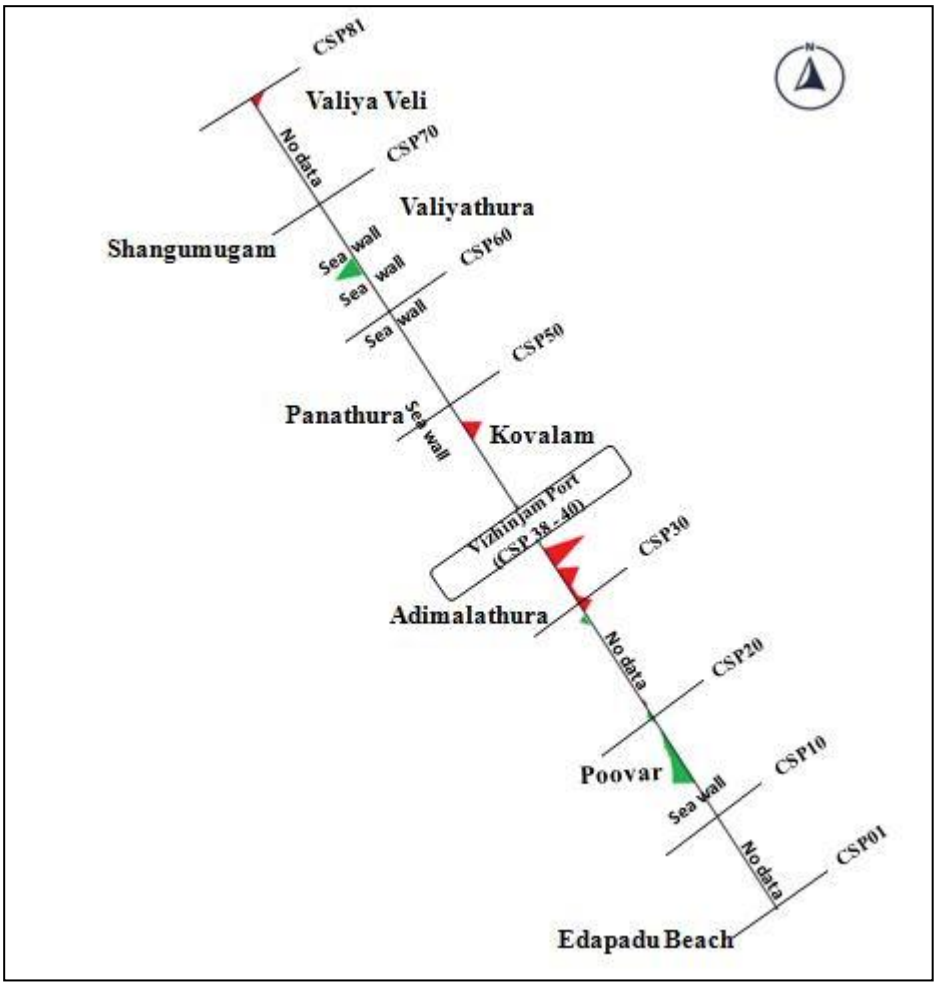


Figure A.9 Monthly Beach Volume Changes in June 2025 in m^3/m (onshore)



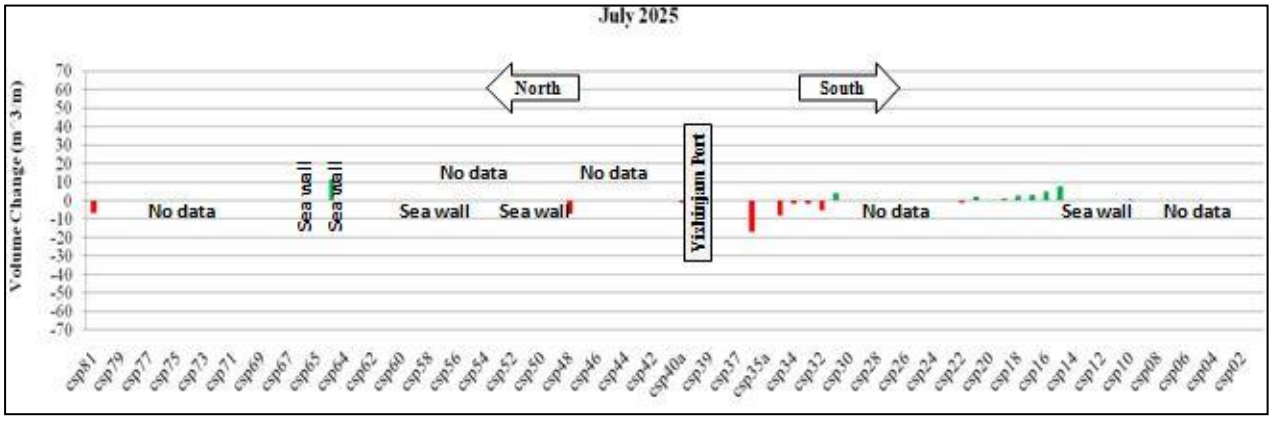
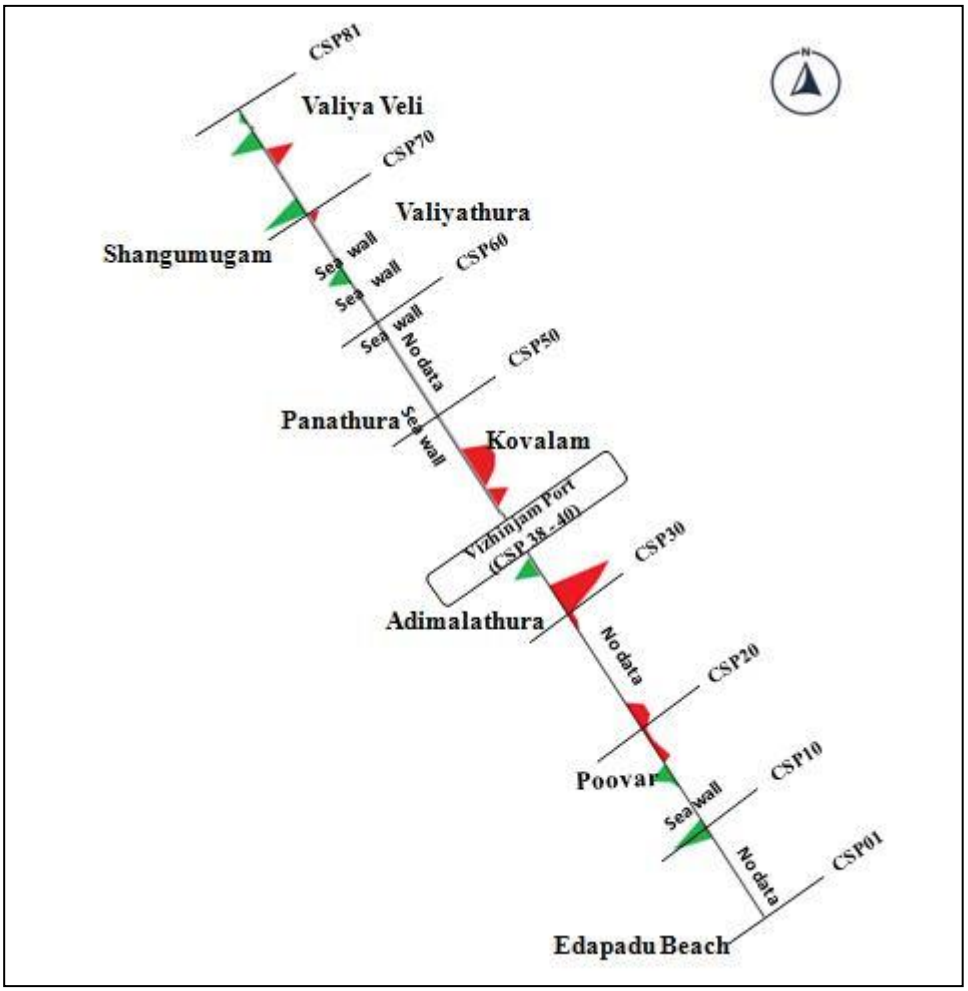


Figure A.10 Monthly Beach Volume Changes in July 2025 in m^3/m (onshore)



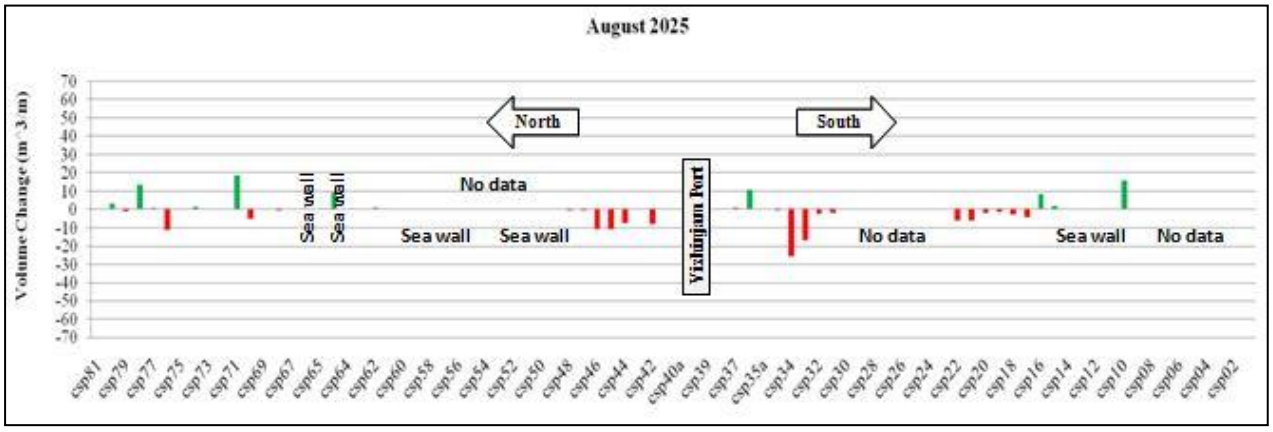
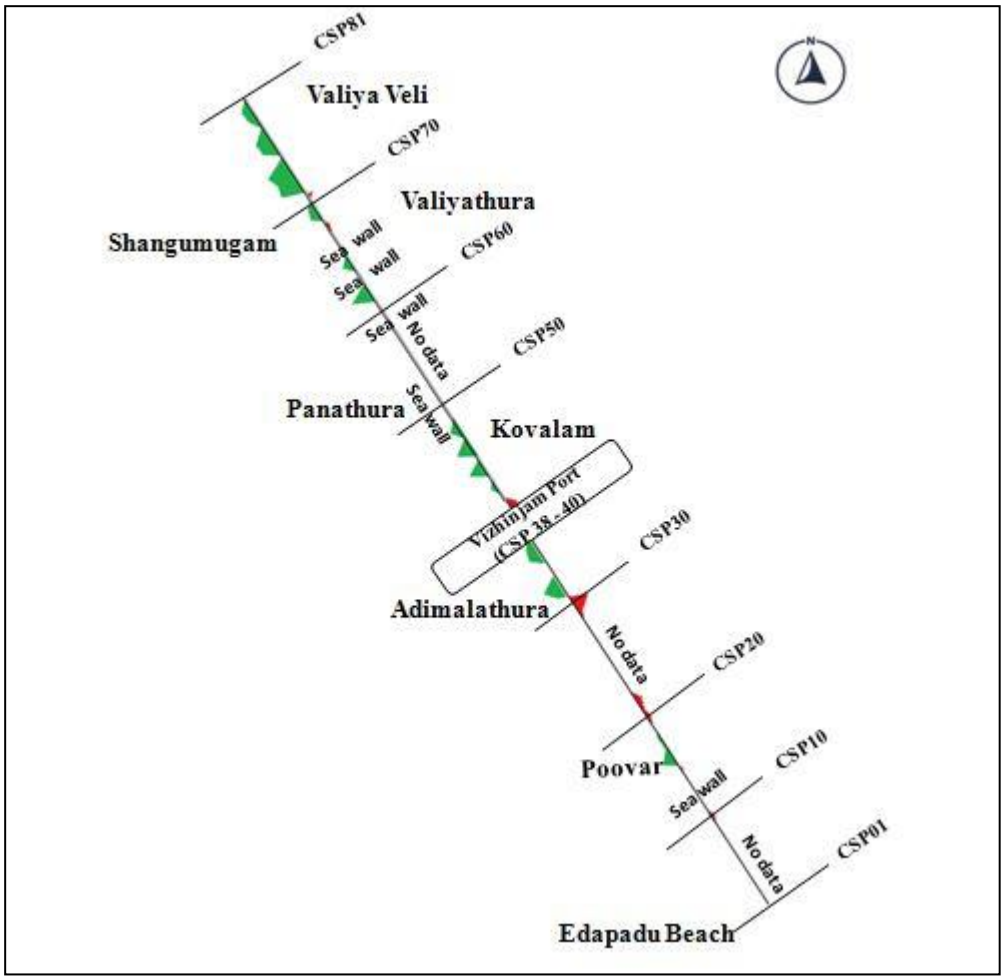


Figure A.11 Monthly Beach Volume Changes in August 2025 in m^3/m (onshore)



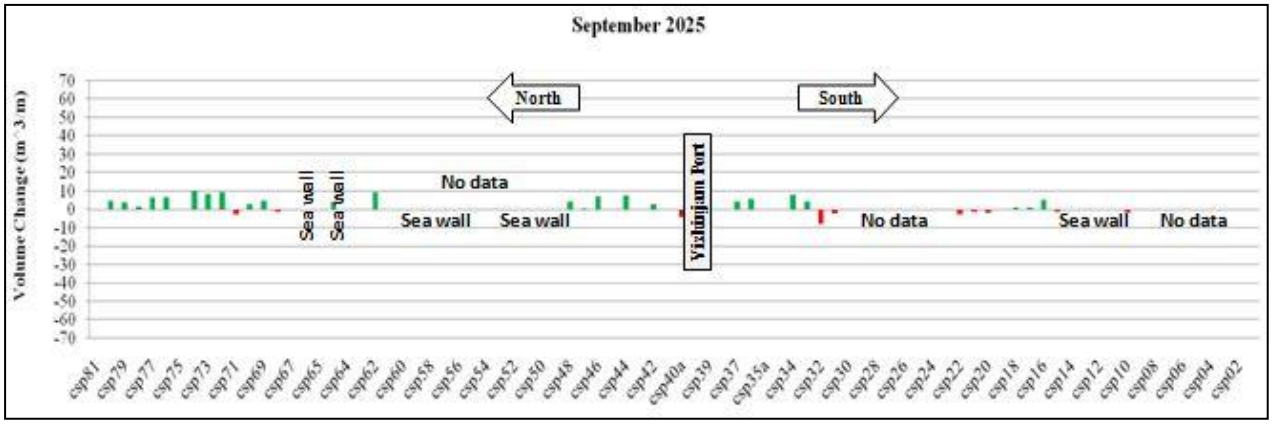


Figure A.12 Monthly Beach Volume Changes in September 2025 in m^3/m (onshore)

Table A.1 Monthly Beach Volume Changes from October 2024 to September 2025 in m^3/m (onshore)

CSP NOs.	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	April 2025	May 2025	June 2025	July 2025	Aug 2025	Sept 2025
CSP01	Sea wall											
CSP02	-	-	-	-	-	-	-	-	-	-	-	-
CSP03	Sea wall											
CSP04	-	-	-	-	-	-	-	-	-	-	-	-
CSP05	-	-	-	-	-	-	-	-	-	-	-	-
CSP06	Sea wall											
CSP07	-	-	-	-	-	-	-	-	-	-	-	-
CSP08	-	-	-	-	-	-	-	-	-	-	-	-
CSP09	-	-	-	-	-	-	-	-	-	-	-	-
CSP10		-1.98	1.27	7.26	-2.56	0.31	-5.81	-1.77	-0.89	0.83	15.83	-1.75
CSP11												
CSP12												
CSP13												
CSP14	Sea wall											
CSP15	0.29	-18.17	5.09	-0.56	-0.31	-0.65	4.76	8.11	-1.30	7.73	1.91	-1.35
CSP16	9.12	-2.91	-37.96	-15.61	22.37	-	-	-	-	5.03	8.16	5.15
CSP17	1.26	6.96	0.27	-1.36	4.32	-3.20	-0.58	-7.07	4.15	3.07	-4.07	0.88
CSP18	2.46	-0.49	1.19	-1.54	3.32	-0.69	-0.03	-10.20	1.10	2.66	-2.83	1.17
CSP19	1.99	-1.02	2.15	2.67	-1.44	-0.83	0.85	-12.30	2.22	0.93	-1.57	0.00
CSP20	4.15	0.26	1.74	0.06	5.05	-2.48	-2.19	-20.05	6.43	0.26	-1.76	-1.61
CSP21	-0.84	3.30	-0.38	1.12	0.56	-1.24	0.79	-8.81	-5.94	2.05	-6.33	-1.47
CSP22	1.96	2.29	4.26	0.14	0.62	0.33	0.15	-10.15	-1.88	-1.31	-6.04	-2.95
CSP23	-	-	-	-	-	-	-	-	-	-	-	-
CSP24	-	-	-	-	-	-	-	-	-	-	-	-
CSP25	-	-	-	-	-	-	-	-	-	-	-	-
CSP26	-	-	-	-	-	-	-	-	-	-	-	-
CSP27	-	-	-	-	-	-	-	-	-	-	-	-
CSP28	-	-	-	-	-	-	-	-	-	-	-	-
CSP29	-	-	-	-	-	-	-	-	-	-	-	-
CSP30	-	-	-	-	-	-	-	-	-	-	-	-
CSP31	5.34	-2.60	0.75	1.13	1.51	-5.61	1.64	3.32	-6.45	3.98	-2.12	-2.10
CSP32	6.42	-0.42	-1.20	-0.86	1.59	-2.12	-0.09	2.35	2.23	-5.39	-2.58	-7.76
CSP33	13.08	4.77	1.66	1.33	-3.76	13.44	1.39	1.03	-22.63	-1.48	-16.91	4.13
CSP34	-0.97	1.83	0.18	13.62	-10.01	11.67	5.08	-1.61	-8.98	-1.74	-25.68	7.92
CSP35	0.09	2.67	-1.30	1.70	-0.85	-0.47	0.95	-0.35	9.21	-8.26	-0.26	-0.03
CSP35A	-	-	33.28	37.03	4.36	2.44	41.23	-5.82	-	-	-	-
CSP36	1.99	-21.78	10.16	4.92	-10.31	0.06	10.71	0.17	8.42	-17.16	10.57	5.69
CSP37	13.10	-4.20	-3.46	-3.86	-11.15	9.52	7.89	-7.01	-8.66	0.16	0.65	4.28
CSP38	Port Area											
CSP39												
CSP40												
CSP40A	-6.08	-5.01	-8.84	6.45	0.30	5.54	-22.51	-41.13	69.47	-1.24	0.55	-4.07
CSP41	Sea wall											
CSP42	-5.21	7.31	0.35	1.43	0.67	-0.45	0.20	-0.19	-1.18	-0.29	-8.05	2.81
CSP43	1.64	1.36	-1.32	2.10	0.63	-0.59	0.11	0.80	-	-	-	-
CSP44	0.04	-0.57	2.18	-0.78	0.69	-0.35	0.33	0.87	-	-	-7.34	7.28
CSP45	0.43	4.10	-1.86	1.49	-0.02	0.76	-8.93	11.08	0.49	-0.35	-10.65	-0.57
CSP46	2.28	4.58	0.58	3.03	0.65	-0.22	1.09	0.98	*	*	-10.67	7.07
CSP47	-0.38	-0.14	0.11	0.24	-0.07	-4.57	4.29	0.10	-0.05	-0.01	-0.68	0.63
CSP48	-0.56	0.48	1.81	1.16	0.47	-0.12	1.06	-0.18	-0.03	-7.21	-0.58	4.26
CSP49	Sea wall											
CSP50												
CSP51												
CSP52												
CSP53	-0.89	-0.70	1.39	-20.20	-7.96	9.05	17.22	-5.83	-	-	-	-
CSP54	3.25	1.87	1.32	0.15	-4.55	0.67	0.77	-11.71	-	-	-	-
CSP55	18.91	1.97	-0.69	-3.28	-0.06	1.15	2.48	-1.14	-	-	-	-
CSP56	Sea wall											
CSP57												
CSP58												

CSP59												
CSP60	2.48	-4.75	8.35	-0.77	3.87	1.75	-2.11	*	*	*	*	*
CSP61	-	-	7.81	2.12	0.36	-3.44	-4.61	*	*	*	*	*
CSP62	-7.90	2.47	-3.48	1.65	-0.99	0.14	0.15	0.71	-	-	0.70	9.16
CSP63	Sea wall											
CSP64												
CSP64A	-	0.87	3.30	0.77	-0.70	-4.01	-1.19	1.13	-21.03	11.57	9.10	4.39
CSP65	Sea wall											
CSP66	*	*	*	*	-1.74	*	*	*	*	*	*	*
CSP67	-0.05	4.54	10.27	11.36	-0.47	-7.87	*	*	-	-	-	-
CSP68	-1.06	1.30	-1.93	0.26	-0.27	0.33	0.10	1.58	-0.09	-0.18	-0.41	-1.46
CSP69	-2.74	2.19	-0.19	2.92	0.69	-0.98	-0.08	-6.59	*	*	0.34	4.59
CSP70	-0.21	0.03	-0.20	0.30	0.30	0.18	-0.64	0.11	*	*	-5.06	3.04
CSP71	5.12	0.20	-0.21	1.18	1.17	-0.51	-0.18	-9.41	-	-	18.62	-2.88
CSP72	1.07	1.26	-0.49	1.87	0.15	0.19	-0.17	1.05	*	*	-	9.42
CSP73	-1.05	1.77	-0.32	-0.93	0.82	0.03	-1.27	1.56	*	*	*	8.24
CSP74	-0.36	2.19	0.85	-1.19	1.50	-0.67	-0.18	0.38	-	-	1.16	10.00
CSP75	-0.41	2.99	0.02	0.39	-0.57	0.81	-1.19	0.97	*	*	*	*
CSP76	-0.02	0.33	-0.52	0.51	-0.30	0.15	-0.12	0.40	-	-	-11.05	6.51
CSP77	-1.79	2.44	-0.54	0.10	1.95	-1.59	0.75	0.89	-	-	1.09	6.71
CSP78	-0.92	0.70	0.08	-0.37	1.07	-1.39	0.16	3.09	-	-	13.50	1.25
CSP79	-2.31	5.27	-0.38	0.16	0.77	-0.59	-0.74	1.95	-	-	-1.12	4.01
CSP80	-0.41	1.73	-0.22	0.56	-0.05	0.16	0.00	-0.04	-15.24	0.06	2.99	4.56
CSP81	-0.01	-0.11	1.33	-0.39	0.32	-1.88	1.85	-0.02	-4.29	-6.68	*	*

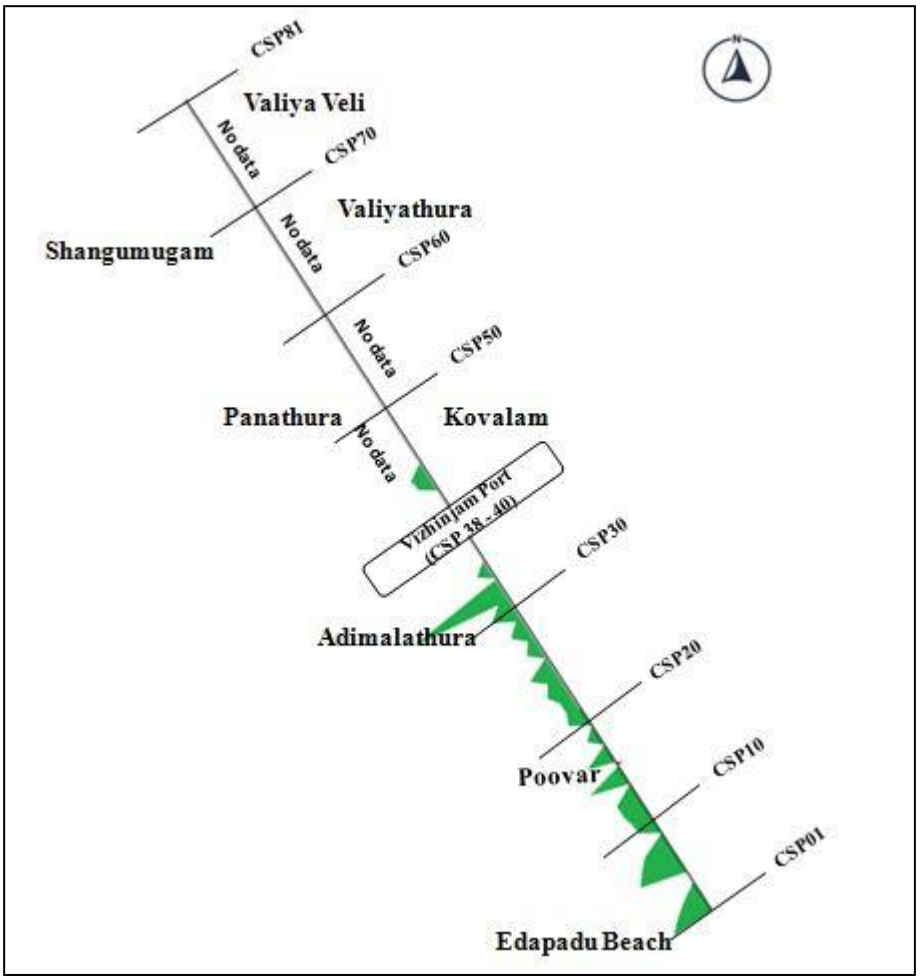
*Data not considered for analysis
-No data

A.1.2 Monthly Beach Volume variations for October 2024 to September 2025 for the offshore part

Offshore surveys were not conducted at any locations during September 2024 to November 2024, February 2025, and June to September 2025; therefore, these months were excluded from the analysis. An error was found in the offshore profiles of April 2025. So analysis of May 2025 could not be carried out. The corresponding results are presented graphically in **Figures A.13** and in **Table A.2.**

Due to the absence of offshore data in the above-mentioned time period, the analysis for October 2024, November 2024, February 2025, March 2025, April 2025, June 2025-September 2025 could not be carried out. Additionally, most profiles north of the port were found to be unreliable in November and December 2024, resulting in the exclusion of these months from the assessment.

The January 2025 analysis was limited to locations south of the port, where offshore accretion was generally observed, except at Poovar South (CSP16), which showed signs of erosion.



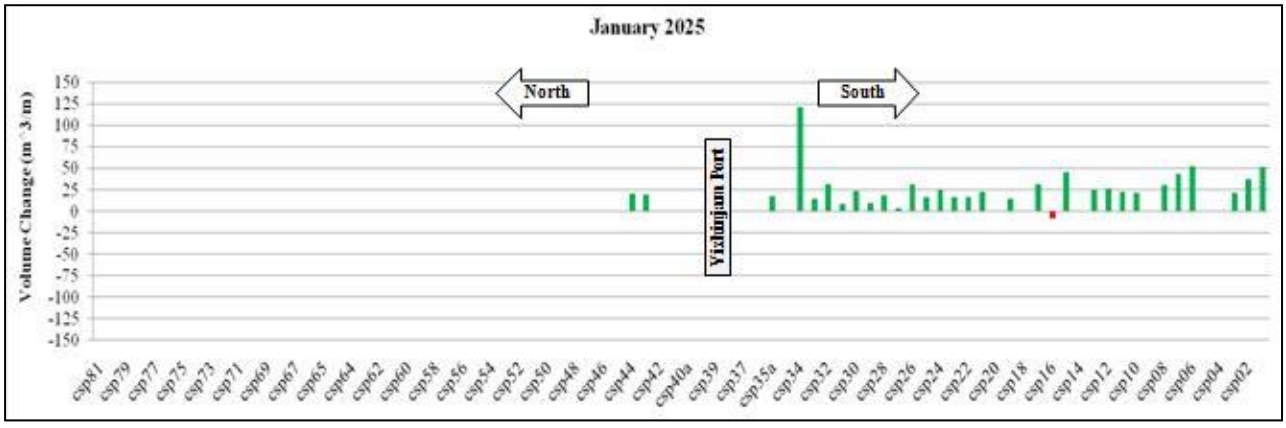


Figure A.13 Monthly Beach Volume Changes in January 2025 in m^3/m (offshore)

Table A.2 Monthly Beach Volume Changes from October 2024 to September 2025 in m^3/m (offshore)

CSP NOs.	Oct 2024	Nov 2024	Dec 2024	Jan 2025	Feb 2025	Mar 2025	April 2025	May 2025	June 2025	July 2025	Aug 2025	Sep 2025
CSP01	-	-	-	50.98	-	-	-	-	-	-	-	-
CSP02	-	-	-	37.71	-	-	-	-	-	-	-	-
CSP03	-	-	-	21.14	-	-	-	-	-	-	-	-
CSP04	-	-	-	*	-	-	-	-	-	-	-	-
CSP05	-	-	-	*	-	-	-	-	-	-	-	-
CSP06	-	-	-	52.74	-	-	-	-	-	-	-	-
CSP07	-	-	-	42.91	-	-	-	-	-	-	-	-
CSP08	-	-	-	30.69	-	-	-	-	-	-	-	-
CSP09	-	-	-	*	-	-	-	-	-	-	-	-
CSP10	-	-	-	21.19	-	-	-	-	-	-	-	-
CSP11	-	-	-	22.79	-	-	-	-	-	-	-	-
CSP12	-	-	-	26.40	-	-	-	-	-	-	-	-
CSP13	-	-	-	25.17	-	-	-	-	-	-	-	-
CSP14	-	-	-	*	-	-	-	-	-	-	-	-
CSP15	-	-	-	45.05	-	-	-	-	-	-	-	-
CSP16	-	-	-	-9.06	-	-	-	-	-	-	-	-
CSP17	-	-	-	31.59	-	-	-	-	-	-	-	-
CSP18	-	-	-	*	-	-	-	-	-	-	-	-
CSP19	-	-	-	14.63	-	-	-	-	-	-	-	-
CSP20	-	-	-	*	-	-	-	-	-	-	-	-
CSP21	-	-	-	22.08	-	-	-	-	-	-	-	-
CSP22	-	-	-	16.55	-	-	-	-	-	-	-	-
CSP23	-	-	-	16.19	-	-	-	-	-	-	-	-
CSP24	-	-	-	25.08	-	-	-	-	-	-	-	-
CSP25	-	-	-	16.24	-	-	-	-	-	-	-	-
CSP26	-	-	-	31.10	-	-	-	-	-	-	-	-
CSP27	-	-	-	3.48	-	-	-	-	-	-	-	-
CSP28	-	-	-	18.56	-	-	-	-	-	-	-	-
CSP29	-	-	-	8.97	-	-	-	-	-	-	-	-
CSP30	-	-	-	22.83	-	-	-	-	-	-	-	-
CSP31	-	-	-	8.22	-	-	-	-	-	-	-	-
CSP32	-	-	-	31.63	-	-	-	-	-	-	-	-
CSP33	-	-	-	14.31	-	-	-	-	-	-	-	-
CSP34	-	-	-	120.80	-	-	-	-	-	-	-	-
CSP35	-	-	-	*	-	-	-	-	-	-	-	-
CSP35A	-	-	-	17.71	-	-	-	-	-	-	-	-
CSP36	-	-	-	*	-	-	-	-	-	-	-	-
CSP37	-	-	-	*	-	-	-	-	-	-	-	-
CSP38												
CSP39												
CSP40												
CSP40A	-	-	-	*	-	-	-	-	-	-	-	-
CSP41	-	-	-	*	-	-	-	-	-	-	-	-
CSP42	-	-	-	*	-	-	-	-	-	-	-	-
CSP43	-	-	-	18.89	-	-	-	-	-	-	-	-
CSP44	-	-	-	20.80	-	-	-	-	-	-	-	-
CSP45	-	-	-	*	-	-	-	-	-	-	-	-
CSP46	-	-	-	*	-	-	-	-	-	-	-	-
CSP47	-	-	-	*	-	-	-	-	-	-	-	-
CSP48	-	-	-	*	-	-	-	-	-	-	-	-
CSP49	-	-	-	*	-	-	-	-	-	-	-	-
CSP50	-	-	-	*	-	-	-	-	-	-	-	-
CSP51	-	-	-	*	-	-	-	-	-	-	-	-
CSP52	-	-	-	*	-	-	-	-	-	-	-	-
CSP53	-	-	-	*	-	-	-	-	-	-	-	-
CSP54	-	-	-	*	-	-	-	-	-	-	-	-
CSP55	-	-	-	*	-	-	-	-	-	-	-	-
CSP56	-	-	-	*	-	-	-	-	-	-	-	-
CSP57	-	-	-	*	-	-	-	-	-	-	-	-

CSP58	-	-	-	*	-	-	-	-	-	-	-	-
CSP59	-	-	-	*	-	-	-	-	-	-	-	-
CSP60	-	-	-	*	-	-	-	-	-	-	-	-
CSP61	-	-	-	*	-	-	-	-	-	-	-	-
CSP62	-	-	-	*	-	-	-	-	-	-	-	-
CSP63	-	-	-	*	-	-	-	-	-	-	-	-
CSP64	-	-	-	*	-	-	-	-	-	-	-	-
CSP64A	-	-	-	*	-	-	-	-	-	-	-	-
CSP65	-	-	-	*	-	-	-	-	-	-	-	-
CSP66	-	-	-	*	-	-	-	-	-	-	-	-
CSP67	-	-	-	*	-	-	-	-	-	-	-	-
CSP68	-	-	-	*	-	-	-	-	-	-	-	-
CSP69	-	-	-	*	-	-	-	-	-	-	-	-
CSP70	-	-	-	*	-	-	-	-	-	-	-	-
CSP71	-	-	-	*	-	-	-	-	-	-	-	-
CSP72	-	-	-	*	-	-	-	-	-	-	-	-
CSP73	-	-	-	*	-	-	-	-	-	-	-	-
CSP74	-	-	-	*	-	-	-	-	-	-	-	-
CSP75	-	-	-	*	-	-	-	-	-	-	-	-
CSP76	-	-	-	*	-	-	-	-	-	-	-	-
CSP77	-	-	-	*	-	-	-	-	-	-	-	-
CSP78	-	-	-	*	-	-	-	-	-	-	-	-
CSP79	-	-	-	*	-	-	-	-	-	-	-	-
CSP80	-	-	-	*	-	-	-	-	-	-	-	-
CSP81	-	-	-		-	-	-	-	-	-	-	-

*Data not considered for analysis
-No data

A.1.3 Seasonal and Overall Beach Volume Variations from October 2024 to September 2025

Seasonal variation has been analysed as post-monsoon (October 2024 to November 2024), fair weather period (December 2024 to March 2025), pre-monsoon period (April 2025 to May 2025), and Monsoon (June 2025 to September 2025) for the period October 2024 to September 2025. The results have been presented to depict the total changes that occur in a particular season by analysing profiles between each month in a season–shown graphically in **Figures A.14 to A.19** and **Table A.3 and Table A.4.**

No offshore surveys were conducted from June 2025 to September 2025 for any of the 81 locations. As a result, the analysis for the monsoon season (June-September 2025) for the offshore could not be performed. No onshore surveys were carried out from CSP1-10 and CSP23-30 during any month from September 2024 to September 2025.

No onshore surveys in October 2024, there were no surveys performed at CSP16, CSP35A; during March 2024, there were no surveys at CSP16; in May 2025 there was no surveys at CSP60; in June 2025, no survey occurred at CSP35A, CSP41,43, CSP53-55, CSP60, CSP67, CSP72, CSP73; there was no data for CSP35A,41,60,67 September 2025. Shorter distance examined in comparison to other months at CSP46 in June 2025, CSP57 in October 2024, June 2025, September 2025; CSP58, CSP60, CSP61 in May

2025 to September 2025, CSP66 in October 2024, December 2024, March 2025 and September 2025, CSP67 in April 2025, CSP69 in June 2025, CSP70 in June 2025, CSP72 in June 2025, CSP73 in June 2025, CSP75 in June 2025. Hence, the analysis was not carried out in these areas.

Beach Volume Change in Post Monsoon Period 2024 (October 2024-November 2024)-onshore

In Post monsoon 2024, accretion occurred in the following locations: Poovar South (CSP17), Poovar north to Karumkulam (CSP20-22), Adimalathura to Azhimala (CSP33-35), Kovalam (CSP42-43,45-46), Panathura (CSP48), Punthura (CSP54-55), Cheriyathura (CSP62), Valiyathura (CSP64A), Shangumugham to Thumba (CSP68-80). Pozhiyoor (CSP10), Poovar south (CSP15-16), Poovar (CSP18-19), Adimalathura (CSP31-32), Mullur (CSP36-37), Port reclamation area (CSP40A), Kovalam (CSP44,47), Punthura (CSP53), Beemapally (CSP60), Thumba (CSP81) are the locations where erosion has been reported in Post Monsoon 2024. The findings are displayed in Figure A.14.

Beach Volume Change in Post Monsoon Period 2024 (October 2024-November 2024)-offshore

The assessment for the post-monsoon period of 2024 could not be conducted because the offshore data was unavailable in October 2024 and November 2024.

Beach Volume Change in Fair Weather Period 2025 (December 2024-March 2025)-onshore

In fair weather, the beach displays accretion along Pozhiyoor (CSP10), Poovar to Karumkulam (CSP18-22), Adimalathura to Azhimala(CSP33-35A), Port reclamation area (CSP40A), Kovalam (CSP42-43,45-46), Panathura (CSP48), Punthura (CSP57), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham to Vettucaud (CSP68-72), Kochuveli (CSP75-77), Valiyaveli to Thurmba (CSP79-80). The following areas have demonstrated erosion during the fair weather season: Poovar South (CSP15,17), Adimalathura (CSP31-32), Mullur (CSP36-37), Kovalam (CSP44,47), Punthura (CSP53-55), Cheriyathura (CSP61), Valiyathura (CSP64A), Vettucaud (CSP73-74), Valiyaveli (CSP78), and Thumba (CSP81). Figure A.15 displays the results.

Beach Volume Change in Fair Weather Period 2025 (December 2024-March 2025)-offshore

Due to the inaccurate profiles discovered north of the port in December 2024, data from January 2025 is utilized for the analysis of fair weather periods instead of that from December 2024.

During the fair weather season of 2025, beach erosion was observed at the following locations offshore: Edappadu (CSP01), Vallavilay (CSP04-06), Neerody (CSP09), Poovar South (CSP17), Karumkulam (CSP24-25), Pulluvila (CSP27-28), Adimalathura (CSP31-33), Kovalam to Punthura (CSP46-55), Punthura to Valliyathura (CSP57-64), Valliyathura to Valiyaveli (CSP65-78), and Thumba (CSP81). Conversely, accretion occurred at Edappadu beach (CSP02-03), Neerody (CSP7-8), Pozhiyoor to Paruthiyoor (CSP10-13), Poovar south (CSP15-16), Poovar to Karumkulam (CSP18-23), Karumkulam (CSP26), Pullavila (CSP29-30), Adimalathura (CSP34), Valiyaveli to Thumba (CSP79-80). Results are shown in Figure A.16.

Beach Volume Change in Pre Monsoon 2025 (April 2025-May 2025)-onshore

In Pre-monsoon 2025, accretion was noted at Poovar South (CSP15), Adimalathura (CSP31-33), Mullur (CSP36), Kovalam (CSP43-47), Cheriyathura (CSP62), Valliyathura (CSP64A), Shangumugham South (CSP68,70), Vettucaud to Valiyaveli (CSP72-79). Erosion was recorded at Pozhiyoor (CSP10), Poovarsouth to Karumkulam (CSP17-22), Adimalathura to Azhimala (CSP34-35A), Mullur (CSP37), Port reclamation area (CSP40A), Kovalam (CSP42), Panathura (CSP48), Punthura (CSP53-55,57), Shangumugham(CSP69-71), and Thumba (CSP80-81). Results are shown in Figure A.17.

Beach Volume Change in Pre Monsoon 2025 (April 2025-May 2025)-offshore

No suitable offshore profile found during April 2025, hence pre-monsoon analysis could not be carried out.

Beach Volume Change in Monsoon 2025 (June 2025-September 2025)-onshore

Locations Pozhiyoor (CSP10), Poovar south (CSP15-16), Mullur(CSP37), Valliyathura (CSP64A) and Thumba (CSP80) were observed to have accretion, whereas areas Poovar south (CSP17), Poovar-Karumkulam(CSP19-22), Adimalathura to Azhimala (CSP31-35), Mullur (CSP36), the port reclamation area (CSP40A), Kovalam (CSP42,45,47), Panathura (CSP48), Shangumugham(CSP68), Kochuveli (CSP76), and Thumba (CSP81)experienced erosion during the monsoon season of 2025 on the onshore. The results are illustrated in Figure A.18.

Beach Volume Change in Monsoon 2025 (June 2025-September 2025)-offshore

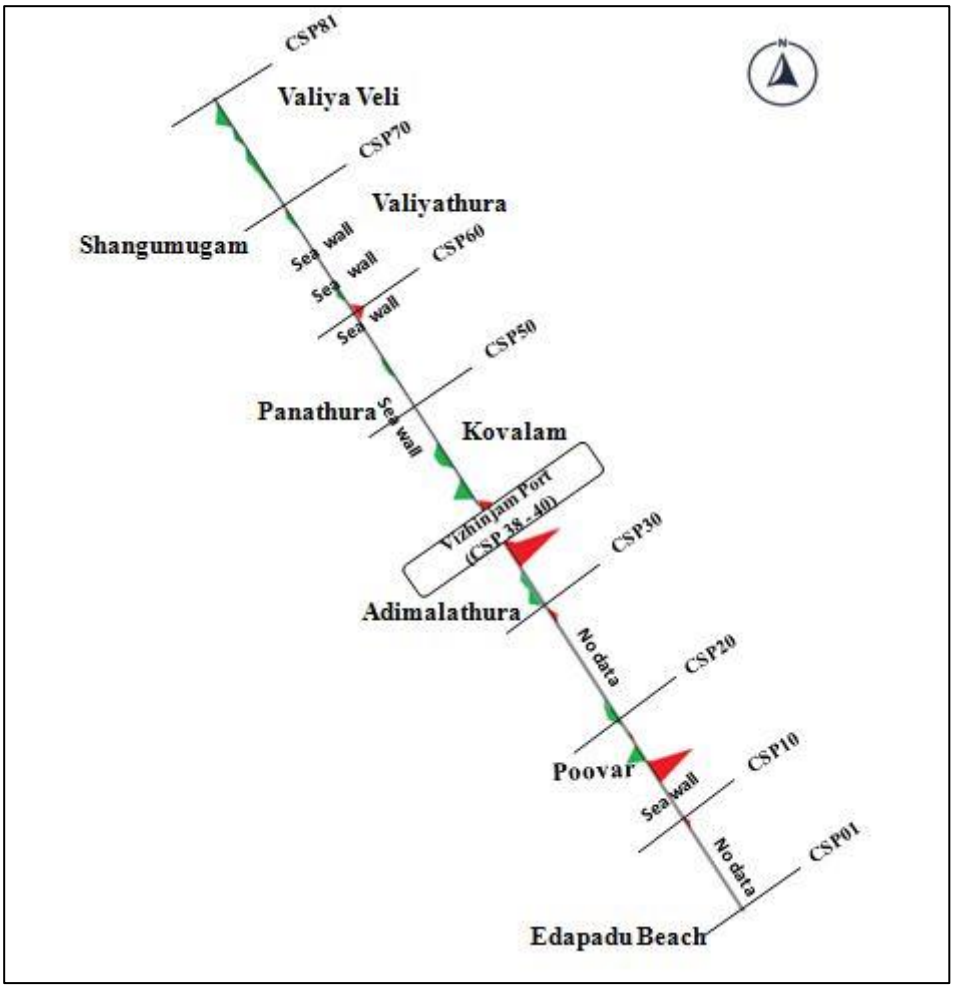
No offshore survey was carried out from June 2025 to September 2025.

Overall beach volume variation from October 2024 to September 2025 (onshore)

From October 2024 to September 2025, erosion has been observed onshore at Poovar south (CSP16), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP31-34), Mullur (CSP37), the port reclamation area (CSP40A), Kovalam (CSP43-45,46), Punthura (CSP54-55), Cheriyathura (CSP62), Shangumugham (CSP68), Shangumugham to Thumba (CSP70-81). Meanwhile, accretion has been detected onshore at Pozhiyoor (CSP10), Poovar south (CSP15,17), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP42,46), Panathura (CSP48), Punthura (CSP53), Valliyathura (CSP64A), and Shangumugham (CSP69). The results are illustrated in Figure A.19.

Overall beach volume variation from October 2024 to September 2025 (offshore)

No offshore survey was conducted for October 2024 and September 2025 in any of the locations.



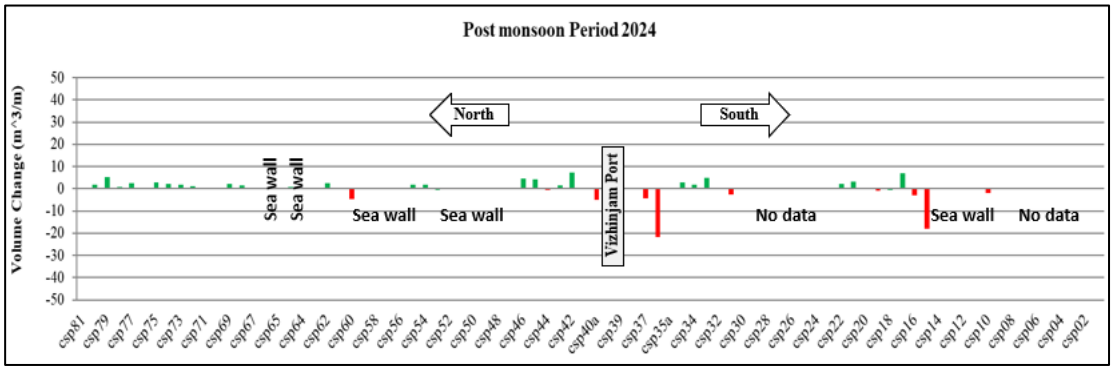
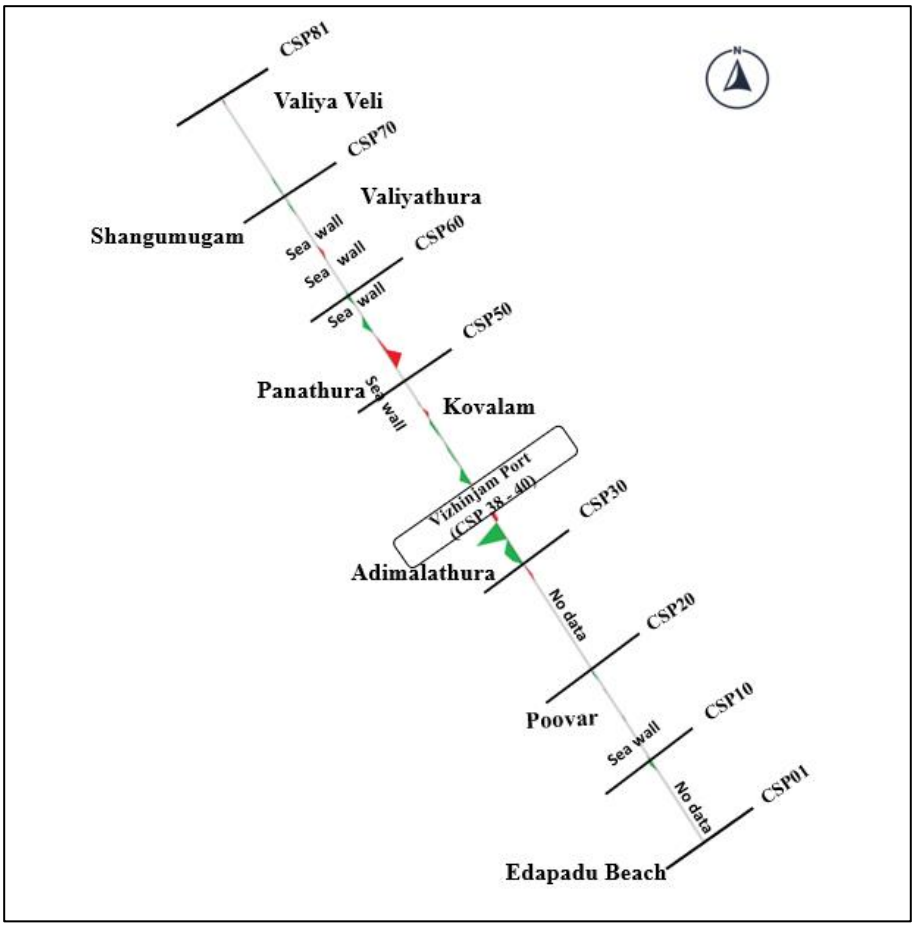


Figure A.14 Seasonal Beach Volume Changes during Post Monsoon Period in m³/m (onshore)



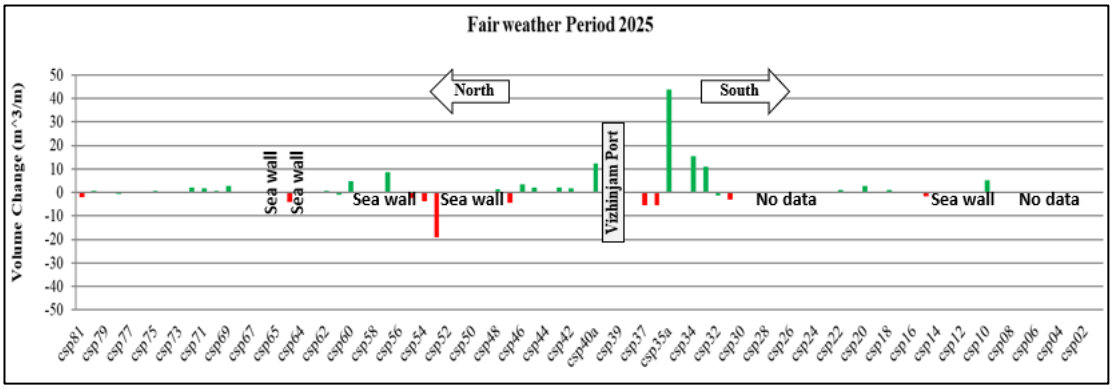
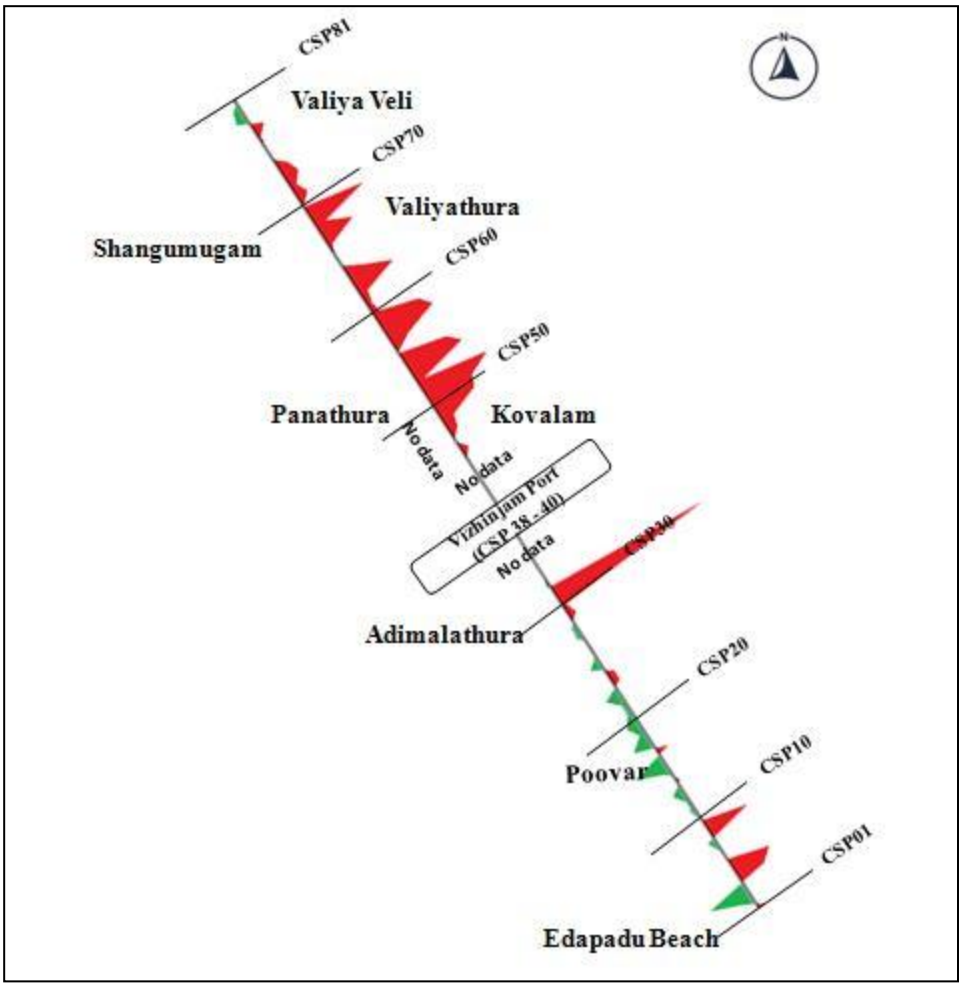


Figure A.15 Seasonal Beach Volume Changes during Fair Weather Period in m³/m (onshore)



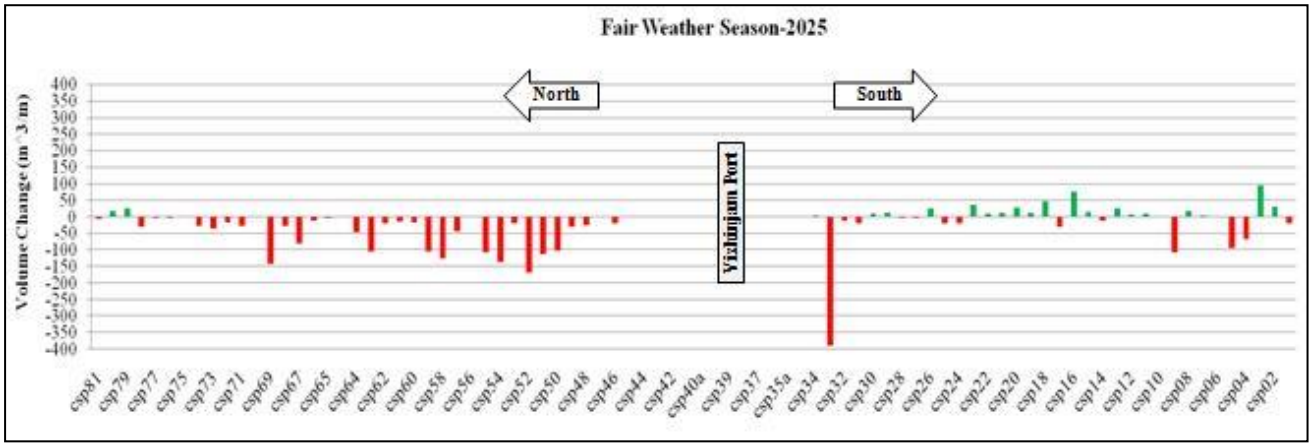
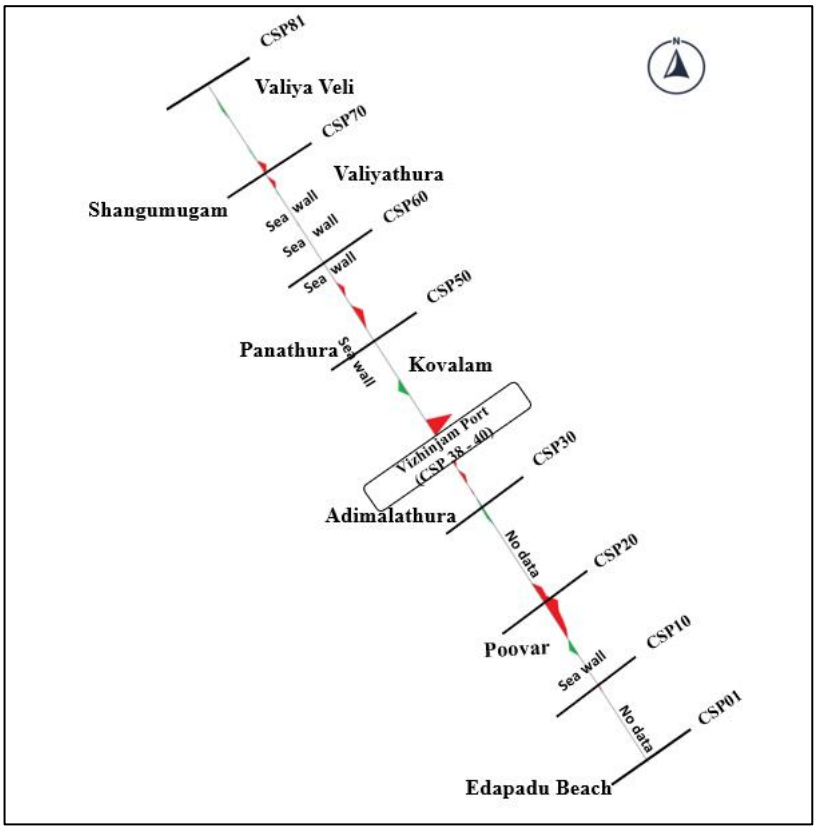


Figure A.16 Seasonal Beach Volume Changes during Fair Weather Period in m³/m (offshore)



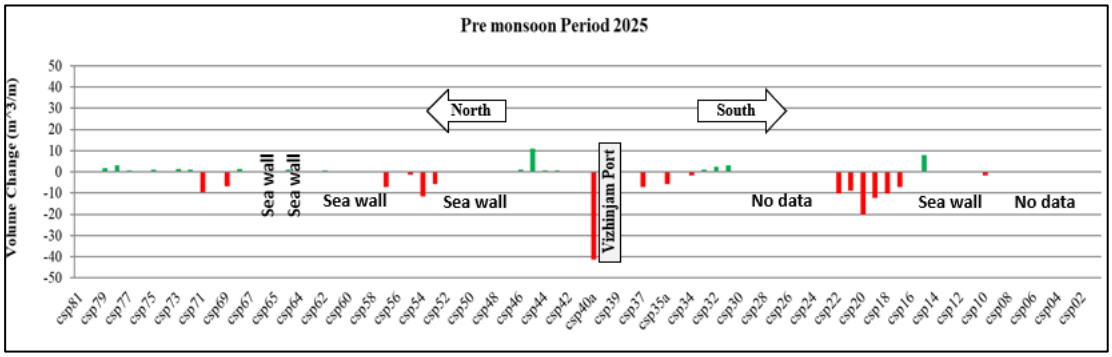
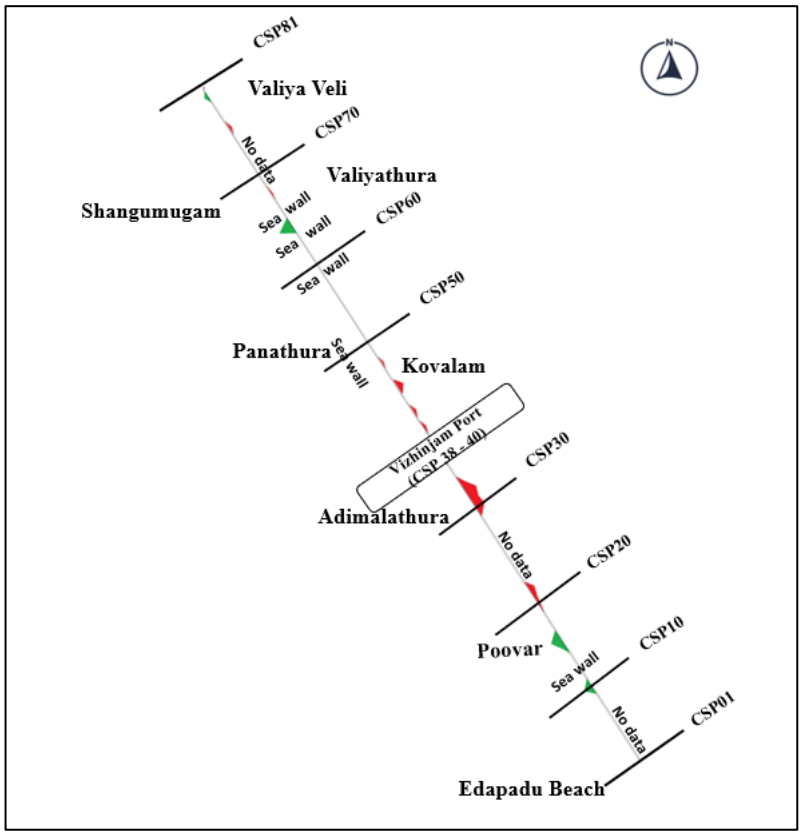


Figure A.17 Seasonal Beach Volume Changes during the Pre-monsoon Period in m³/m (onshore)



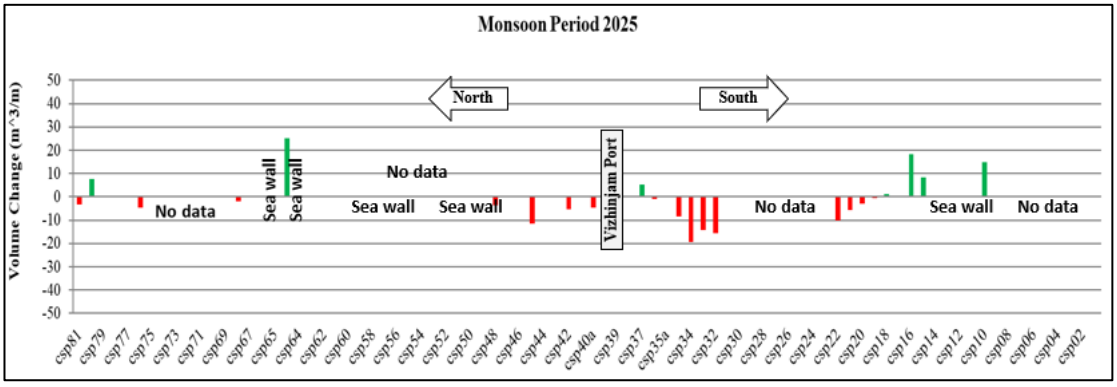
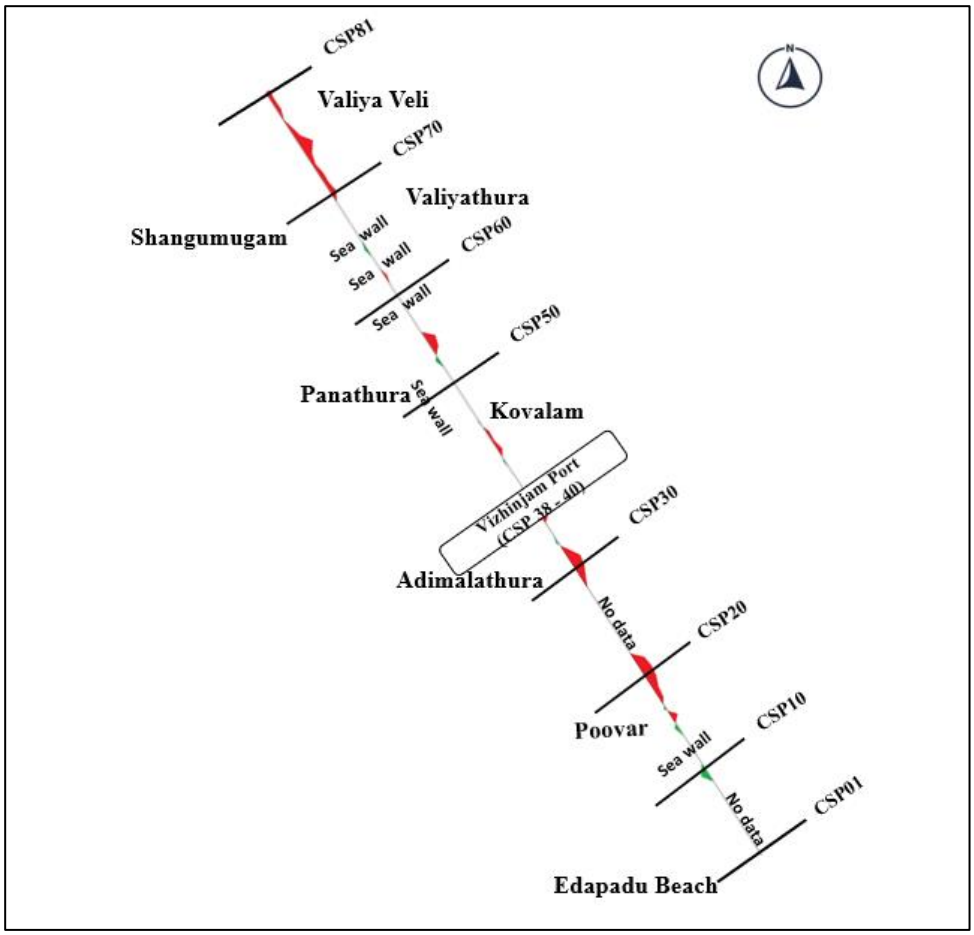


Figure A.18 Seasonal Beach Volume Changes in Monsoon Period in m^3/m (onshore)



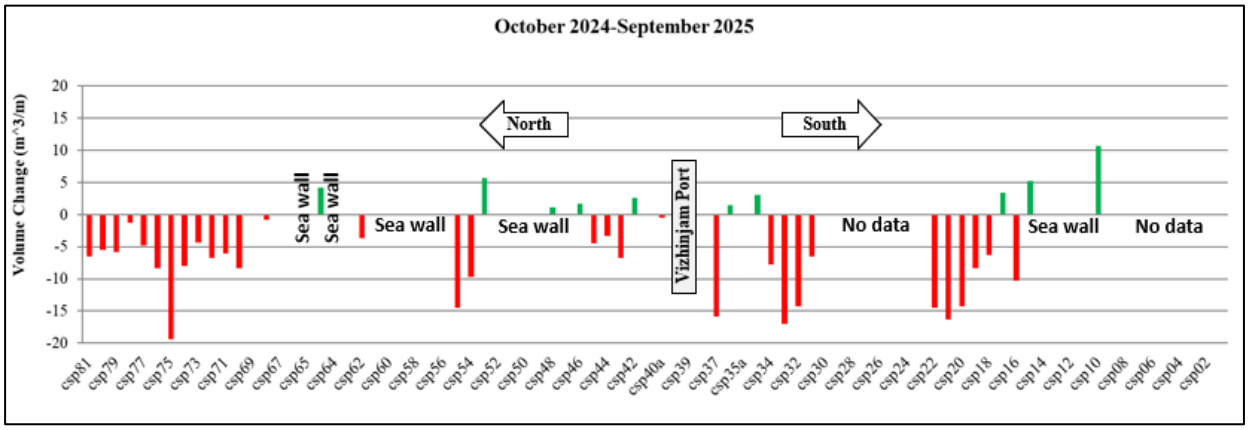


Figure A.19 Overall Beach Volume Changes for the period of October 2024 to September 2025 in m3/m (onshore)

Table A.3 Seasonal and Overall Beach Volume Changes in m³/m (onshore)

CSP NOs.	AREA	October 2024 to November 2024 (Post monsoon Period 2024)	December 2024 to March 2025 (Fair weather Period 2025)	April 2025 to May 2025 (Pre-monsoon Period 2025)	June 2025 to September 2025 (Monsoon Period 2025)	October 2024 to September 2025 (overall)
CSP01	SOUTH OF PORT	Sea wall				
CSP02		-	-	-	-	-
CSP03		Sea wall				
CSP04		-	-	-	-	-
CSP05		-	-	-	-	-
CSP06		Sea wall				
CSP07		-	-	-	-	-
CSP08		-	-	-	-	-
CSP09		-	-	-	-	-
CSP10		-1.98	5.01	-1.77	14.91	10.74
CSP11		Sea wall				
CSP12						
CSP13						
CSP14						
CSP15		-18.17	-1.52	8.11	8.28	5.25
CSP16		-2.91	-	-	18.34	-10.33
CSP17		6.96	-0.25	-7.07	-0.12	3.36
CSP18		-0.49	1.08	-10.20	1.00	-6.34
CSP19		-1.02	0.41	-12.30	-0.64	-8.33
CSP20		0.26	2.63	-20.05	-3.12	-14.31
CSP21		3.30	0.44	-8.81	-5.75	-16.35
CSP22		2.29	1.09	-10.15	-10.29	-14.54
CSP23		-	-	-	-	-
CSP24		-	-	-	-	-
CSP25		-	-	-	-	-
CSP26		-	-	-	-	-
CSP27		-	-	-	-	-
CSP28		-	-	-	-	-
CSP29		-	-	-	-	-
CSP30		-	-	-	-	-
CSP31		-2.60	-2.97	3.32	-0.24	-6.55
CSP32		-0.42	-1.38	2.35	-15.73	-14.25
CSP33		4.77	11.01	1.03	-14.26	-17.04
CSP34		1.83	15.27	-1.61	-19.50	-7.73
CSP35		2.67	0.37	-0.35	-8.55	3.00
CSP35A		-	43.83	-5.82	-	-
CSP36		-21.78	-5.33	0.17	-0.90	1.45
CSP37		-4.20	-5.49	-7.01	5.10	-15.83
CSP38	PORT AREA					
CSP39						
CSP40						
CSP40A	NORTH OF PORT	-5.01	12.28	-41.13	-4.75	-0.49
CSP41		Sea wall				
CSP42		7.31	1.64	-0.19	-5.53	2.60
CSP43		1.36	2.15	0.80	-	-6.72
CSP44		-0.57	-0.44	0.87	-	-3.37
CSP45		4.10	2.23	11.08	-11.57	-4.46
CSP46		4.58	3.46	0.98	*	1.75
CSP47		-0.14	-4.39	0.10	-0.06	-0.14
CSP48		0.48	1.51	-0.18	-3.53	1.12
CSP49						
CSP50						
CSP51						
CSP52						
CSP53		-0.70	-19.10	-5.83	-	5.73
CSP54		1.87	-3.73	-11.71	-	-9.72
CSP55		1.97	-2.19	-1.14	-	-14.56
CSP56		Sea wall				
CSP57						
CSP58						
CSP59						
CSP60		-4.75	4.85	*	*	*
CSP61		-	-0.96	*	*	*
CSP62		2.47	0.80	0.71	-	-3.65
CSP63		Sea wall				
CSP64						

CSP64A		0.87	-3.94	1.13	25.06	4.19
CSP65 CSP66 CSP67		Sea wall				
CSP68		1.30	0.32	1.58	-2.05	-0.78
CSP69		2.19	2.63	-6.59	*	0.07
CSP70		0.03	0.78	0.11	*	-8.36
CSP71		0.20	1.84	-9.41	-	-6.11
CSP72		1.26	2.21	1.05	*	-6.70
CSP73		1.77	-0.09	1.56	*	-4.41
CSP74		2.19	-0.36	0.38	-	-8.02
CSP75		2.99	0.64	0.97	*	-19.44
CSP76		0.33	0.36	0.40	-4.83	-8.33
CSP77		2.44	0.45	0.89	-	-4.83
CSP78		0.70	-0.69	3.09	-	-1.25
CSP79		5.27	0.34	1.95	-	-5.85
CSP80		1.73	0.67	-0.04	7.60	-5.51
CSP81		-0.11	-1.94	-0.02	-3.30	-6.49

*Data not considered for analysis

-No data

Table A.4 Beach volume variation from December 2024 to March 2025 (offshore)

CSP NOs.	AREA	December 2024 to March 2025 (Fair weather Period 2025)
CSP01	SOUTH OF PORT	-21.15
CSP02		29.70
CSP03		93.93
CSP04		-67.11
CSP05		-95.68
CSP06		-1.92
CSP07		4.37
CSP08		16.58
CSP09		-107.10
CSP10		1.05
CSP11		9.32
CSP12		5.98
CSP13		24.79
CSP14		-11.94
CSP15		13.26
CSP16		74.30
CSP17		-31.83
CSP18		45.42
CSP19		12.66
CSP20		28.60
CSP21		11.31
CSP22		9.66
CSP23		35.21
CSP24		-19.46
CSP25		-19.26
CSP26		26.01
CSP27		-5.17
CSP28		-4.22
CSP29		12.03
CSP30		9.05
CSP31		-20.38
CSP32		-11.71
CSP33		-389.69
CSP34		4.79
CSP35		*
CSP35A		*
CSP36		*
CSP37		*
CSP38	PORT AREA	
CSP39		
CSP40		
CSP40A	NORTH OF PORT	
CSP41		*
CSP42		*

CSP43		*
CSP44		*
CSP45		*
CSP46		-20.61
CSP47		-0.11
CSP48		-24.75
CSP49		-31.69
CSP50		-102.23
CSP51		-112.17
CSP52		-168.01
CSP53		-20.06
CSP54		-136.06
CSP55		-109.01
CSP56		*
CSP57		-45.13
CSP58		-125.63
CSP59		-105.70
CSP60		-16.55
CSP61		-14.74
CSP62		-21.47
CSP63		-105.10
CSP64		-47.37
CSP64A		*
CSP65		-3.25
CSP66		-11.13
CSP67		-81.42
CSP68		-27.73
CSP69		-143.68
CSP70		-1.96
CSP71		-29.30
CSP72		-17.10
CSP73		-37.56
CSP74		-27.19
CSP75		-0.16
CSP76		-4.02
CSP77		-5.20
CSP78		-31.05
CSP79		24.55
CSP80		17.45
CSP81		-7.15

*Data not considered for analysis
-No data

A.1.4 Seasonal Beach Volume comparison between the period October 2023 and October 2024, February 2024 and February 2025, May 2024 and May 2025, and September 2024 and September 2025

Beach Volume comparison between October 2023 and October 2024

In October 2023, there was a failure to conduct the onshore survey at CSP16,31,32,33,35,67 and CSP35A in October 2024. Data was not found suitable for the analysis at CSP57, 58, 61, and 66 in October 2024; hence, analysis in these locations is not carried out.

Beaches at Pozhiyoor (CSP10), Poovar South (CSP15), Port reclamation area (CSP40A), Kovalam (CSP44 and 47), Punthura (CSP53), Valiyathura (CSP64A), Shangumugham to Kochuveli (CSP69-76), and Valiyaveli to Thumba (CSP78-81) showed accretion from October 2023 to October 2024 on the onshore. Beach erosion occurred from October

2023 to October 2024 in the following locations on the onshore: Poovar south to Karumkulam (CSP17-22), Adimalathura (CSP34), Mullur (36-37), Kovalam (CSP42-43 and 45-46), Panathura (CSP48), Punthura (CSP54-55), Beemapally (CSP60), Cheriyathura (CSP62), Shanghaimugham (CSP68), and Kochuveli (CSP77). Results are displayed in Figure A.20.

No offshore survey was carried out in October 2024. Hence, it was not possible to compare the beach volume in October 2023 and October 2024 offshore.

Beach Volume comparison between February 2024 and February 2025

In February 2024, no onshore survey was conducted at CSP53, and an erroneous profile was found at CSP35 and 66, leading to the inability to analyse these locations.

Beaches in the following locations showed accretion between February 2024 and February 2025 on the onshore: Pozhiyoor (CSP10), Poovar south (CSP16-17), Poovar north (CSP21), Adimalathura (CSP32-34), Port reclamation area (CSP40A), Kovalam (CSP42-43), Kovalam to Panathura (CSP45-48), Punthura (CSP54-55 and 57), Cheriyathura (CSP61), Valiyathur (CSP64A), and Valiyathura to Thumba (CSP67-81). The following beaches showed signs of erosion between February 2024 and February 2025: Poovar South (CSP15), Poovar to Poovar North (CSP18-20), Karumkulam (CSP22), Adimalathura (CSP31), Azhimala to Mullur (CSP35A-37), Kovalam (CSP44), Beemapally (CSP58 and 60), and Cheriyathura (CSP62) on the onshore. Results are shown in Figure 5.13.

No offshore survey was carried out at any of the locations in February 2025. Hence, the offshore analysis for this period is not included in the analysis.

Beach Volume comparison between May 2024 and May 2025

In May 2025, there were no surveys at CSP60, and less distance was covered at CSP61. Onshore surveys at CSP23-30,16 were not carried out in May 2024. During this timeframe, the beach experienced accretion Poovar south (CSP17), Adimalathura (CSP31,33-34), Kovalam (CSP42-46), Shangumugham (CSP68), Vettucaud to Valiyaveli (CSP73-78), while erosion took place at Pozhiyoor (CSP10), Poovar South (CSP15), Poovarto Karumkulam(CSP18-22), Mullur (CSP36-37), port reclamation area (CSP40A), Panathura (CSP48), Punthura (CSP53-55,57), Cheriyathura (CSP62), Valiyathura(CSP64A),

Shangumugham to Vettucaud (CSP69-72) and Valiyaveli to Thumba (CSP79-81). Results are shown in Figure A.22.

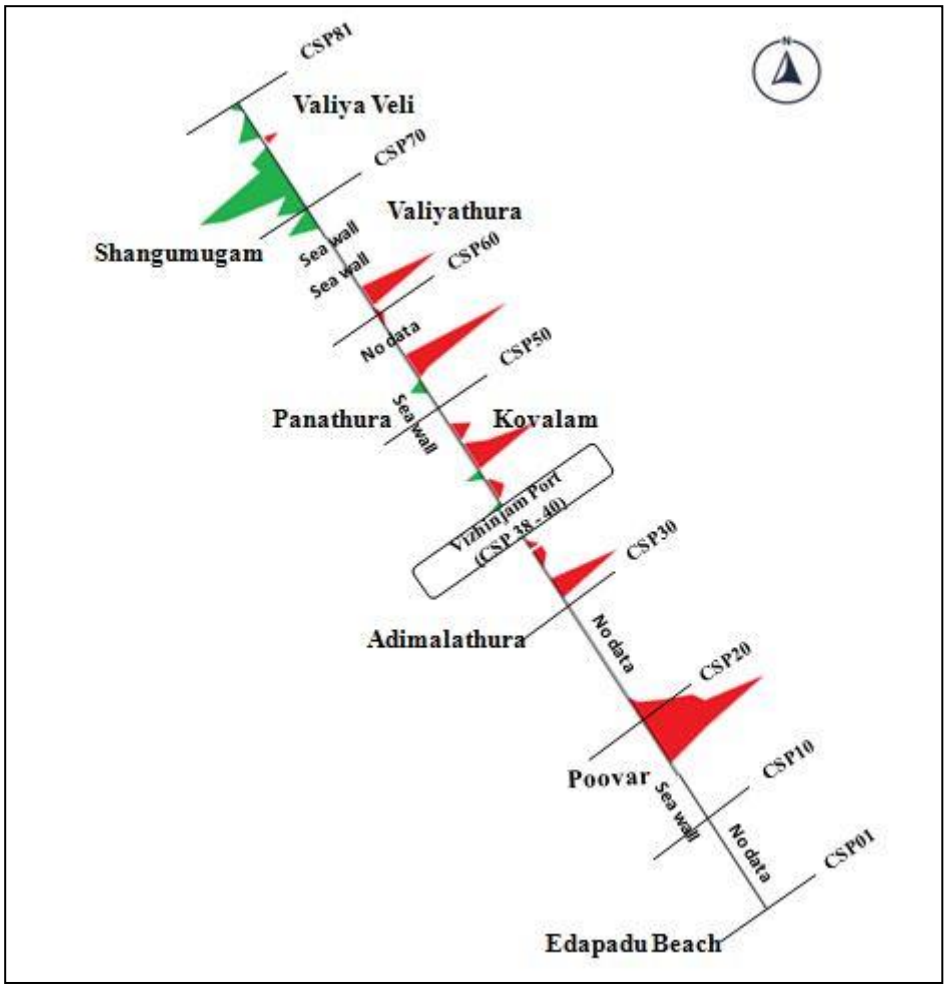
There was no offshore survey carried out in May 2024; hence, it was not possible to compare the beach volume in May 2024 and May 2025.

Beach Volume comparison between September 2024 and September 2025

No onshore surveys were conducted at CSP01-11, CSP35A, and CSP64A in September 2024.

From September 2025 to September 2024, erosion was observed on the onshore at Poovar south (CSP16), Poovarto Karumkulam (CSP18-22), Adimalathura (CSP31-34), Mullur (CSP37), port reclamation area (CSP40A), Kovalam (CSP42-45,47), Punthura (CSP54), Cheriyathura (CSP62), and Shangumugham to Thumba (CSP68-81).In contrast, accretion occurred at Poovar south (CSP15,17), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP46), and Punthura (CSP53,55). The results are illustrated in Figure A.23.

No offshore surveys were conducted either in September 2025 or September 2024.



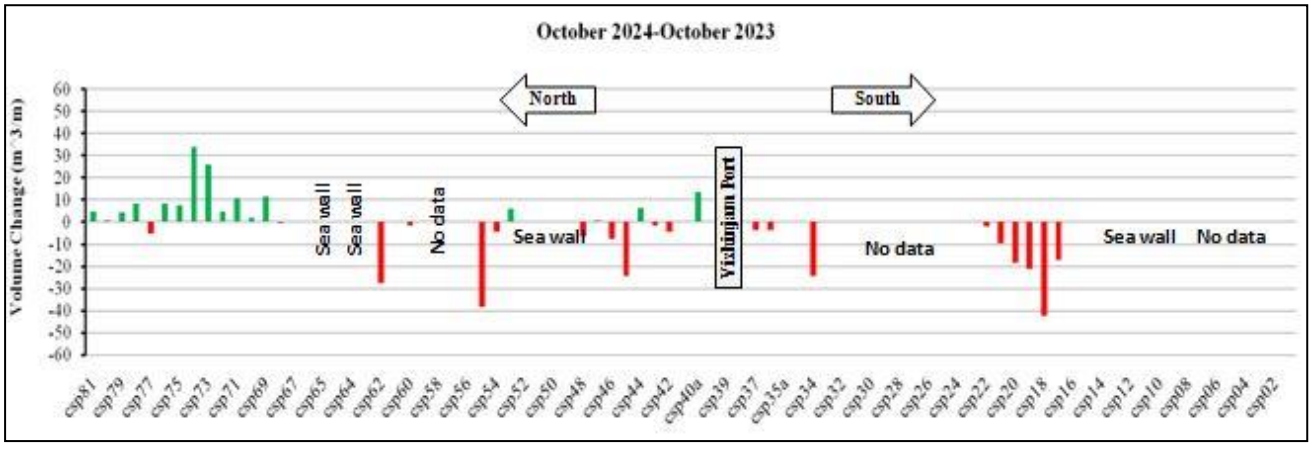
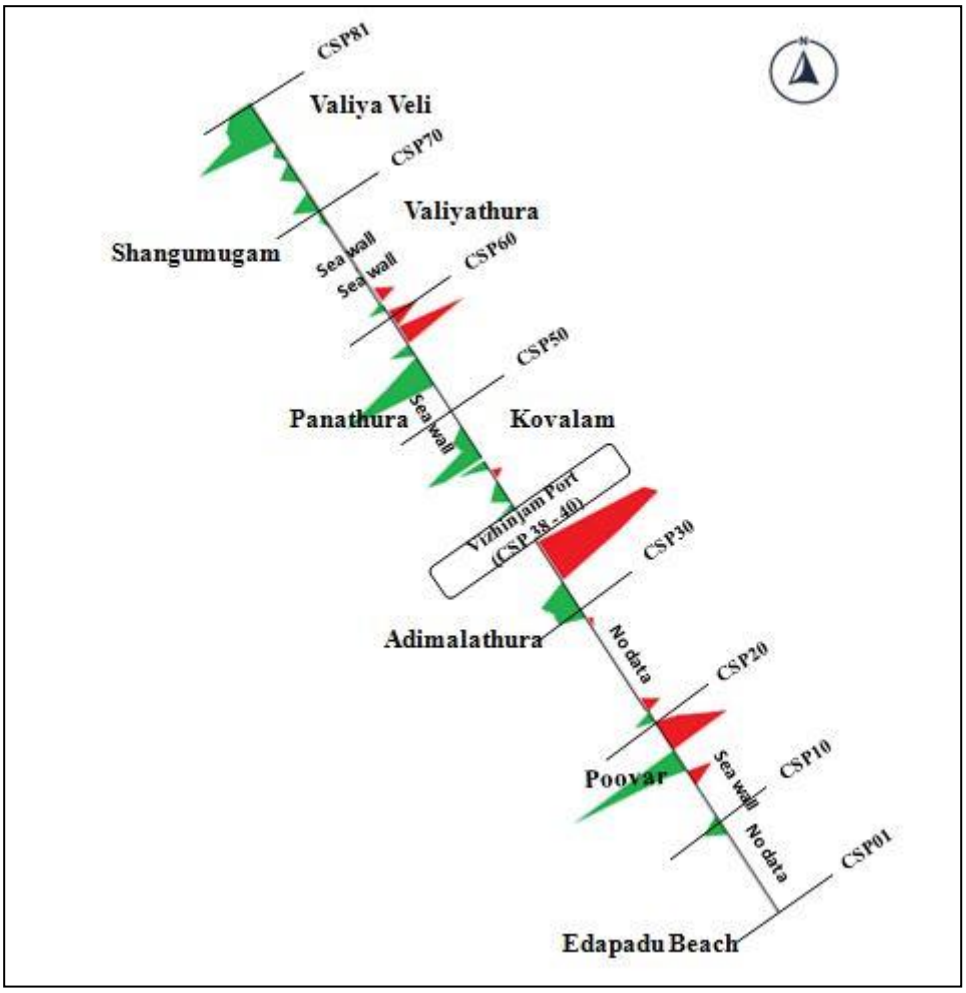


Figure A.20 Beach Volume Change comparison between October 2023 and October 2024 in m^3/m (onshore)



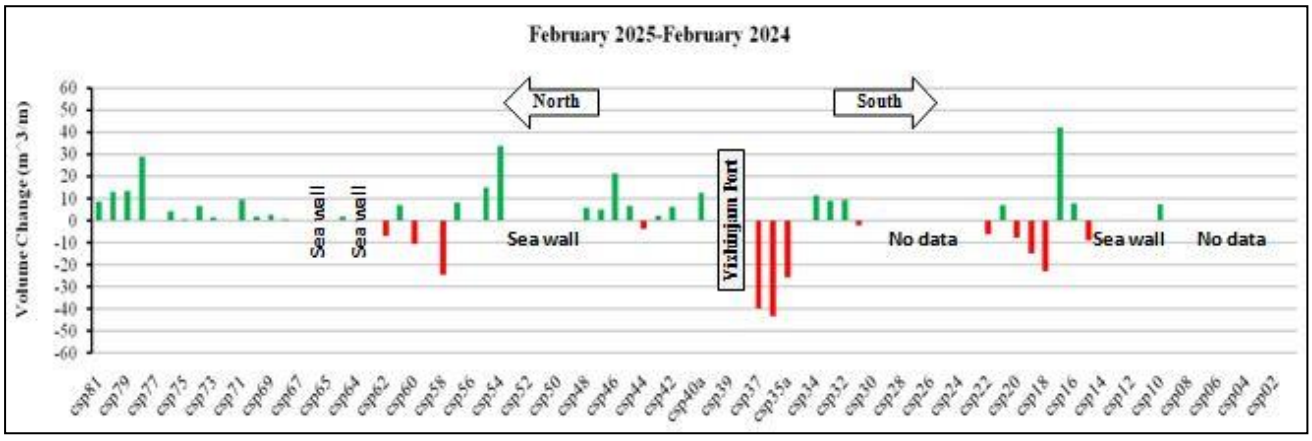
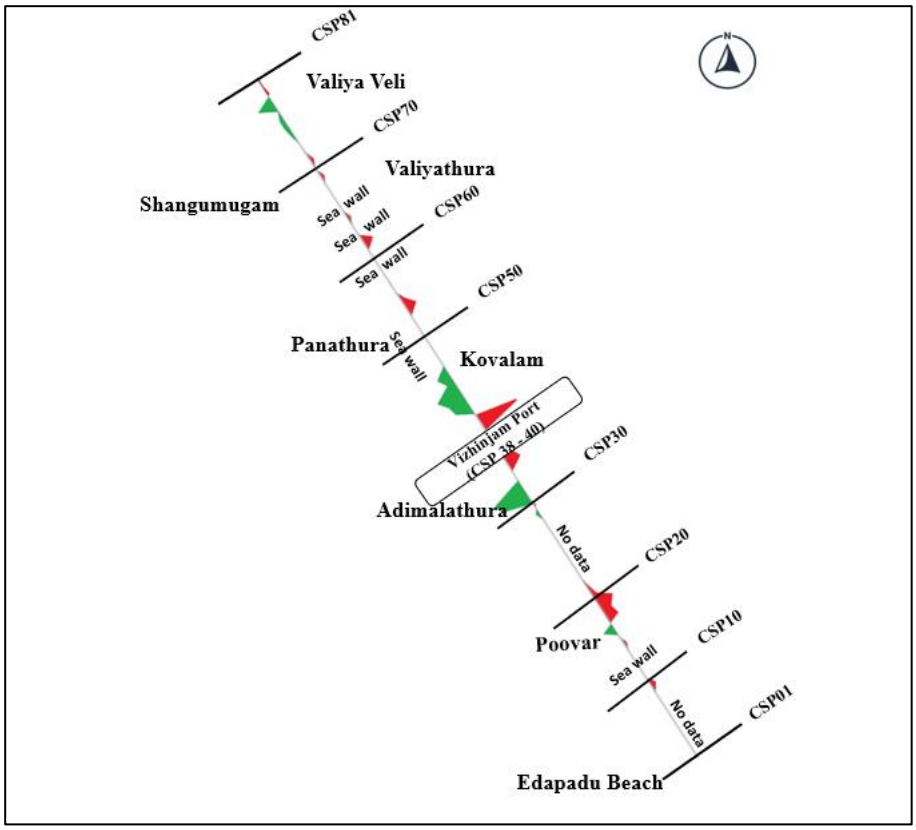


Figure A.21 Beach Volume Change comparison between February 2024 and February 2025 in m^3/m (onshore)



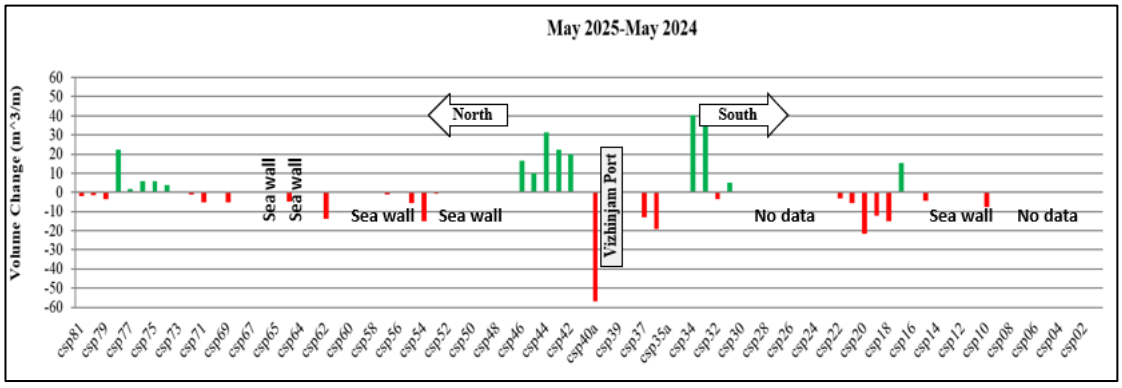
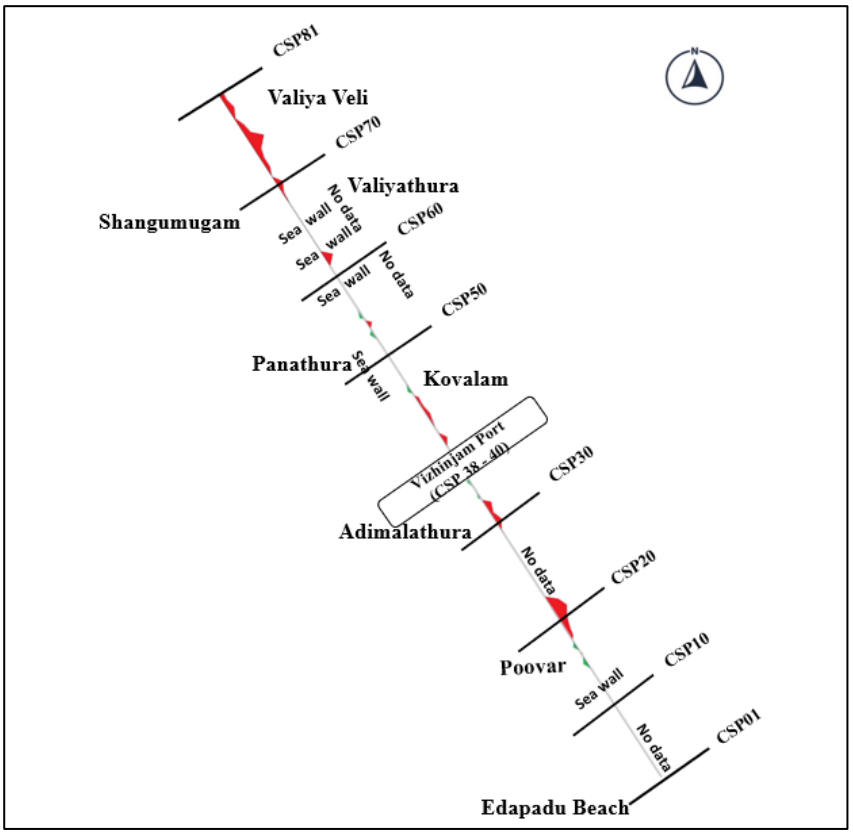


Figure A.22 Beach Volume Change comparison between May 2024 and May 2025 in m^3/m (onshore)



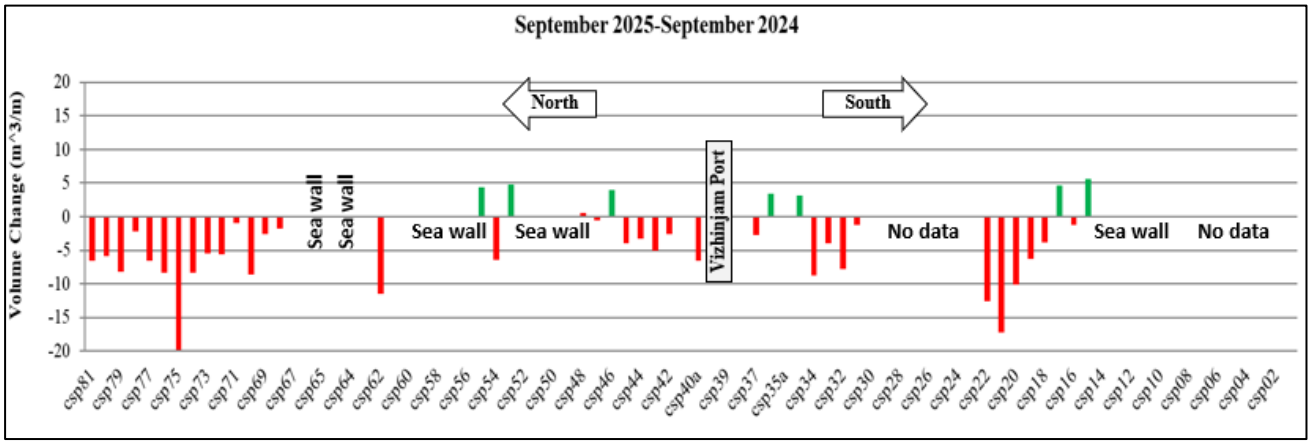


Figure A.23 Beach Volume Change comparison between September 2024 and September 2025 in m^3/m (onshore)

Table A.5 Beach Volume Changes comparing the months of October 2023 and October 2024, February 2024 and February 2025, May 2024 and May 2025, September 2024 and September 2025 in m^3/m

CSP NOs.	October 2023 and October 2024 (onshore)	February 2024 and February 2025 (onshore)	May 2024 and May 2025(onshore)	September 2024 and September 2025(onshore)
CSP01	Sea wall	Sea wall	Sea wall	Sea wall
CSP02	-	-	-	-
CSP03	Sea wall	Sea wall	Sea wall	Sea wall
CSP04	-	-	-	-
CSP05	-	-	-	-
CSP06	-	-	-	-
CSP07	-	-	-	-
CSP08	-	-	-	-
CSP09	-	-	-	-
CSP10	0.39	7.24	-7.73	-
CSP11	Sea wall	Sea wall	Sea wall	Sea wall
CSP12				
CSP13				
CSP14				
CSP15	0.39	-9.08	-4.27	5.54
CSP16	-	7.91	-	-1.21
CSP17	-17.29	41.95	15.33	4.62
CSP18	-42.47	-22.88	-15.09	-3.89
CSP19	-21.14	-14.92	-12.39	-6.34
CSP20	-18.69	-7.83	-21.47	-10.16
CSP21	-9.71	7.04	-5.59	-17.19
CSP22	-2.27	-6.30	-3.01	-12.58
CSP23	-	-	-	-
CSP24	-	-	-	-
CSP25	-	-	-	-
CSP26	-	-	-	-
CSP27	-	-	-	-
CSP28	-	-	-	-
CSP29	-	-	-	-
CSP30	-	-	-	-
CSP31	-	-2.18	5.05	-1.22
CSP32	-	9.32	-3.60	-7.83
CSP33	-	8.80	35.70	-3.96
CSP34	-24.39	11.32	40.50	-8.70
CSP35	-	*	-	3.10
CSP35A	-	-25.65	-	-
CSP36	-3.54	-43.29	-19.19	3.44
CSP37	-3.85	-39.93	-12.98	-2.73
CSP38	PORT AREA			
CSP39				
CSP40				
CSP40A	13.54	12.39	-57.04	-6.57
CSP41	Sea wall	Sea wall	Sea wall	Sea wall
CSP42	-4.61	6.11	19.86	-2.61
CSP43	-1.58	1.96	22.29	-5.09
CSP44	6.44	-4.01	31.28	-3.33
CSP45	-24.32	6.70	10.08	-4.03
CSP46	-7.56	21.40	16.66	4.02
CSP47	0.53	4.81	-	-
CSP48	-6.46	5.94	-0.15	-
CSP49	Sea wall	Sea wall	Sea wall	Sea wall
CSP50				
CSP51				
CSP52				
CSP53	5.66	-	-0.71	4.84
CSP54	-4.38	33.59	-14.99	-6.47
CSP55	-38.48	14.91	-5.80	4.35
CSP56	Sea wall	Sea wall	Sea wall	Sea wall
CSP57	*	8.33	-0.97	*
CSP58	*	-24.45	*	*
CSP59	Sea wall	Sea wall	Sea wall	Sea wall
CSP60	-1.89	-10.69	*	*
CSP61	*	6.77	*	*
CSP62	-27.77	-6.83	-13.89	-11.54

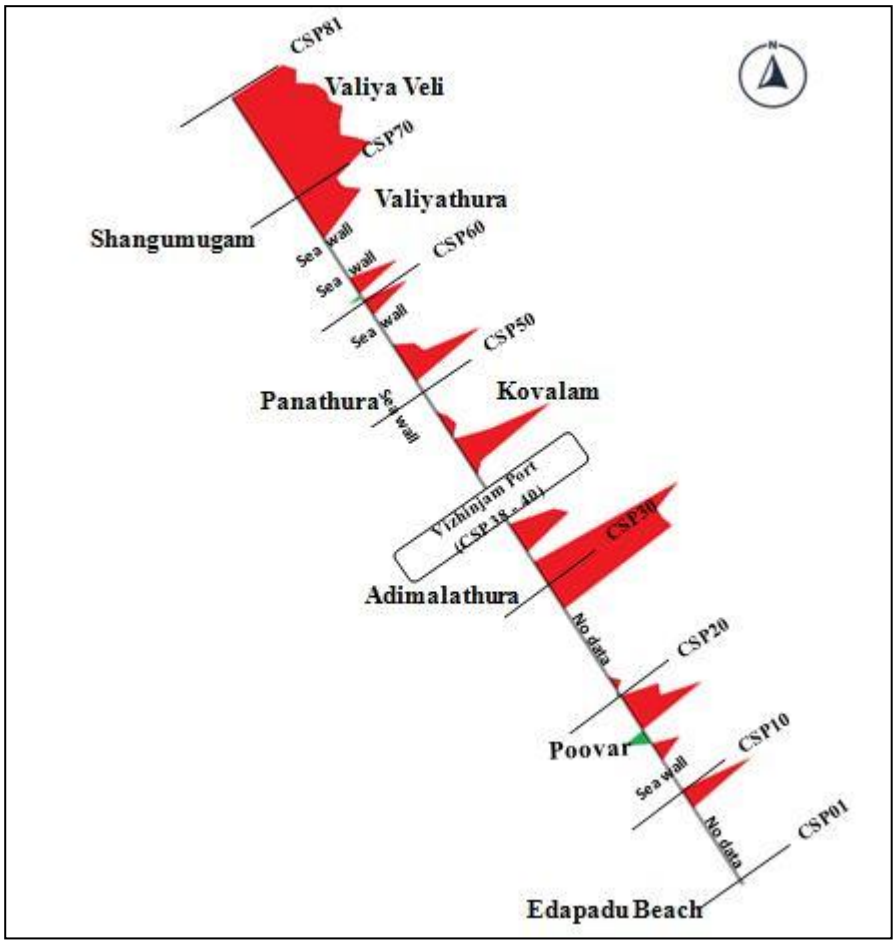
CSP63	Sea wall	Sea wall	Sea wall	Sea wall
CSP64				
CSP64A	0.09	1.73	-4.69	-
CSP65	Sea wall	Sea wall	Sea wall	Sea wall
CSP66	*	*	*	*
CSP67	-	0.07	-	-
CSP68	-0.24	0.59	0.21	-1.83
CSP69	11.42	2.64	-5.05	-2.66
CSP70	2.05	1.67	-0.40	-8.56
CSP71	10.77	9.32	-5.08	-0.99
CSP72	4.65	0.19	-1.18	-5.63
CSP73	25.69	1.52	0.45	-5.46
CSP74	33.83	6.54	3.78	-8.38
CSP75	7.40	0.60	5.77	-19.85
CSP76	8.34	4.18	5.95	-8.36
CSP77	-5.44	0.26	1.60	-6.62
CSP78	8.24	28.76	22.12	-2.18
CSP79	4.20	13.34	-3.43	-8.16
CSP80	0.66	12.74	-1.64	-5.91
CSP81	4.47	8.39	-2.05	-6.50

*Data not considered for analysis
-No data

A.1.5 Beach volume variation during February 2015 and February 2025

This analysis was carried out to identify and compare the beach volume variation before the commencement of port construction with the current scenario. However, only the profiles with the available coverage (up to 10m depth only in 2015) have been used to compute the volume. The beach volume changes for February 2015 and February 2025 are given in graphs in Figure A.24 and Table A.6.

During February 2015 to February 2025, all the locations except Poovar south (CSP16-17), Poovar north (CSP21), and Cheriyathura (CSP61) showed erosion. Results shown in Figure A. 24. There were no offshore surveys conducted in February 2025 at any of the locations.



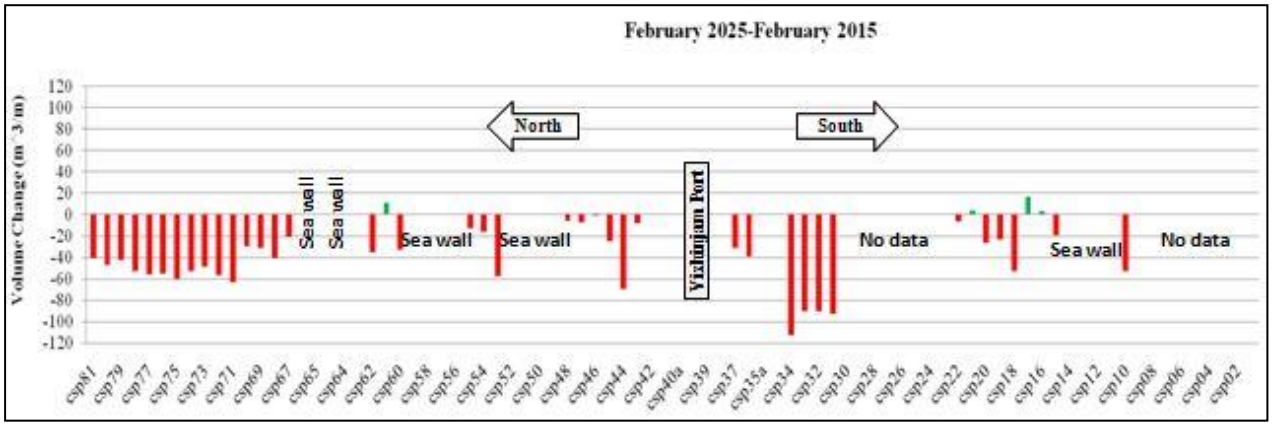


Figure A.24 Beach Volume Changes - February 2015 and February 2025 in m^3/m (onshore)

Table A.6 Beach Volume Changes comparing the inter-annual months of February 2015 and February 2025 (onshore and offshore) m^3/m

CSP NOs.	AREA	February 2015 and February 2024 (onshore)
CSP01	SOUTH OF PORT	Sea wall
CSP02		-
CSP03		Sea wall
CSP04		-
CSP05		-
CSP06		Sea wall
CSP07		-
CSP08		-
CSP09		-
CSP10		-52.99
CSP11		Sea wall
CSP12		
CSP13		
CSP14		
CSP15		-19.38
CSP16		3.27
CSP17		16.63
CSP18		-52.79
CSP19		-23.60
CSP20		-26.79
CSP21		3.38
CSP22		-6.74
CSP23		-
CSP24		-
CSP25		-
CSP26		-
CSP27		-
CSP28		-
CSP29		-
CSP30		-
CSP31		-92.66
CSP32		-90.42
CSP33		-90.23
CSP34		-112.84
CSP35		-
CSP35A		-
CSP36		-39.16
CSP37		-31.42
CSP38	PORT AREA	
CSP39		
CSP40		
CSP40A	NORTH OF PORT	-
CSP41		Sea wall
CSP42		-
CSP43		-7.96
CSP44		-69.91
CSP45		-24.87
CSP46		-0.16
CSP47		-7.73
CSP48		-5.47
CSP49		
CSP50		
CSP51		
CSP52		Sea wall
CSP53		-57.70
CSP54		-16.46
CSP55		-13.43
CSP56		
CSP57		
CSP58		
CSP59		Sea wall
CSP60		-33.23
CSP61		10.94
CSP62		-35.60
CSP63		
CSP64		
CSP64A		
CSP65		Sea wall

CSP66		*
CSP67		-20.86
CSP68		-40.60
CSP69		-31.07
CSP70		-30.11
CSP71		-63.00
CSP72		-56.68
CSP73		-48.56
CSP74		-52.76
CSP75		-60.37
CSP76		-55.15
CSP77		-56.16
CSP78		-52.77
CSP79		-42.43
CSP80		-47.48
CSP81		-41.16

*Data not considered for analysis
-No data
Note: Volume calculation upto 10m water depth (since 2015, data was surveyed up to 10m depth only by the then survey agency appointed by VISL/AVPPL)

A.2 Results for Shoreline Change Analysis from Satellite Images

This report provides the shoreline change (monthly, seasonal, and annual shoreline change analysis)over the period from October 2024 to September 2025, using satellite images that were carried out and presented.

A.2.1 Monthly and Overall Shoreline Change from October 2024 to September 2025

The monthly shoreline change analysis from October 2024 to September 2025 has been shown in Figures A.25 to A.36.

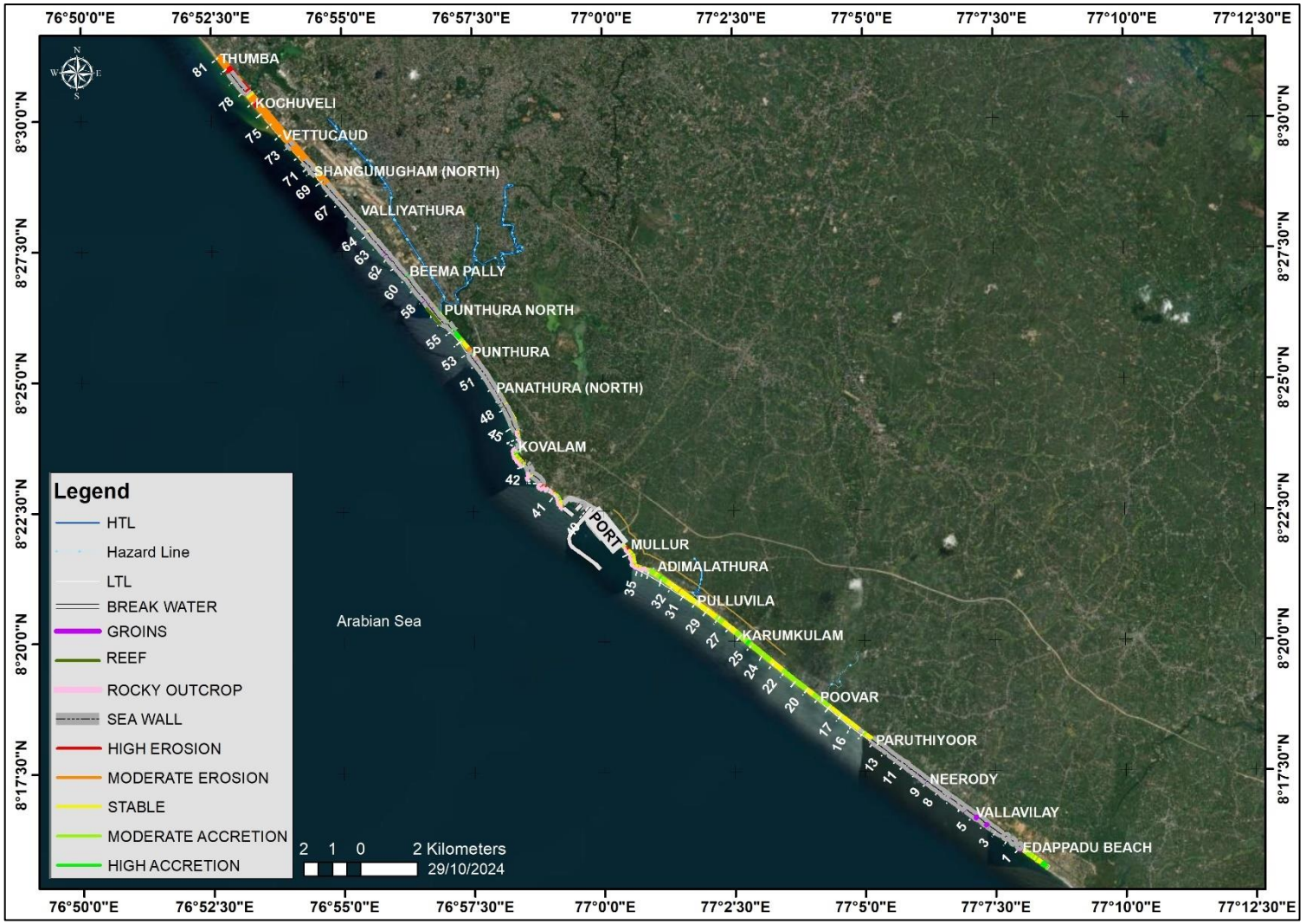


Figure A.25 Shoreline Change Map - October 2024

The shoreline analysis for October 2024 shows erosion at Edappadu beach (CSP01), Mullur (CSP37), Kovalam (CSP41-42), Punthura (CSP52-53), Valliyathura to Thumba (CSP66-81), while accretion at Edapadu to Vallavilay (CSP02-05), Neerody (CSP07), Poovar North to Karumkulam (CSP18-26), Adimalathura (CSP32-34), Kovalam (CSP42-44), Punthura to Valliyathura (CSP54-65).

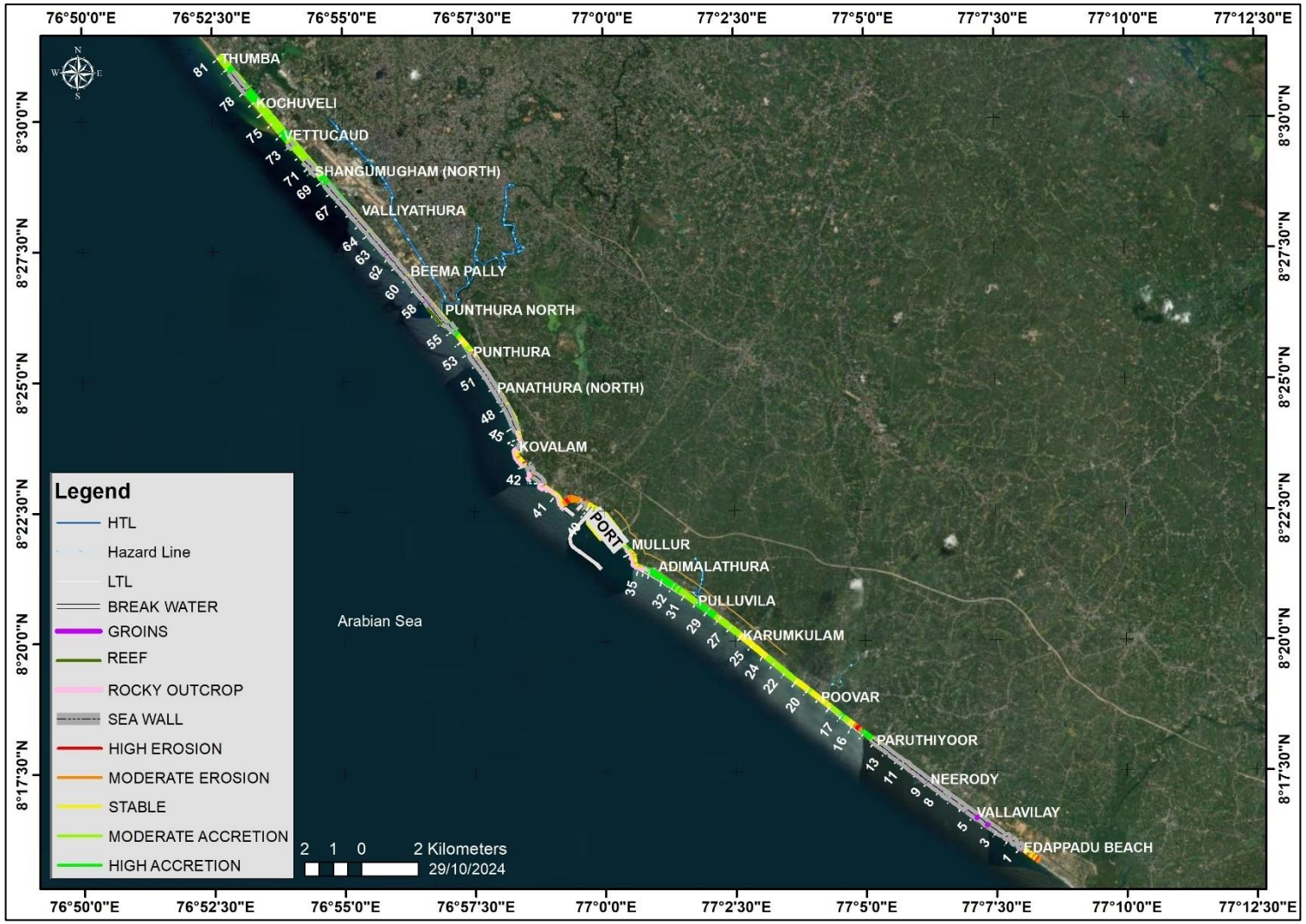
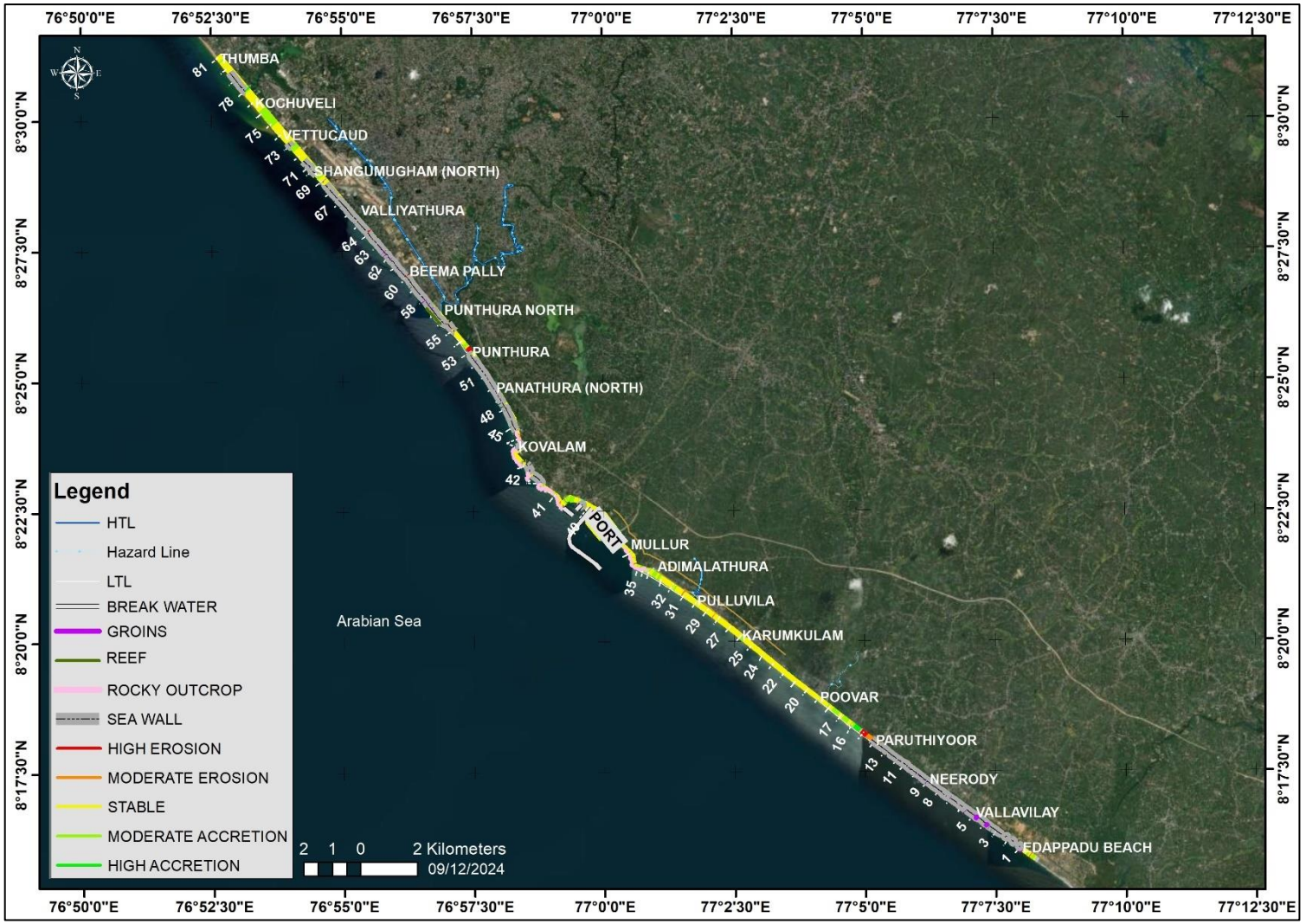


Figure A.26 Shoreline Change Map - November 2024

The shoreline analysis for November 2024 shows erosion at Edapadu to Neerody (CSP01-09), Poovar (CSP16), Kovalam (CSP41-44), Punthura (CSP53), Valiyathura (CSP63), while accretion at Poovar to Adimalathura (CSP17-34), Punthura (CSP54-58), Beemapally (CSP59-60), Valliyathura to Thumba (CSP64-81).



The shoreline analysis for December 2024 shows erosion at Paruthiyoor (CSP14), Punthura (CSP53), Beemapally (CSP60), Valliyathura (CSP64), while accretion at Edapadu to Neerody (CSP01-11), Poovar (CSP15-18), Adimalathura (CSP33-35), Punthura (CSP56-58), (CSP78). Shangumugham (CSP68-71), Vettucaud (CSP72), Kochuveli (CSP74-75), Thumba (CSP78).

Figure A.27 Shoreline Change Map - December 2024

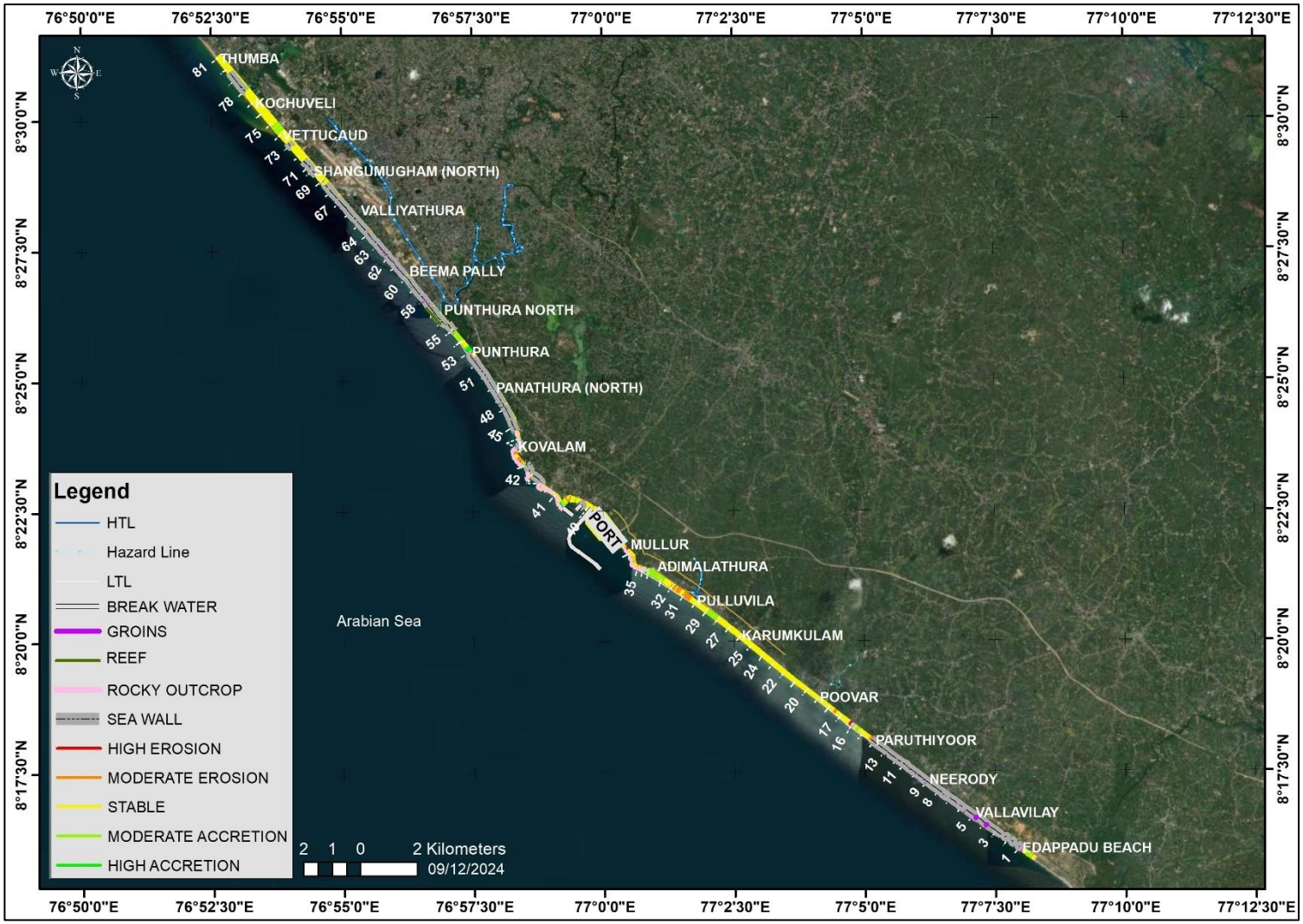


Figure A.28 Shoreline Change Map - January 2025

The shoreline analysis for January 2025 shows erosion at Poovar (CSP16), Pulluvila (CSP30-32), Mullur (CSP37), Beemapally to Cheriyathura (CSP59-61), Valliyathura (CSP63-65), while accretion at Edapadu (CSP01-04), Pulluvila(CSP28-29), Adimalathura (CSP32-35), Pannathura (CSP48-52), Punthura (CSP53-58), Shangumugham (CSP71), Vettucaud (CSP74-75).

The shoreline analysis for February 2025 shows erosion at Edapadu (CSP01), Poovar (CSP14-15,17-21), Punthura (CSP53), Cheriyathura (CSP61), Valliyathura (CSP63,66), Vettucaud (CSP73), Valliyaveli (CSP79), Thumba (CSP80), while accretion at Vallavilay (CSP03-05), Karumkulam (CSP22-24), Adimalathura (CSP33-35), Kovalam (CSP41-43), Pannathura to Punthura (CSP48-52,56-57).

Figure A.29 Shoreline Change Map - February 2025

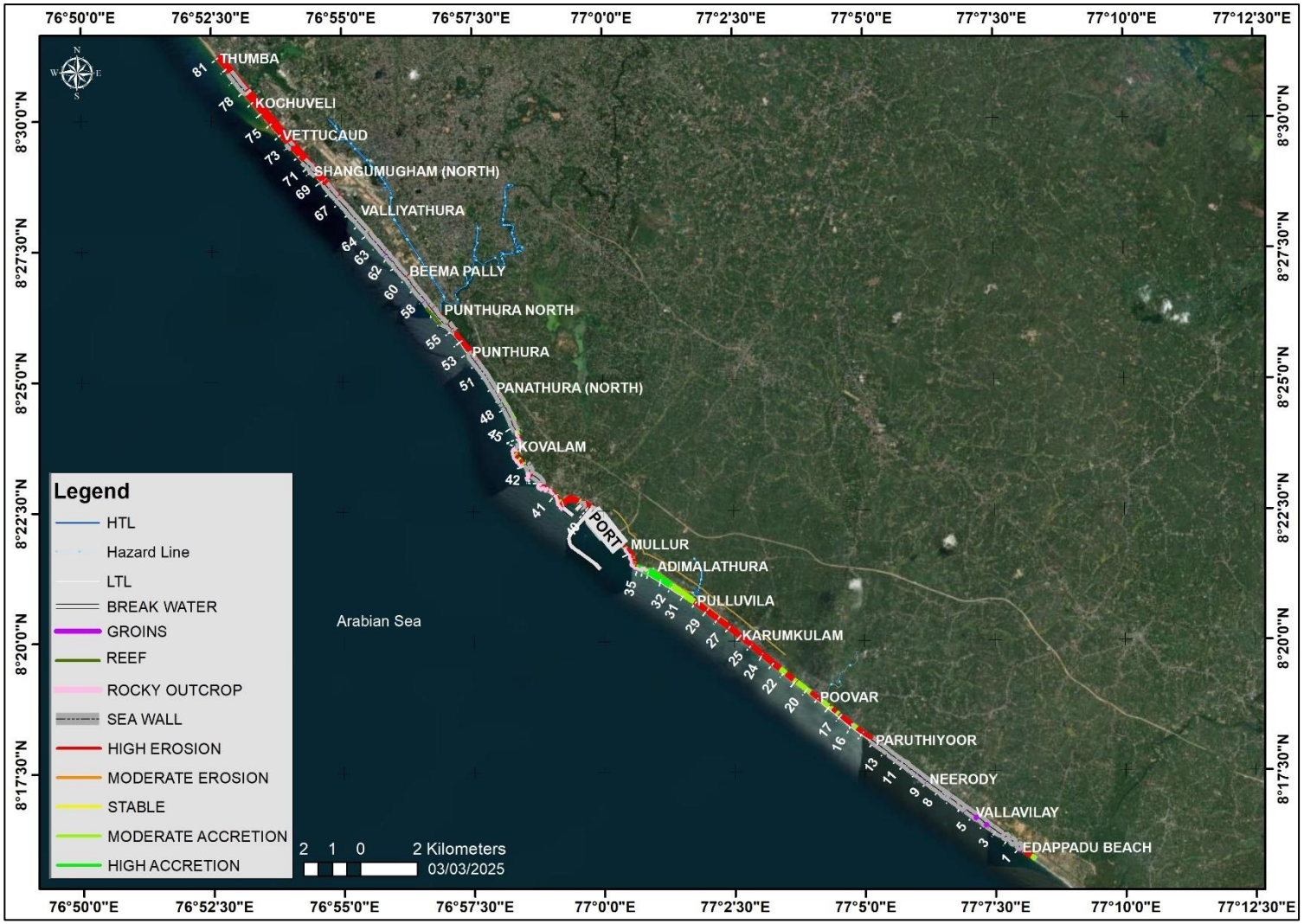


Figure A.30 Shoreline Change Map - March 2025

The shoreline analysis for March 2025 shows erosion at Edapadu to Vallavilay (CSP01-03), Neerody to Paruthiyoor (CSP08-09, 11-15), Poovar (CSP18-19), Kaurmkulam to Pulluvila (CSP23-30), Mullur (CSP36-37), Kovalam (CSP40-45), Pannathura (CSP50-51), Punthura (CSP52-55), Beemapally (CSP60), Valliyathura (CSP63-66), Shangumugham to Thumba (CSP67-81), while accretion at Vallavilay (CSP05), Neerody (CSP07), Poovar (CSP17,20), Adimalathura (CSP30-35), Pannathura (CSP48), Punthura (CSP56-58), Beemapally (CSP61), Valliyathura (CSP63-66).

Figure A.31 Shoreline Change Map - April 2025

The monthly shoreline change analysis for April 2025 indicates erosion at Paruthiyoor (CSP14-16), Puuluvia to Adimalathura (CSP28-33), Kovalam (CSP43-44), Pannathura (CSP47-53), Valliyathura (CSP63-65), while accretion at Edapadu to Paruthiyoor (CSP01-13), Poovar (CSP16-27), Kovalam (CSP40-42), Pannathura (CSP45-46), Punthura (CSP54-57), Beemapally (CSP58-62), Valliyathura to Thumba (CSP66-81).

Figure A.32 Shoreline Change Map - May 2025

The monthly shoreline change analysis for May 2025 exhibits erosion at Paruthiyoor to Poovar (CSP11-18), Karumkulam (CSP24-25), Kovalam (CSP41, 45), Pannathura (CSP46, 48), Punthura (CSP53-54), Valliyathura (CSP63-64), Shangumugham (CSP66-70) while accretion at Edapadu to Neerody (CSP01-10), Karumkulam to Adimalathura (CSP26-36), Kovalam (CP42-44), Pannathura (CSP49-52), Punthura to Beemapally (CSP55-58, 61-62), Vettacud to Thumba (CSP70-81).

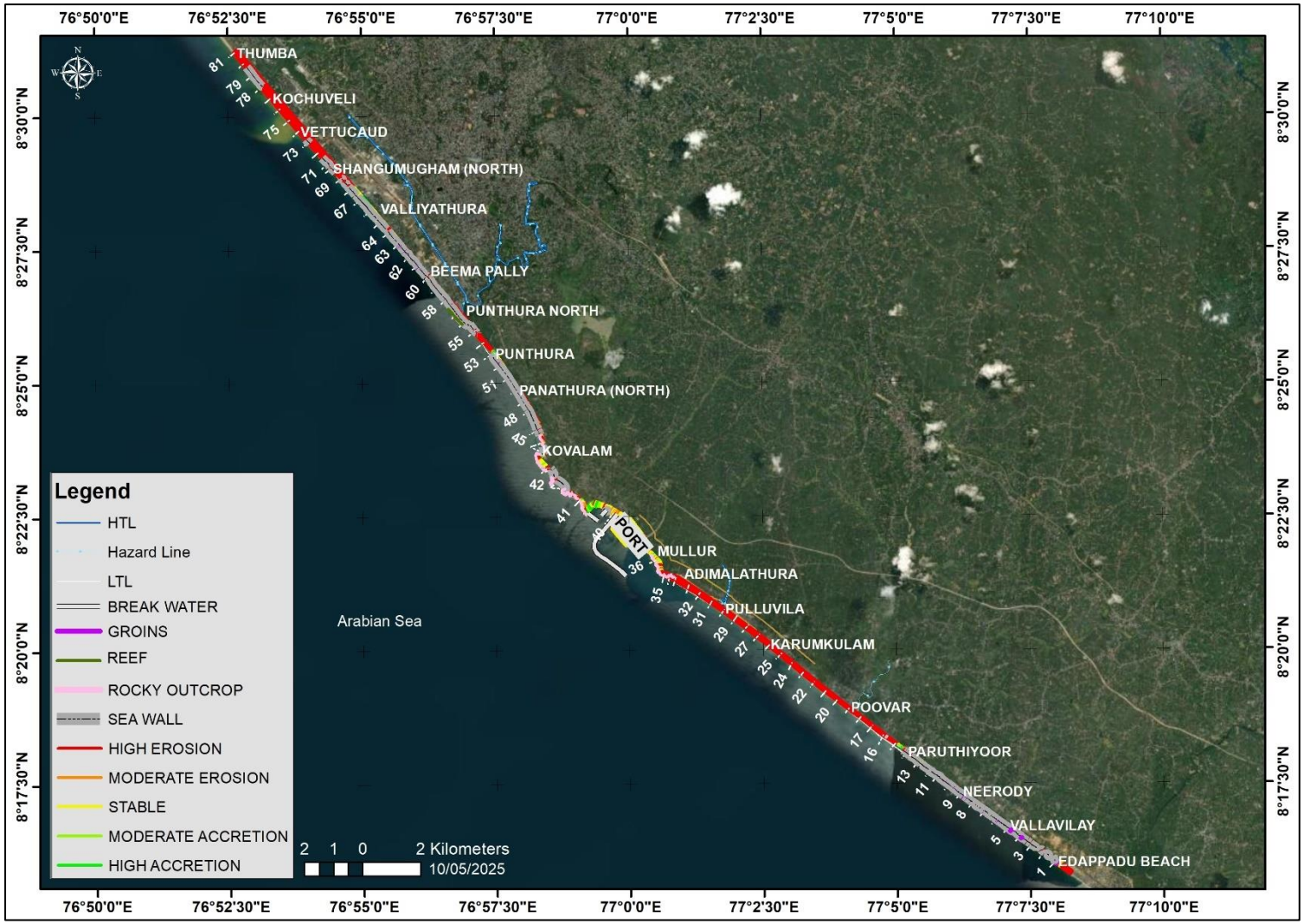


Figure A.33 Shoreline Change Map - June 2025

For June 2025, the shoreline change analysis shows accretion at Edapadu (CSP01), Paruthiyoor (CSP11-15), Mullur (CSP36), Kovalam (CSP40-42), Punthura (CSP51-53), Valliyathura (CSP65-68), while erosion occurs at Edapadu to Neerody (CSP02-10), Poovar to Adimalthura (CSP16-35), Kovalam to Pannathura (CSP43-50), Punthura to Valliyathura (CSP54-64), Shangumugham to Thumba (CSP59-81).

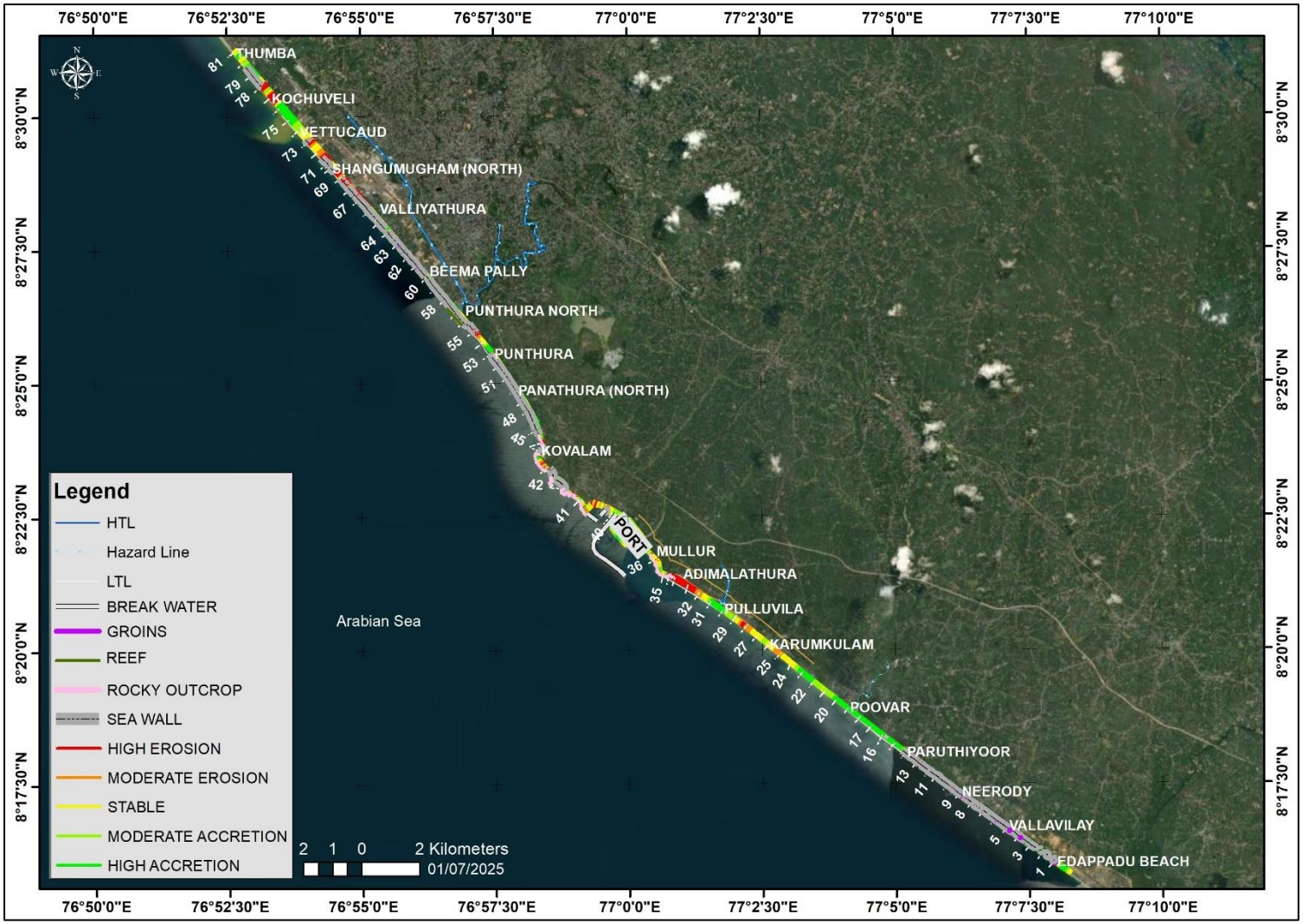


Figure A.34 Shoreline Change Map - July 2025

For July 2025, the shoreline change analysis shows erosion at Paruthiyoor (CSP11-13), Karumkulam (CSP25), Pulluvila (CSP28), Adimalathura (CSP32-35), Kovalam (CSP42-44), Punthura (CSP55), Beemapally (CSP61), Valliyathura to Shangumugham (CSP68-73), Kochuveli (CSP77-78) while accretion at Edapadu to Paruthiyoor (CSP01-10), Poovar (CSP14-24), Pulluvila (CSP29-31), Kovalam to Punthura (CSP41, 45-52, 54), Punthura North (CSP57-60), Valliyathura (CSP64-66), Vettucaud (CSP74-76), Thumba (CSP79-81).

Figure A.35 Shoreline Change Map - August 2025

The monthly shoreline change analysis for August 2025 indicates accretion at Edapadu (CSP01), Paruthiyoor (CSP11-15), while erosion at Edapadu (CSP02), Poovar to Adimalathura (CSP17-35), Kovalam (CSP45), Punthura North (CSP54-57), Valliyathura (CSP68), Shangumugham (CSP70), Vettucaud (CSP71, 74), Kochuveli (CSP75-76), Thumba (CSP80-81).

Figure A.36 Shoreline Change Map - September 2025

The monthly shoreline change analysis for September 2025 indicates erosion at Edapadu (CSP01), Poovar (CSP18), Karumkulam (CSP23), Mullur (CSP36), Punthura (CSP53), while accretion at Edapadu (CSP02), Paruthiyoor (CSP14-16), Poovar (CSP21), Karumukulam to Adimalathura (CSP24-33), Kovalam to Pannathura (CSP43-50), Punthura to Thumba (CSP54-81).

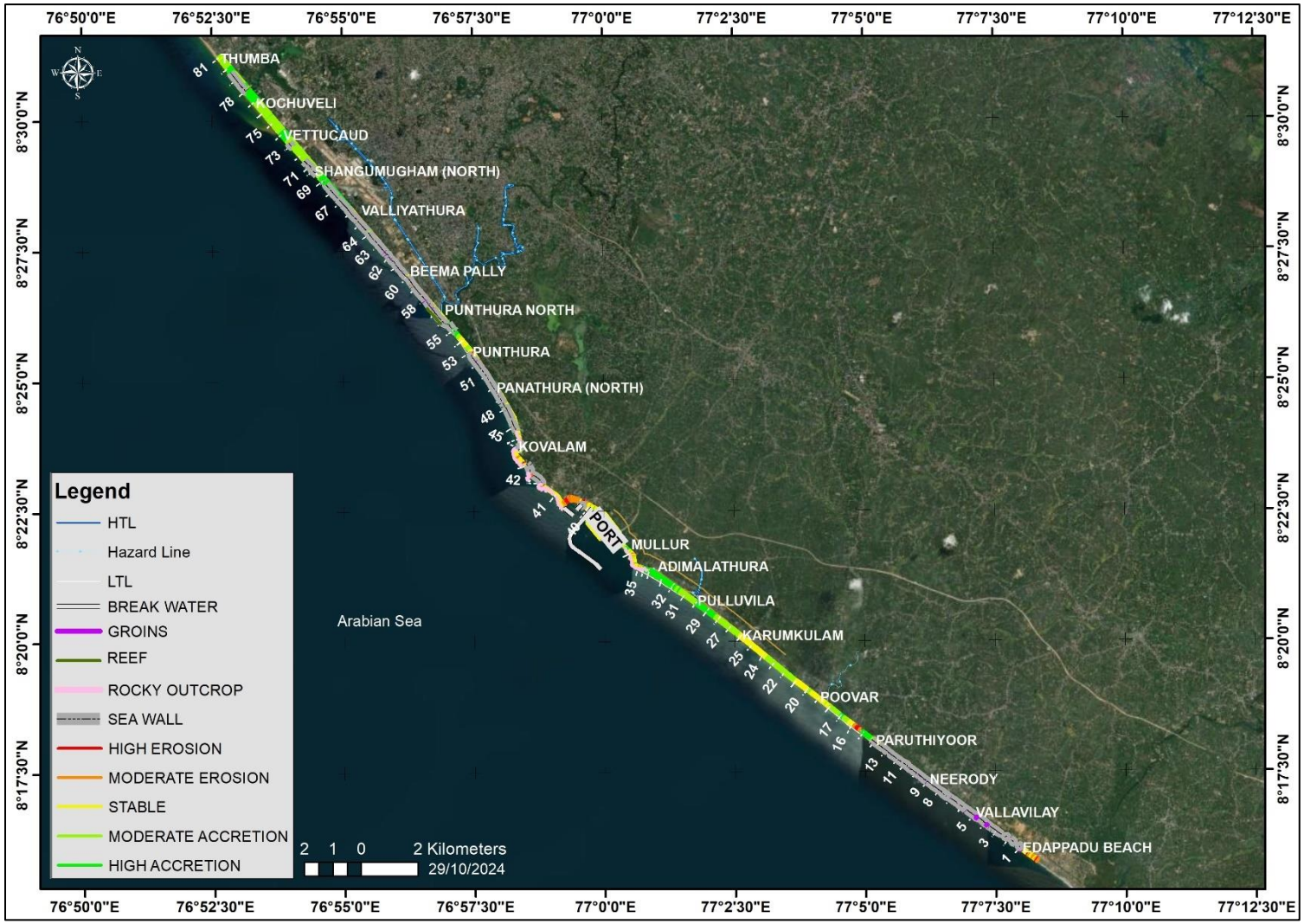


Figure A.37 Shoreline Change Analysis - Post Monsoon Period (October 2024 - November 2024)

A.2.2 Seasonal and Overall Shoreline Change Analysis from October 2024 to September 2025

Post Monsoon Period (October 2024-November 2024)

The shoreline change analysis map shows erosion at Edapadu to Neerody (CSP01-09), Poovar (CSP16), Kovalam (CSP41-44), Punthura (CSP53), Valiyathura (CSP63), while accretion at Poovar to Adimalathura (CSP17-34), Punthura (CSP54-58), Beemapally (CSP59-60), Valliyathura to Thumba (CSP64-81).

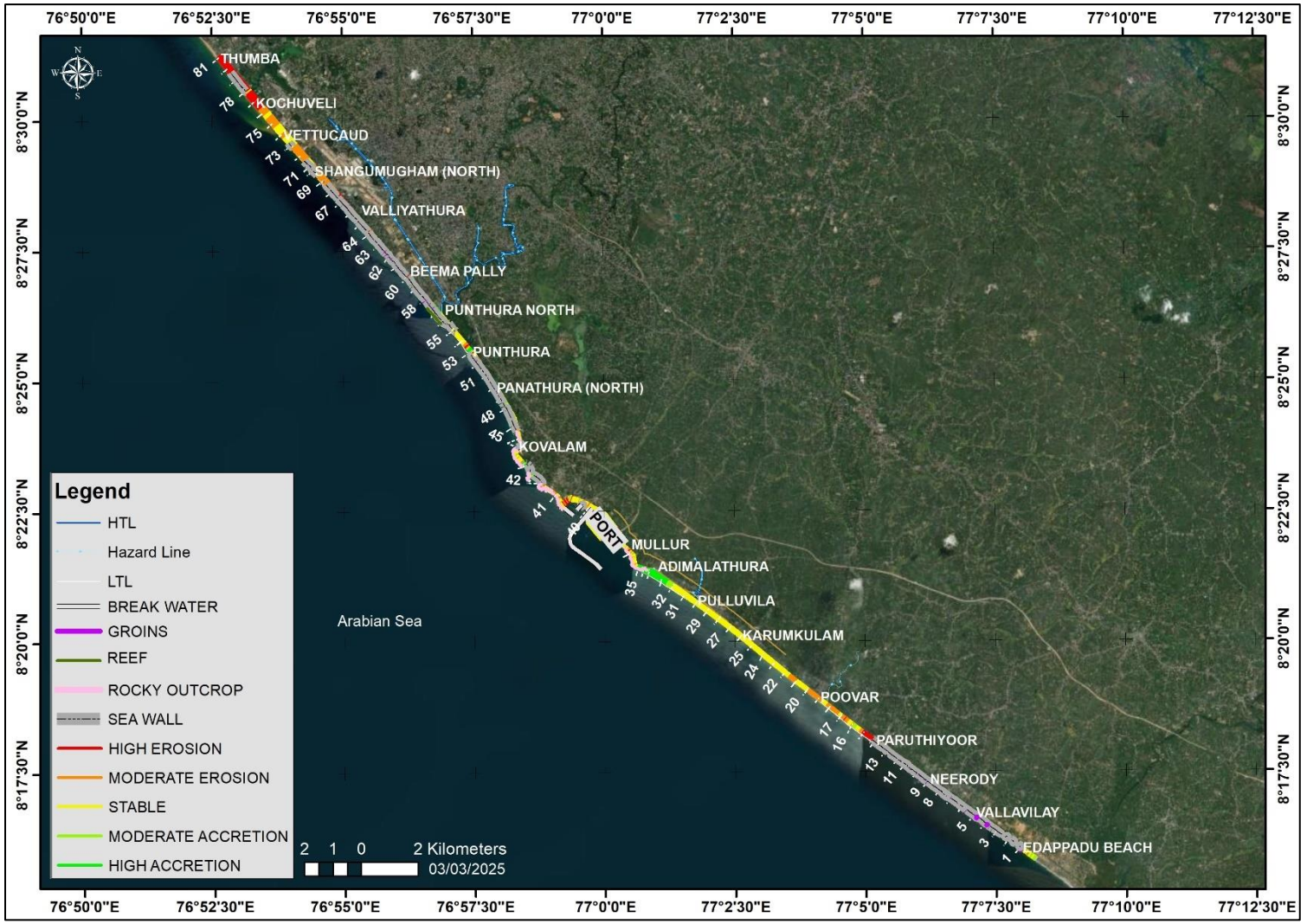


Figure A.38 Shoreline Change Analysis -Fair Weather Period (December 2024 -March 2025)

Fairweather Period (December 2024-March 2025)

The shoreline change analysis map shows accretion at Edapadu (CSP02), Neerody (CSP09), Adimalathura(CSP32-35), Punthura (CSP53), while erosion at Poovar (CSP13-21), Punthura (CSP53-54), Valliyathura to Thumba (CSP64-81)for the fair weather period.

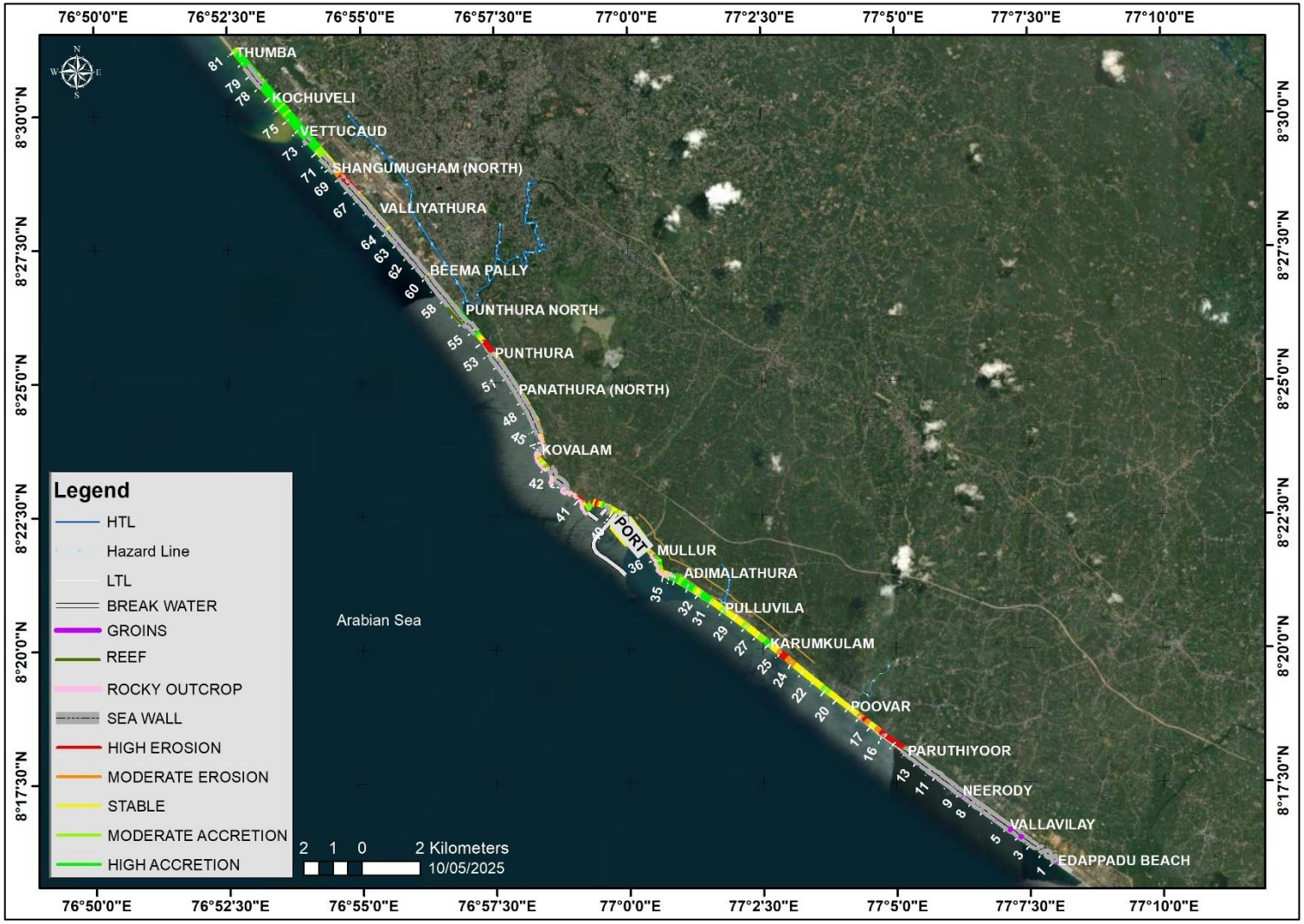


Figure A.39 Shoreline Change Analysis - Pre-Monsoon Period (April 2025-May 2025)

Pre Monsoon Period (April 2025 to May 2025)

Pre-monsoon period (April 2025 to May 2025) exhibits erosion at at Paruthiyoor to Poovar (CSP11-18), Karumkulam (CSP24-25), Kovalam (CSP41, 45), Pannathura (CSP46, 48), Punthura (CSP53-54), Valliyathura (CSP63-64), Shangumugham (CSP66-70) while accretion at Edapadu to Neerody (CSP01-10), Karumkulam to Adimalathura (CSP26-36), Kovalam (CP42-44), Pannathura (CSP49-52), Punthura to Beemapally (CSP55-58, 61-62), Vettacud to Thumba (CSP70-81).

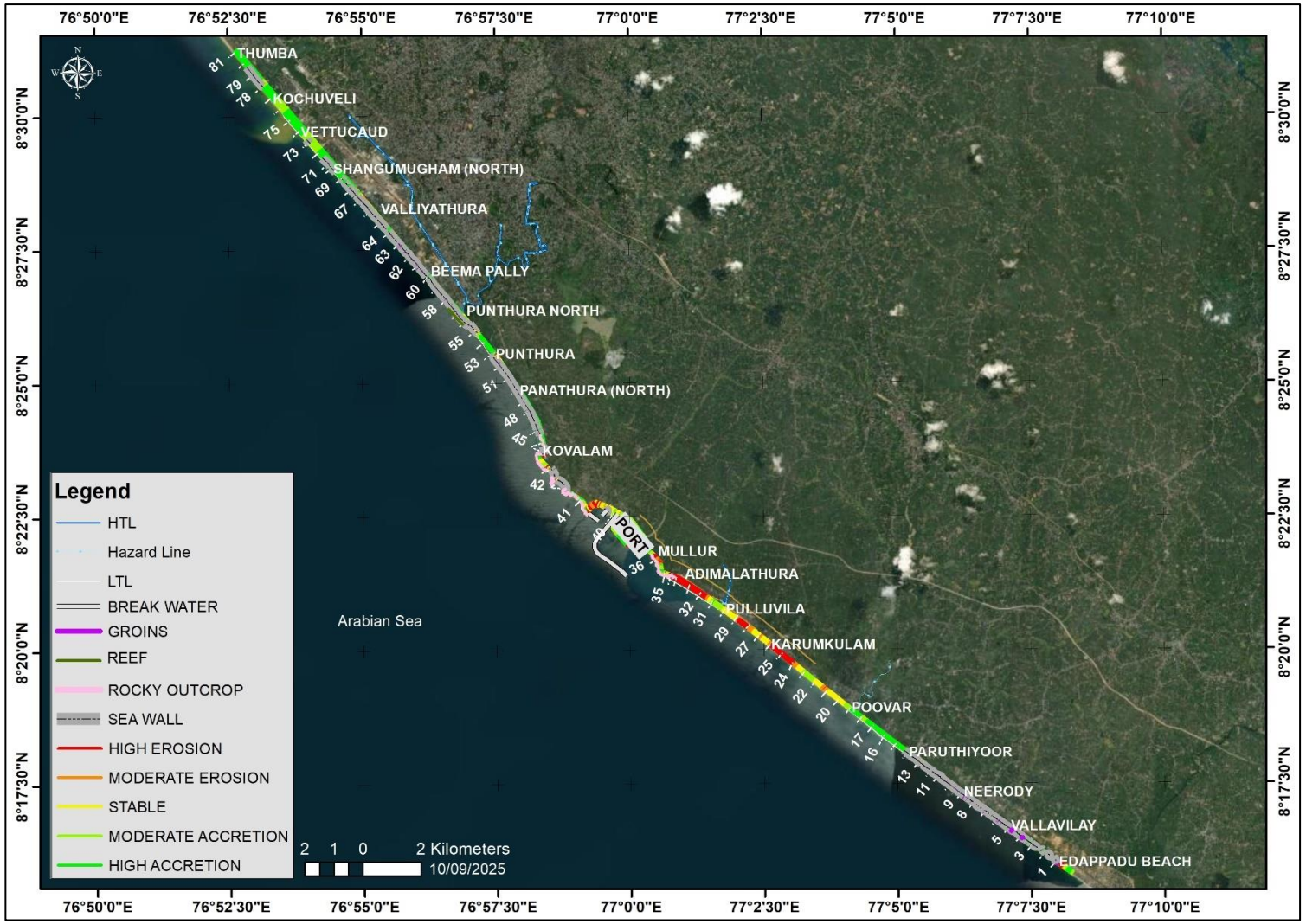


Figure A.40 Shoreline Change Analysis - Monsoon Period (June 2025 - September 2025)

Monsoon Period (June 2025 to September 2025)

Monsoon period for 2025 indicates erosion at Edapadu (CSP01), Poovar (CSP21), Karumkulam (CSP24-26), Pulluvila (CSP28-29), Adimalathura (CSP32-36), Kovalam (CS45), Punthura (CSP53), Valliyathura (CSP67), while accretion is noticed at Edapadu to Poovar (CSP02-20, 22-24), Adimalathura (CSP30-31), Kovalam to Pannathura (CSP41-50), Punthura to Valliyathura (CSP54-66), Shangumugham to Thumba (CSP68-81).

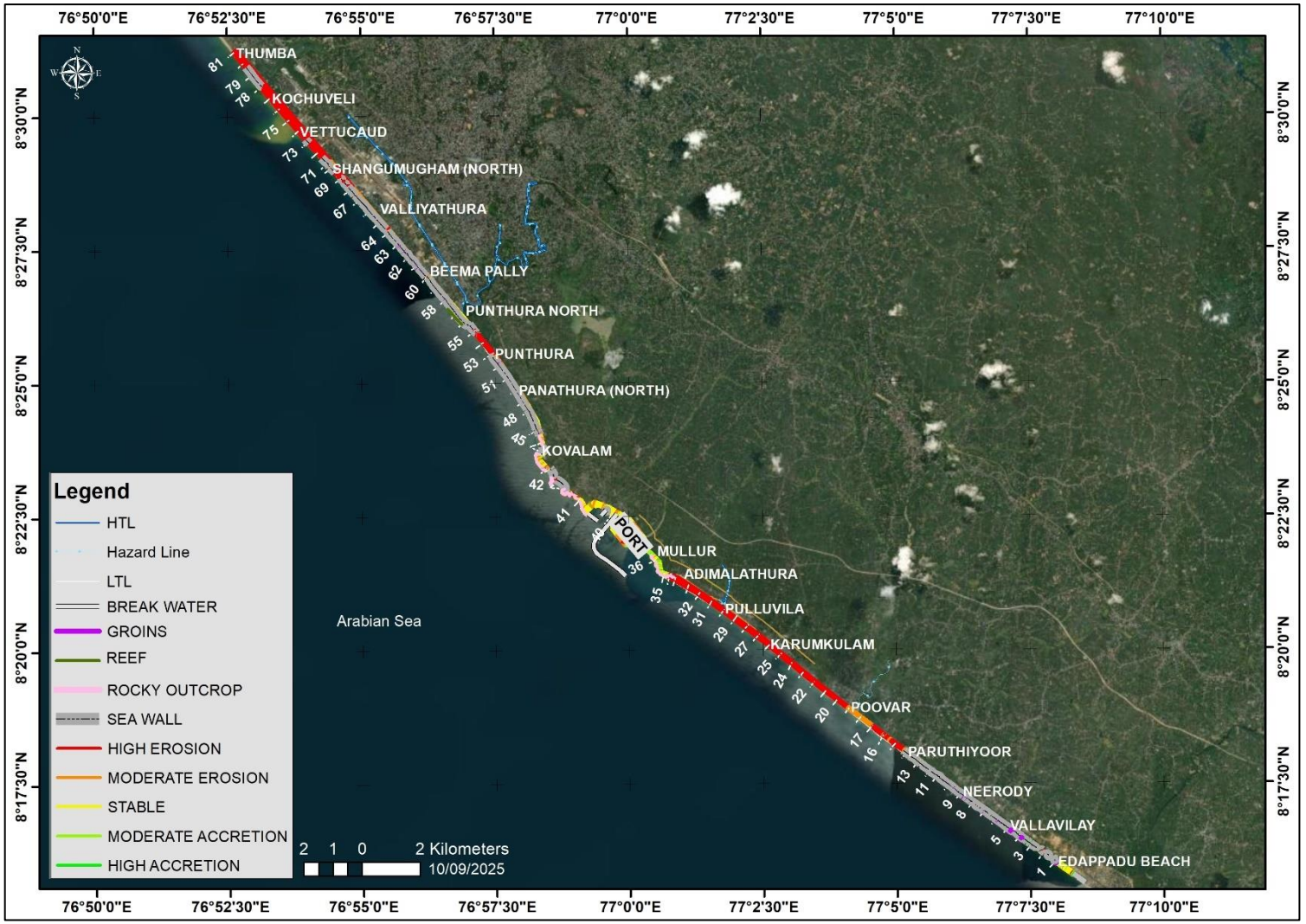


Figure A.41 Overall Shoreline Change Map for October 2024 - September 2025

Overall Shoreline Changes for October 2024- September 2025

Erosion is noticed at Paruthiyoor to Adimalathura (CSP14-34), Punthura (CSP53-55), Beemapally (CSP61), Valliyathura (CSP66), Vettucaud to Thumba (CSP71-77, 79-81), while accretion is noticed at Edapadu to Paruthiyoor (CSP01-15), Adimalathura to Mullur (CSP35-36), Kovalam to Pannathura (CSP40-47), Punthura to Beemapally (CSP56-60), Valliyathura (CSP63-65), Shangumugham (CSP67-70), Kochuveli (CSP78).

A.2.3 Shoreline comparison for the period October 2023-September 2024 and October 2024- September 2025

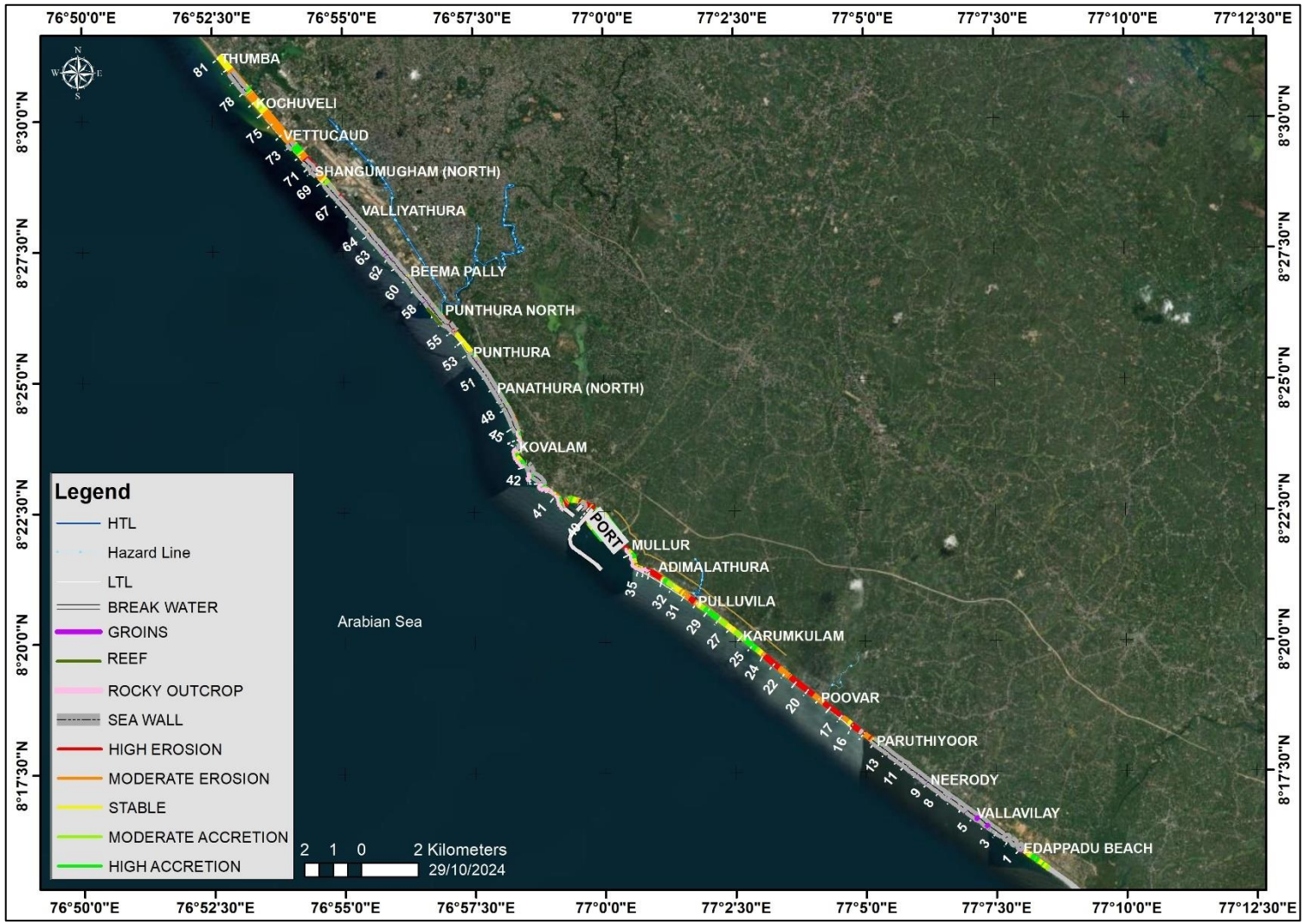


Figure A.42 Shoreline Change Map for October 2023 - October 2024

Shoreline comparison between October 2023 and October 2024

Erosion is noticed at Poovar to Karumkulam (CSP14-24), Adimalathura (CSP33-35), Mullur (CSP37), Kovalam (CSP41), Punthura (CSP55-56), Valliyathura (CSP66-68), Shangumugham (CSP70-72) and Vettucaud to Thumba (CSP 73-80), while accretion at Edapadu Beach to Paruthiyoor (CSP01-10), Karumkulam (CSP 24-29), Adimalathura (CSP32), Kovalam to Panathura North (CSP42-51), Punthura (CSP57-61), Valliyathura (CSP65), Shangumugham (CSP69) and Vettucaud (CSP72).

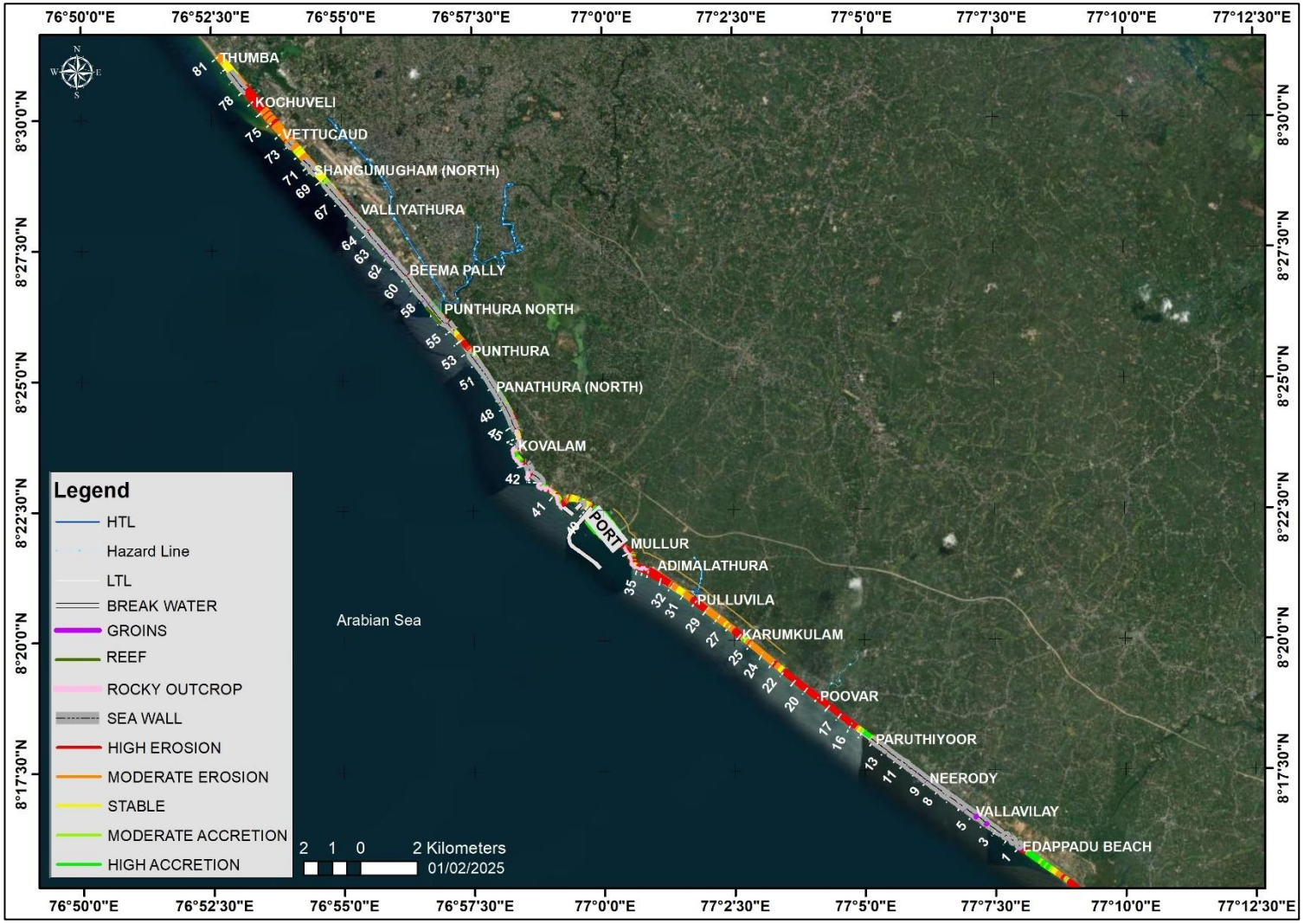


Figure A.43 Shoreline Change Map for February 2024 - February 2025

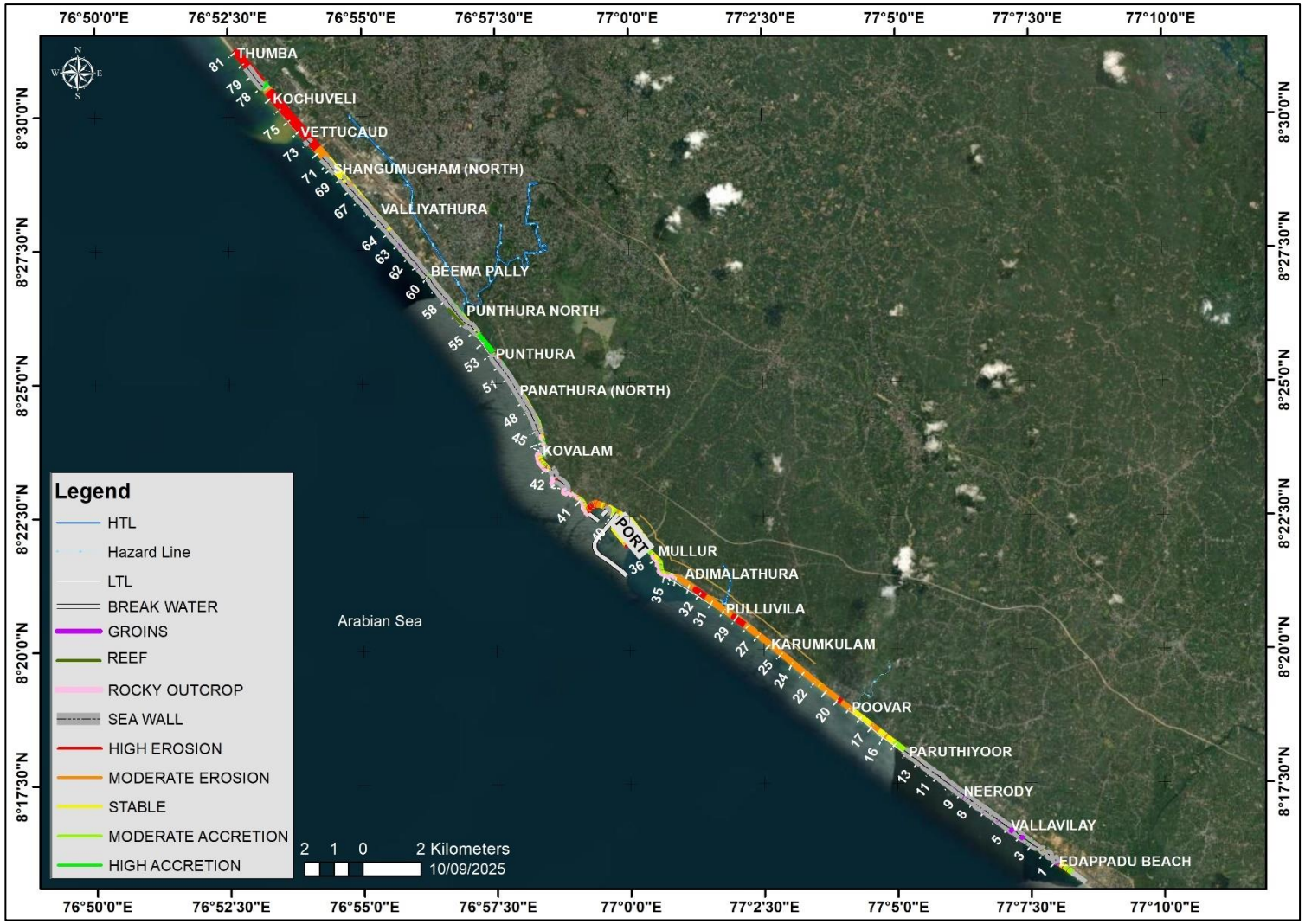
Shoreline comparison between February 2024 and February 2025

The shoreline comparison shows accretion at Poovar (CSP14-15), Kovalam (CSP43-44), Pannathura (CSP48-50), Punthura (CSP56-58), and Shangumugham (CSP69), while erosion at Edapadu beach (CSP01-13), Poovar to Mullur (CSP16-35), Pannathura (CSP45-48), Punthura (CSP53-56), Beemapally to Valliyathura (CSP59-68), and Shangumugham to Thumba (CSP71-81).

Figure A.44 Shoreline Change Map - May 2024 and May 2025

Shoreline comparison between May 2024 and May 2025

Accretion is noticed at Edapadu to Paruthiyoor (CSP01-18), Pulluvila to Adimalathura (CSP28-34), Kovalam to Pannathura (CSP43-52), Punthura (CSP55-57), Valliyathura to Thumba (CSP67-81). In contrast, erosion is noticed at Edapadu to Paruthiyoor (CSP01-18), Pulluvila to Adimalathura (CSP28-34), Kovalam to Pannathura (CSP43-52), Punthura (CSP55-57), Valliyathura to Thumba (CSP67-81).



Shoreline comparison between September 2024 and September 2025

Accretion is noticed at Edapadu (CSP01), Vallavilay to Paruthiyoor (CSP03-13), Adimalathura to Mullur (CSP35-36), Kovalam to Pannathura (CSP40-47), Punthura (CSP56-58), while erosion is noticed at Edapadu (CSP02), Paruthiyoor to Adimalathura (CSP14-34), Punthura (CSP53-55), Beemapally to Thumba (CSP60-81).

Figure A.45 Shoreline Change Map - September 2024 and September 2025

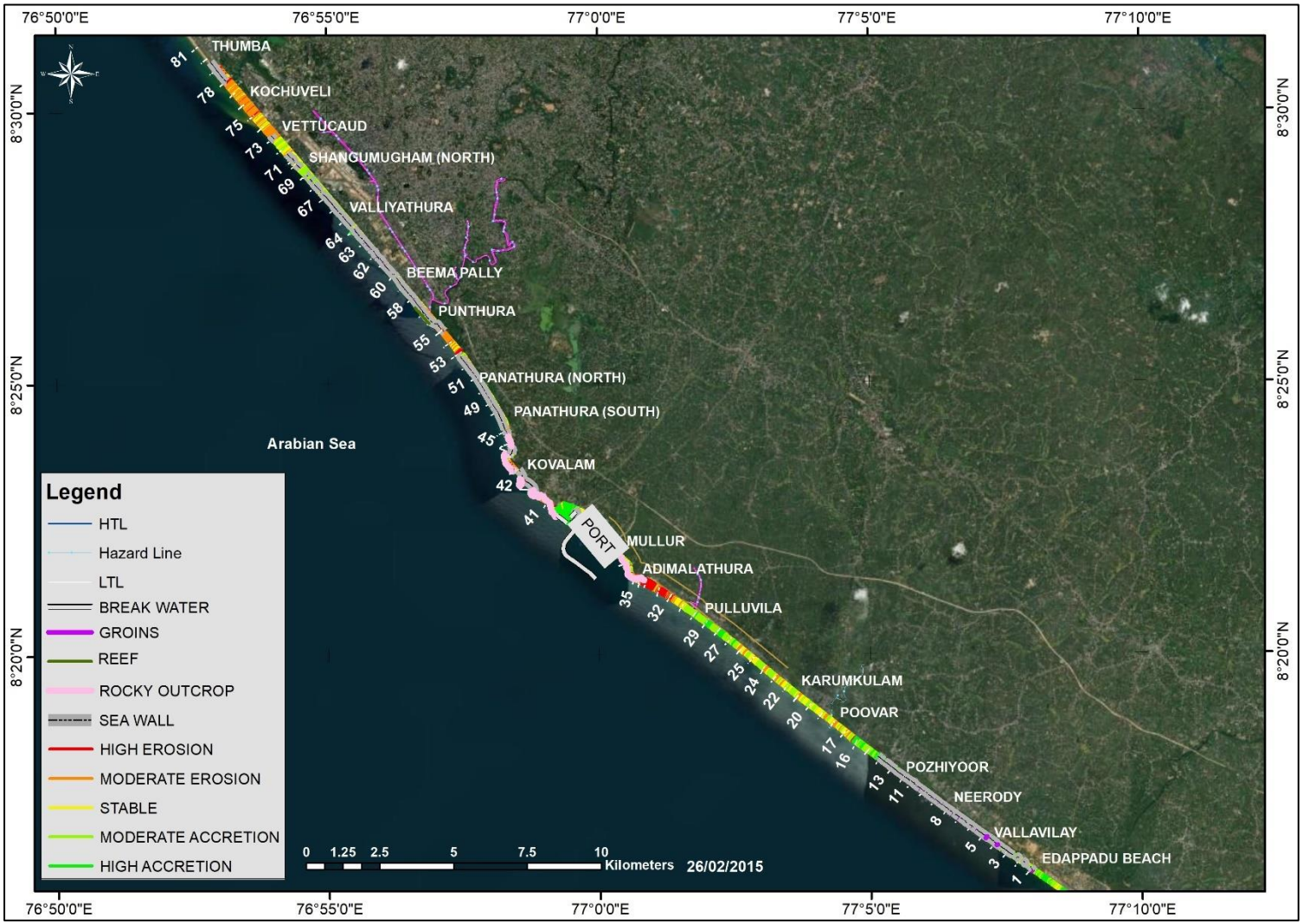


Figure A.46 Shoreline Change Comparison - 2012 to 2015

A.2.4 Shoreline Change comparison before and after 2015

The result from the analysis indicates erosion at Poovar (CSP17), Adimalathura (CSP32-33), Punthura (CSP53-55), Valliyathura (CSP66), and Vettucaud to Valiyaveli (CSP 75-81), while accretion at Poovar South (CSP14-15), Poovar North (CSP18-20), Karumkulam (CSP 22), Pullavila (CSP30), Karumkulam (CSP25), Pullavila (CSP27), Shangumugham (CSP69).

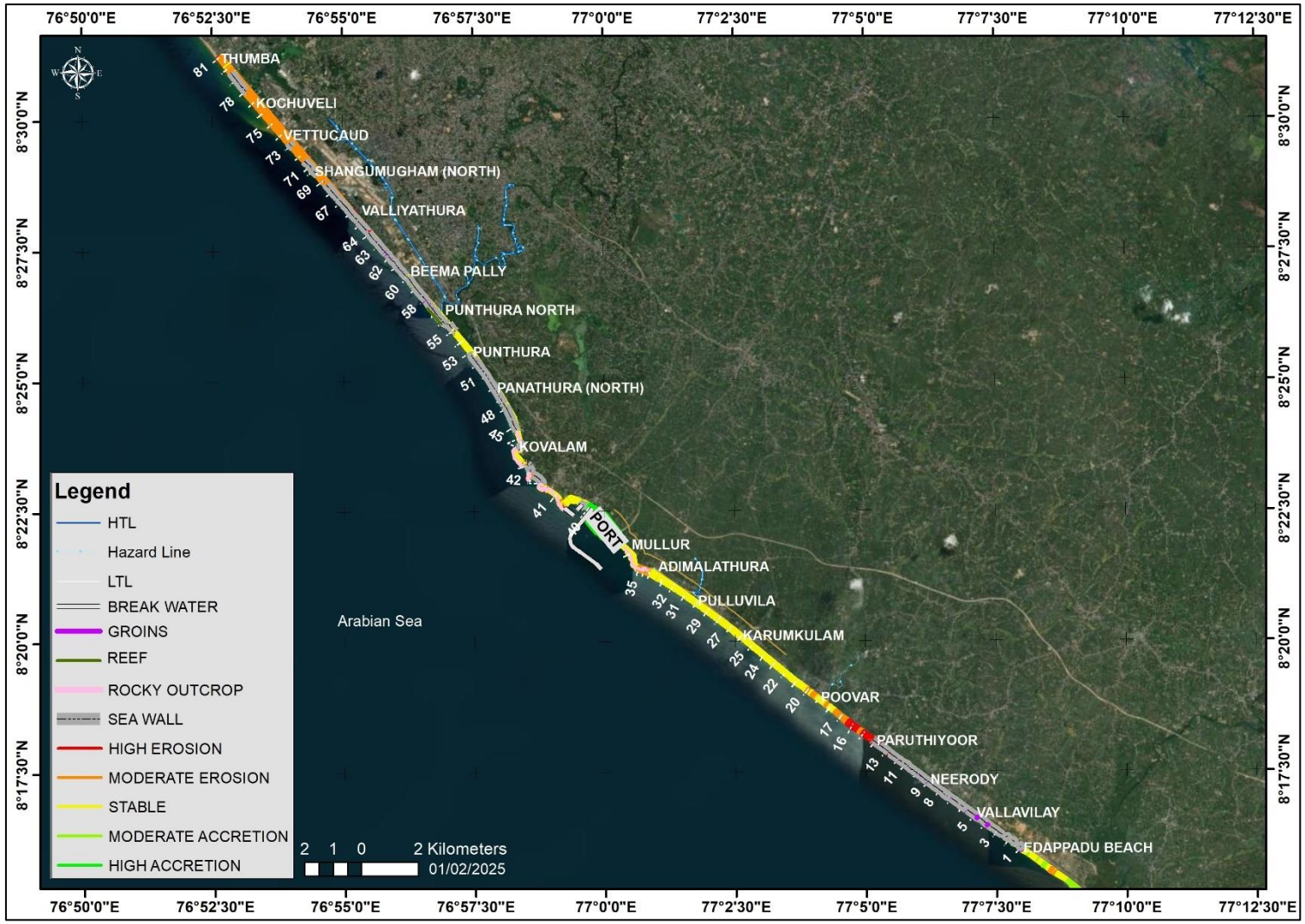


Figure A.47 Shoreline Change Map - 2015 to 2025

The comparison of the February 2015 shoreline with February 2025 using satellite images has been presented in Figure A.47. The comparison shows erosion at Edapadu beach (CSP02,03), Paruthiyoor to Poovar (CSP14-21), Adimalathura (CSP34-35), Kovalam (CSP44), Punthura (CSP57), Valliyathura to Thumba (CSP64-81), while Vallavilay to Pozhiyoor (CSP04-10), Poovar to Adimalathura (CSP16-33), (CSP43-52), Beemapally (CSP58-60) shows stable and accretion at Edapadu beach (CSP01), Neerody (CSP09), Mullur (CSP36-37), Panathura north (CSP53), Cheriyathura (60-63).

Figure A.48 Shoreline Change Map - October 2024

A.3 Results for Shoreline Change Analysis from Field Shoreline Data

A.3.1 Monthly and Overall Shoreline Change from October 2024 to September 2025

The shoreline analysis for October 2024 shows erosion at Poovar Beach (CSP16-18), Pulluvila (CSP31), Punthura (CSP53-54), Valliyathura to Thumba (CSP67-81), while accretion at Poovar Beach (CSP15), Adimalathura (CSP32-34). No data from CSP01 to CSP09 and CSP23 to CSP35.

The shoreline analysis for November 2024 shows erosion at Poovar (CSP15),while accretion at Poovar to Karumkulam (CSP16-22), Adimalathura to Azhimala (CSP 31-35), Kovalam to Thumba (CSP45-81).

Figure A.49 Shoreline Change Map – November 2024

Figure A.50 Shoreline Change Map - December 2024

The shoreline analysis for December 2024 shows erosion at Poovar (CSP15), Pullavila (CSP31), Punthura (CSP53-54), Valliyathura (CSP64-67), while accretion at Poovar (CSP16-17), Adimalathura (CSP34), Kovalam (CSP42-43), Shangumugham to Thumba (CSP69-80).

The shoreline analysis for January 2025 shows erosion at Poovar (CSP14), while accretion at Poovar (CSP16), Adimalathura (CSP32-34), Kovalam (CSP44-46), Punthura (CSP53-58), and Vettucaud to Thumba (CSP73-80).

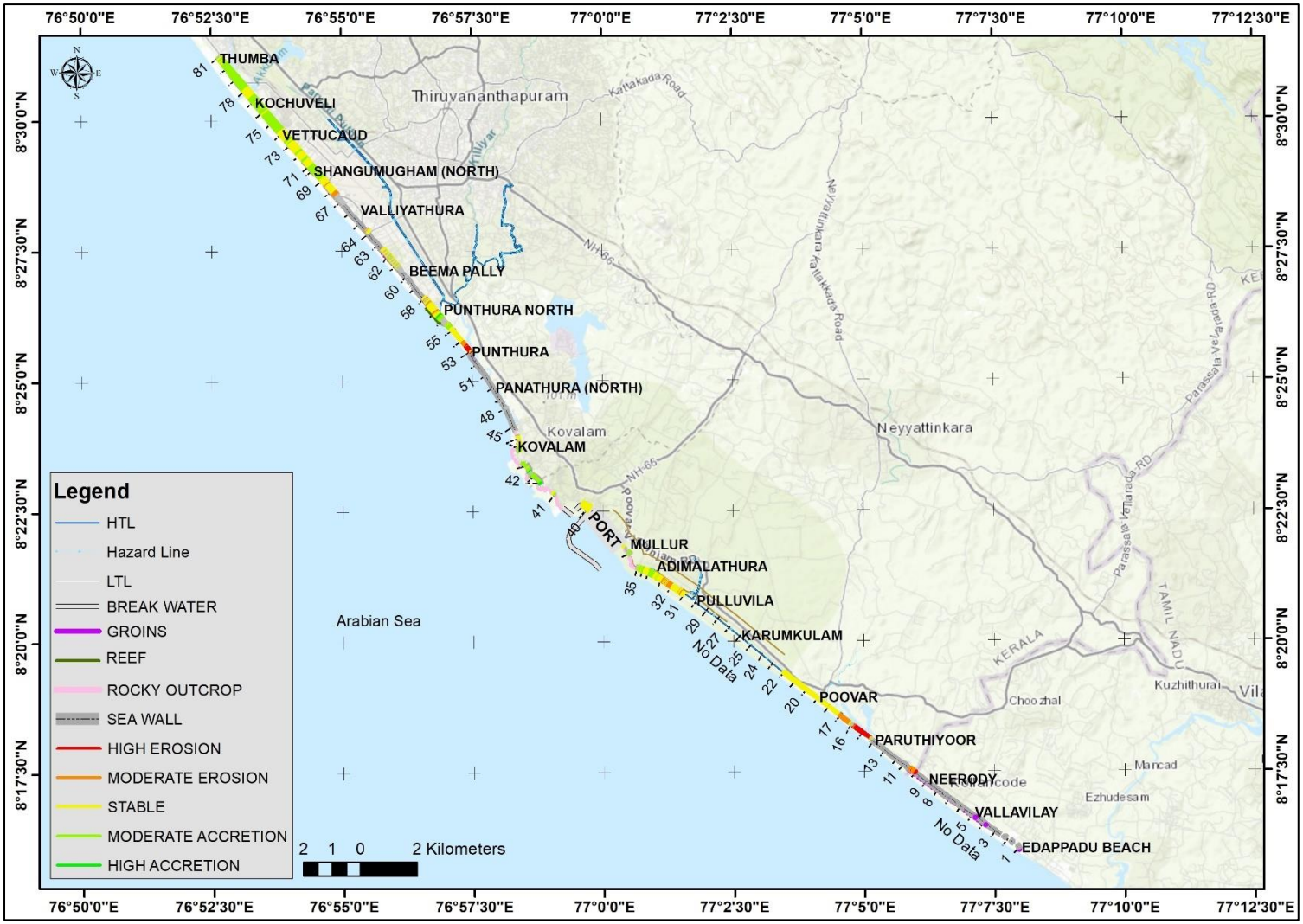
Figure A.51 Shoreline Change Map - January 2025

Figure A.52 Shoreline Change Map - February 2025

The shoreline analysis for February 2025 shows erosion at Poovar (CSP15, 18-21), Punthura (CSP53), Cheriyathura (CSP61-62), Valliyathura (CSP66), Kochuveli (CSP77), Thumba (CSP80), while accretion at Poovar (CSP16), Adimalathura to Azhimala (CSP33-35), Kovalam (CSP42-43), Punthura (CSP54-56).

Figure A.53 Shoreline Change Map - March 2025

The shoreline analysis for March 2025 shows erosion at Poovar (CSP15-17), Punthura (CSP53-55), Beemapally (CSP61), Valliyathura (CSP62, 67), Shangumugham (CSP68-70), and Thumba (CSP78-81), while accretion at Adimalathura (CSP31-34), Punthura (CSP58).



The monthly shoreline change analysis for April 2025 indicates erosion at Neerody (CSP10), Poovar (CSP14-18), Adimalathura (CSP31-33), Punthura (CSP53-54), Shangumugham (CSP67), while accretion at Mullur to Adimalathura (CSP33-36), Kovalam (CSP41-45), Shangumugham to Thumba (CSP69-81).

Figure A.54 Shoreline Change Map - April 2025

Figure A.55 Shoreline Change Map - May 2025

The monthly shoreline change analysis for May 2025 exhibits erosion at Paruthiyoor to Poovar (CSP15-22), Kovalam (CSP42-45), Punthura (CSP53-55), Thumba (CSP80-81), while accretion at Neerody (CSP10), Paruthiyoor (CSP14), Adimalathura (CSP32-35)

Figure A.56 Shoreline Change Map - June 2025

For June 2025, the shoreline change analysis shows accretion at Paruthiyoor (CSP14), Poovar (CSP 17), while erosion occurs at Poovar (CSP15-16, 18-22), Adimalathura (CSP31-34), Kovalam (CSP42-45).

Figure A.57 Shoreline Change Map - July 2025

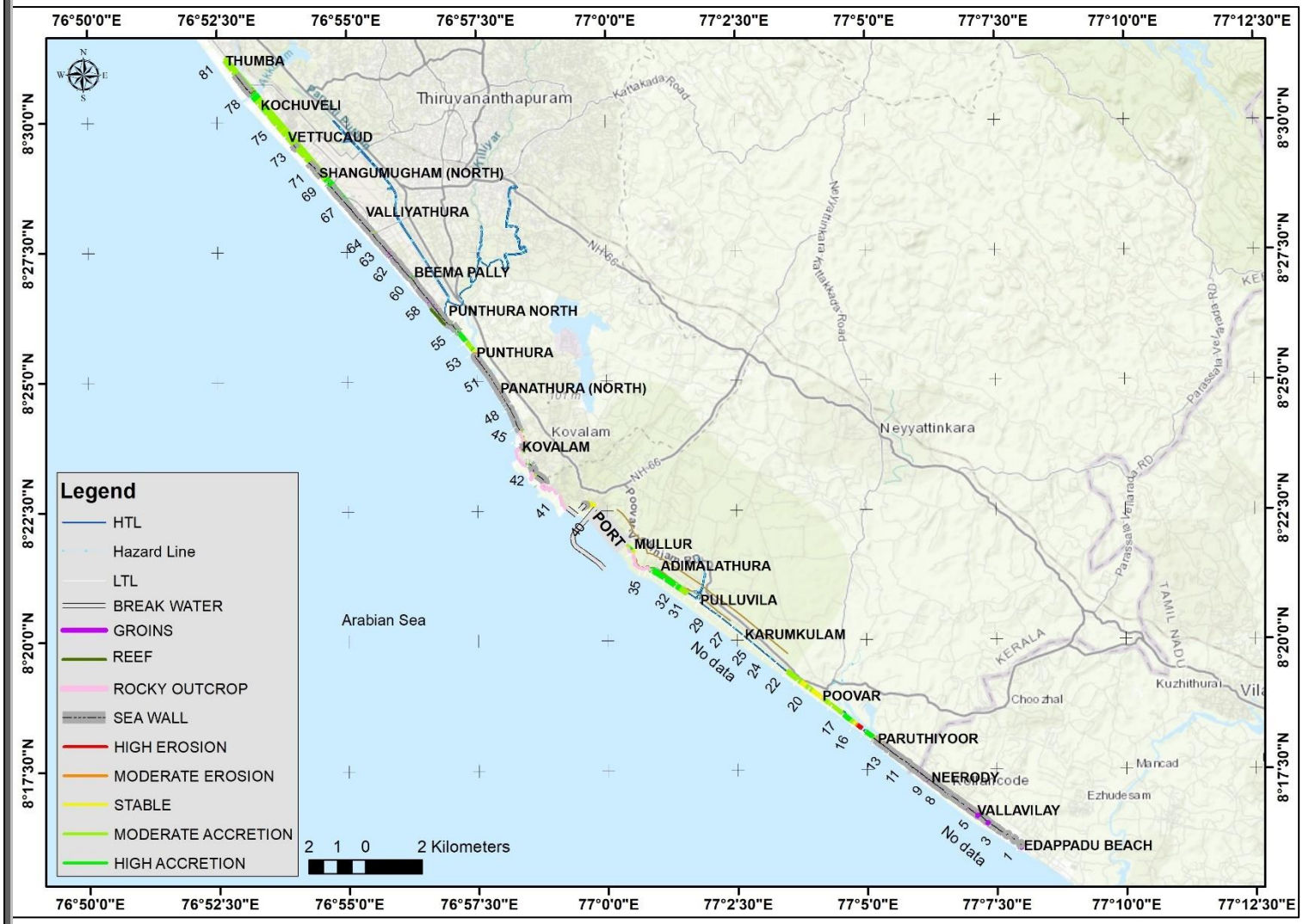
For July 2025, the shoreline change analysis shows erosion at Poovar (CSP17), Adimalathura (CSP33-34), while accretion at Paruthiyoor (CSP13-16), Poovar (CSP18-22). Kovalam (42-45), Thumba (CSP80-81).

Figure A.58 Shoreline Change Map - August 2025

The monthly shoreline change analysis for August 2025 indicates accretion at Neerody (CSP10), Paruthiyoor (CSP13-17), while erosion at Poovar (CSP20-21), Adimalathura (CSP32-34), Kovalam (CSP45), Veetuacud to Kochuveli (CSP73-77).

Figure A.59 Shoreline Change Map - September 2025

The monthly shoreline change analysis for September 2024 indicates accretion at Poovar (CSP17-18, 20-22), Adimlathura (CSP31,33-34), Kovalam (CSP42-45), Valliyathura (CSP62-64), Shangumugham to Thumba (CSP71-81), while erosion at Neerody (CSP10-11), Paruthiyoor (CSP14), Poovar (CSP16, 19), Adimalathura (CSP32). No data from CSP01-10, 23-30, and 46-60.



A.3.2 Seasonal and Overall Shoreline Change Analysis from October 2024 to September 2025

Post Monsoon Period (October 2024-November 2024)

The shoreline change analysis map shows erosion at Poovar (CSP15), while accretion at Poovar to Karumkulam (CSP16-22), Adimalathura to Azhimala (CSP 31-35), Kovalam to Thumba (CSP45-81).

Figure A.60 Shoreline Change Analysis-Post Monsoon Period (October 2024 - November 2024)

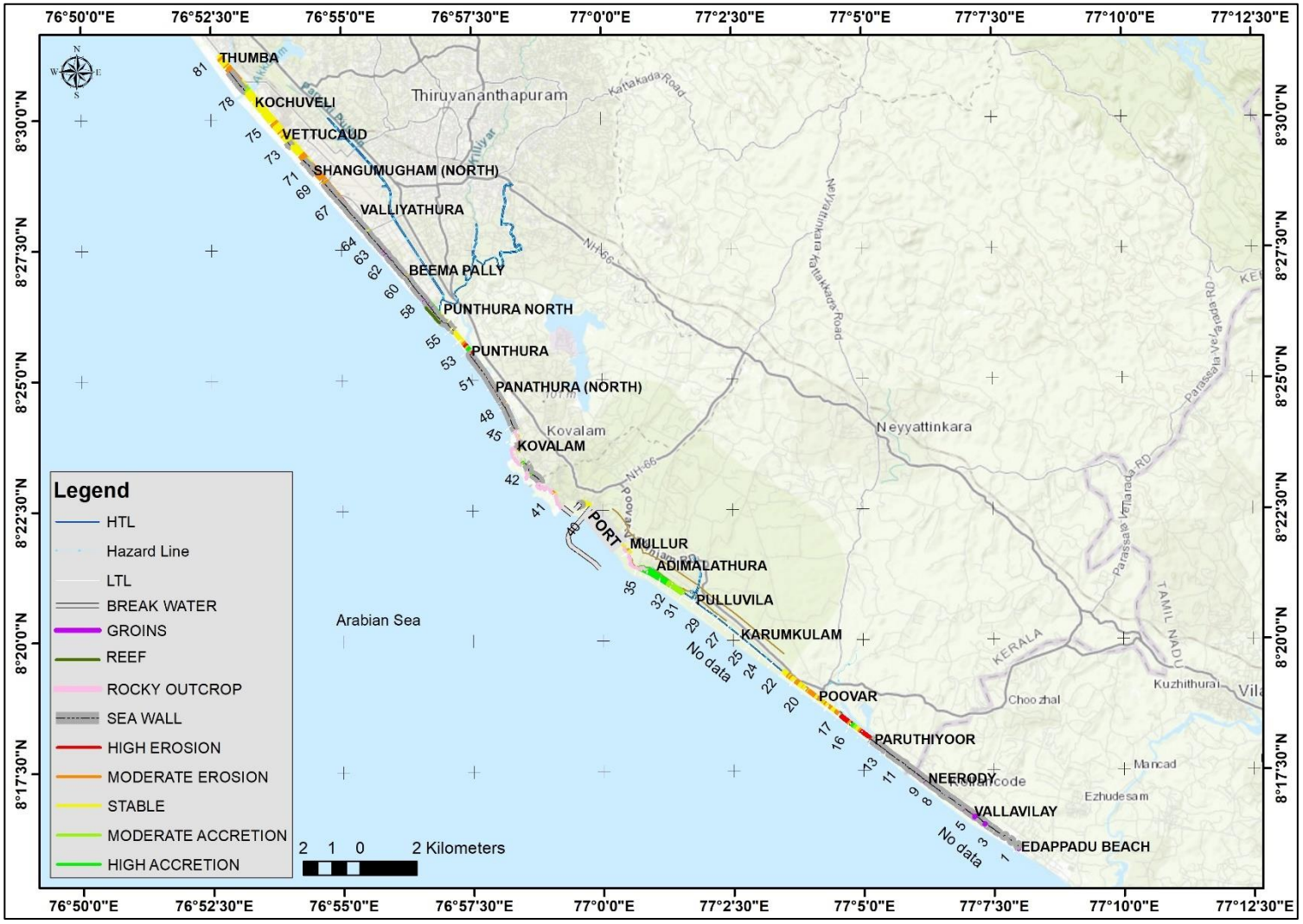


Figure A.61 ShorelineChange Analysis - Fair Weather Period (December 2024 -March 2025)

Fairweather Period (December 2024-March 2025)

The shoreline change analysis map shows accretion at Adimalathura (CSP31-35), Mullur (CSP37), Punthura (CSP56-58), while erosion at Poovar (CSP15-20), Punthura (CSP54), Shangumugham (CSP67-71), Thumba (CSP79-81) for the fair-weather period (December 2024 to March 2025).

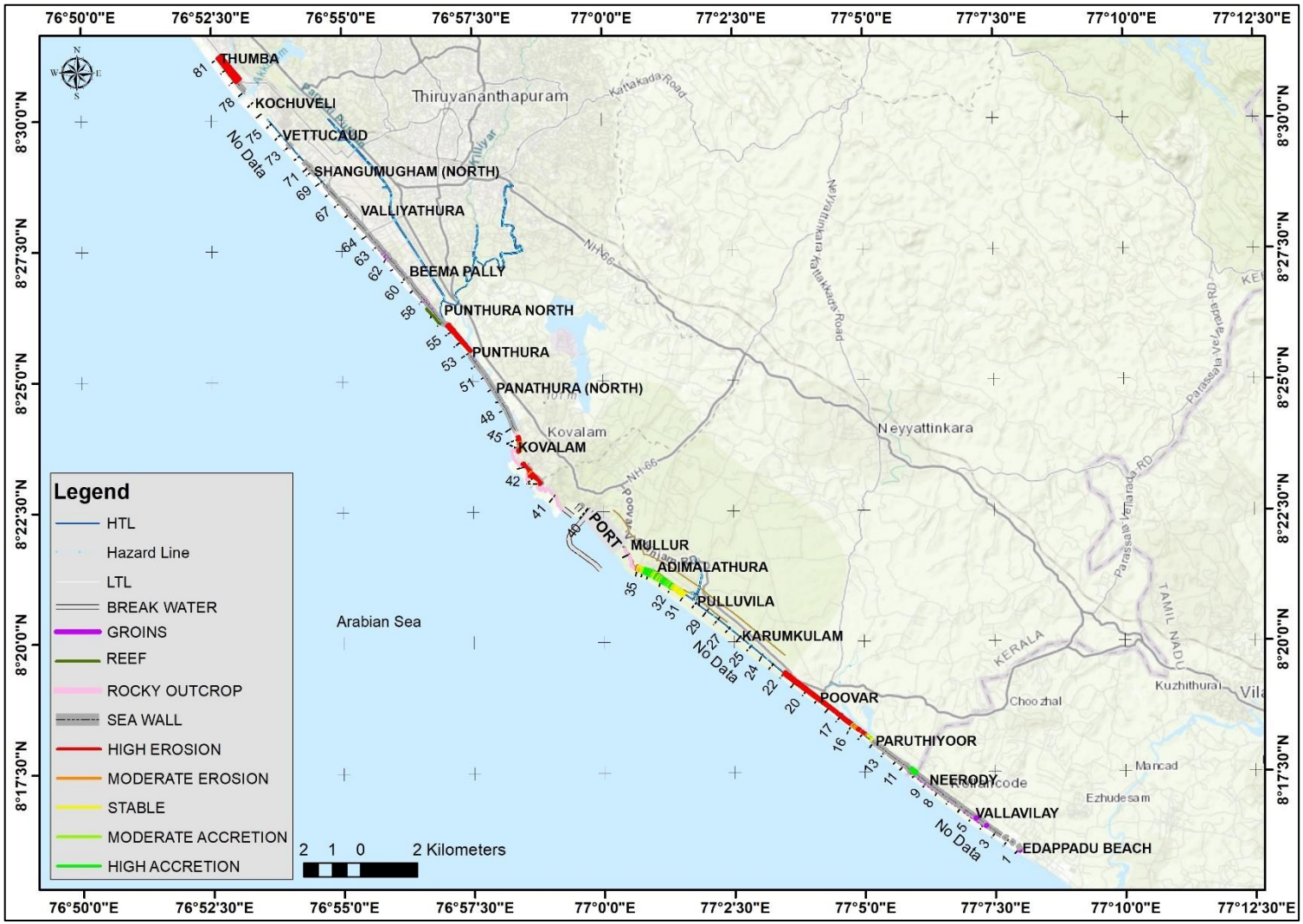


Figure A.62 Shoreline Change Analysis - Pre-Monsoon Period (April 2025-May 2025)

Pre Monsoon Period (April 2025 to May 2025)

Pre-monsoon period (April 2024 to May 2024) exhibits erosion at Paruthiyoor to Poovar (CSP15-22), Kovalam (CSP42-45), Punthura (CSP53-55), Thumba (CSP80-81), while accretion at Neerody (CSP10), Paruthiyoor (CSP14), Adimalathura (CSP32-35).

Figure A.63 Shoreline Change Analysis - Monsoon Period (June 2025 – September 2025)

Monsoon Period (June 2025 to September 2025)

Monsoon period for 2025 indicates erosion at Adimalathura (CSP32-34), while accretion is noticed at Paruthiyoor to Poovar (CSP11-21), Kovalam (CSP42-45), Valliyathura to Thumba (CSP62-81).

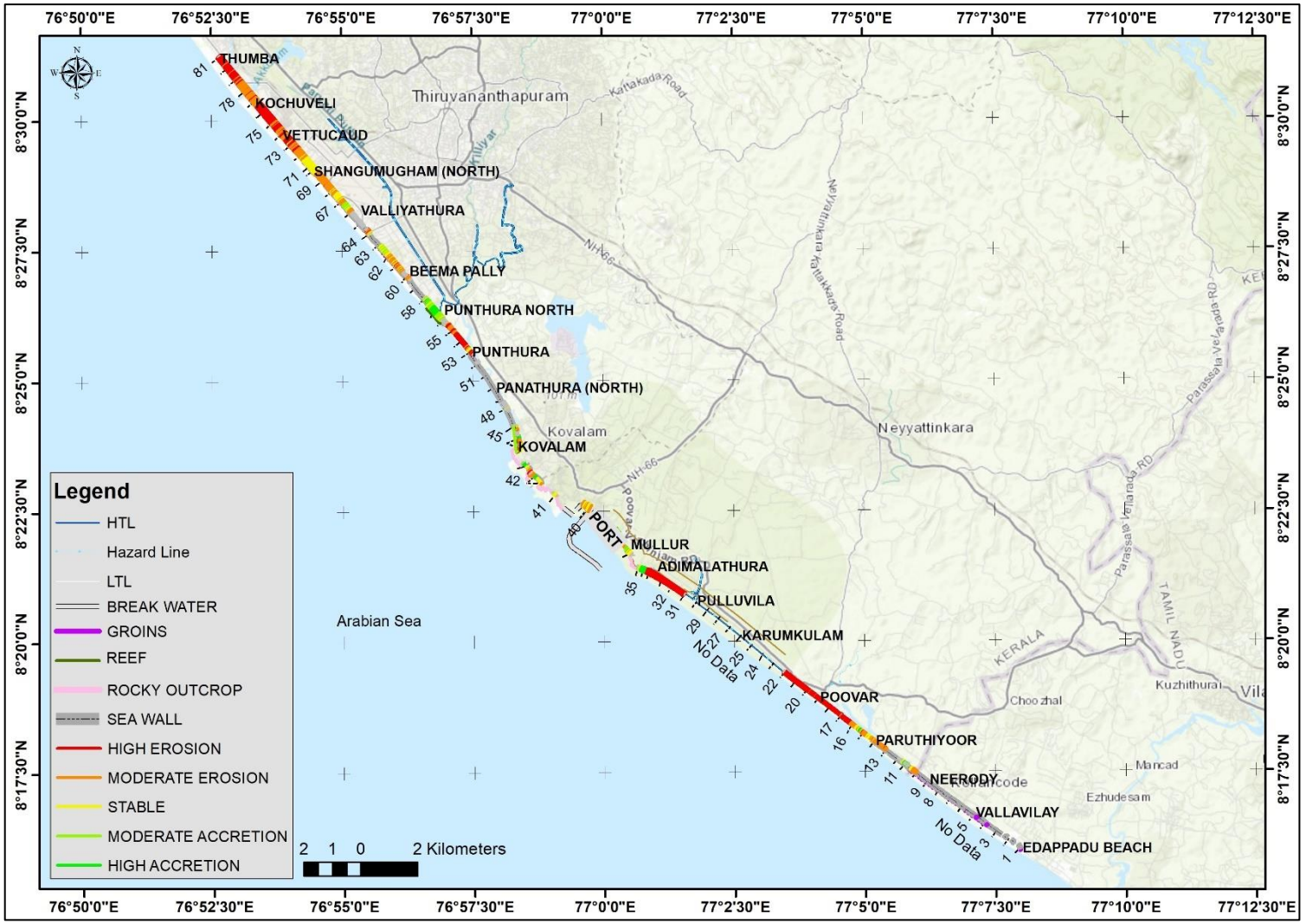


Figure A.64 Overall Shoreline Change Map for October 2024 - September 2025

Overall Shoreline Changes for October 2024- September 2025

Erosion is noticed at Neerody (CSP10), Paruthiyoor to Poovar (CSP13-22), Adimalathura (CSP31-34), Kovalam (CSP42), Punthura (CSP53-55), Beemapally (CSP60-62), Valliyathura (CSP64-66), Shangumugham to Thumba (CSP68-69, 72-81), while accretion is noticed at Neerody (CSP11), Adimalathura to Mullur (CSP34-36), Kovalam (CSP43-45), Punthura (CSP56-58), Valliyathura (CSP63, 66), Shangumugham (CSP70-71).

Figure A.65 Shoreline Change Map for October 2023 - October 2024

A.3.3 Shoreline comparison for the period October 2023-September 2024 and October 2024- September 2025

Shoreline comparison between October 2023 and October 2024

Erosion is noticed at Poovar (CSP16-22), Adimalathura (CSP34-36), Punthura (CSP53-55), Shangumugham to Thumba (CSP67-81), while accretion is noticed at Poovar (CSP15), Punthura (CSP53), and Valliyathura (CSP78).

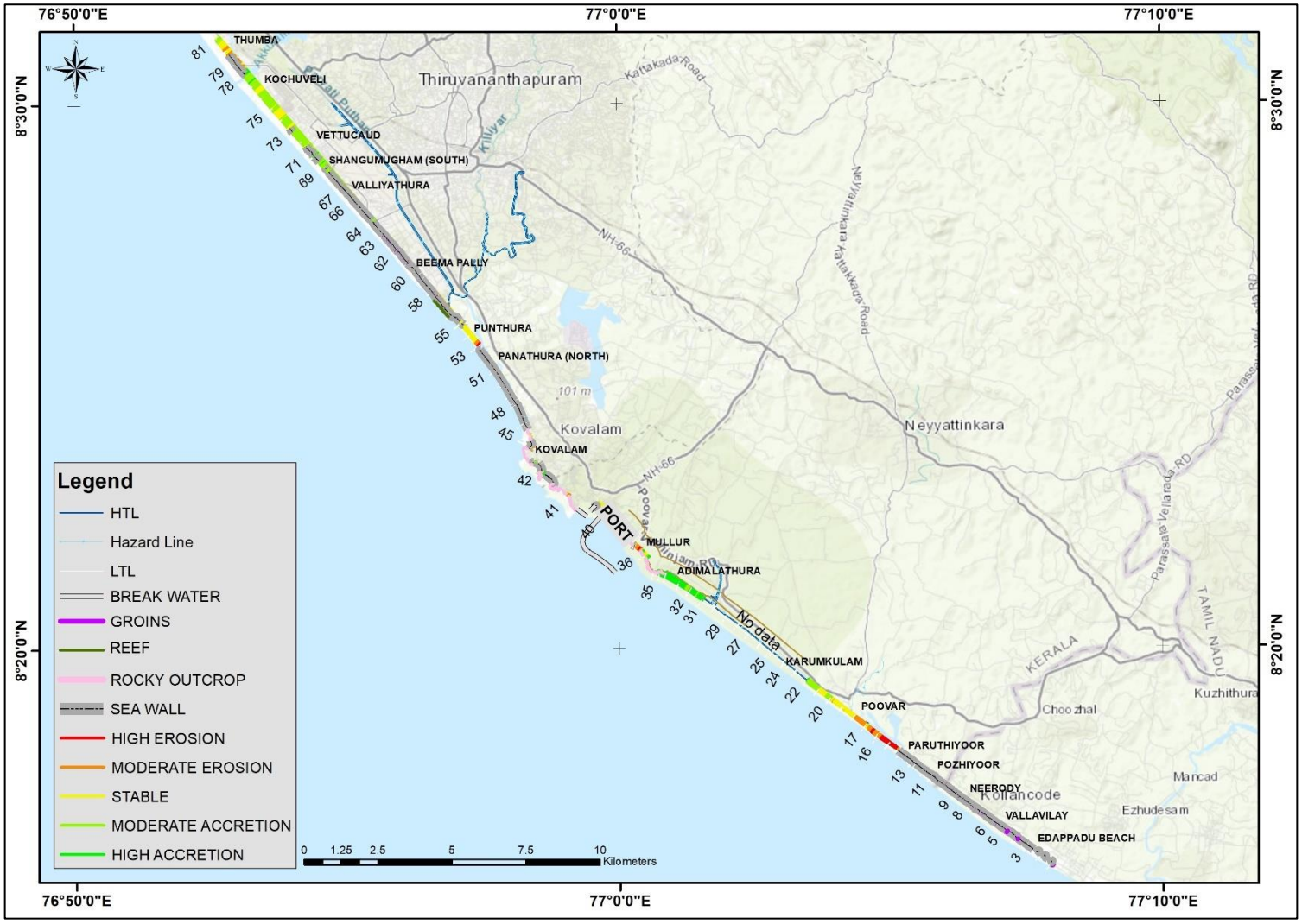


Figure A.66 Shoreline Change Map for February 2024 - February 2025

Shoreline comparison between February 2024 and February 2025

The shoreline comparison shows accretion at Poovar (CSP14-15), Punthura (CSP53, 55-58), Thumba (CSP68-79-80), while erosion at Poovar (CSP16-22), Adimalathura to Mullur (CSP32-37), Punthura (CSP54), and Valliyathura to Thumba (CSP66-78).

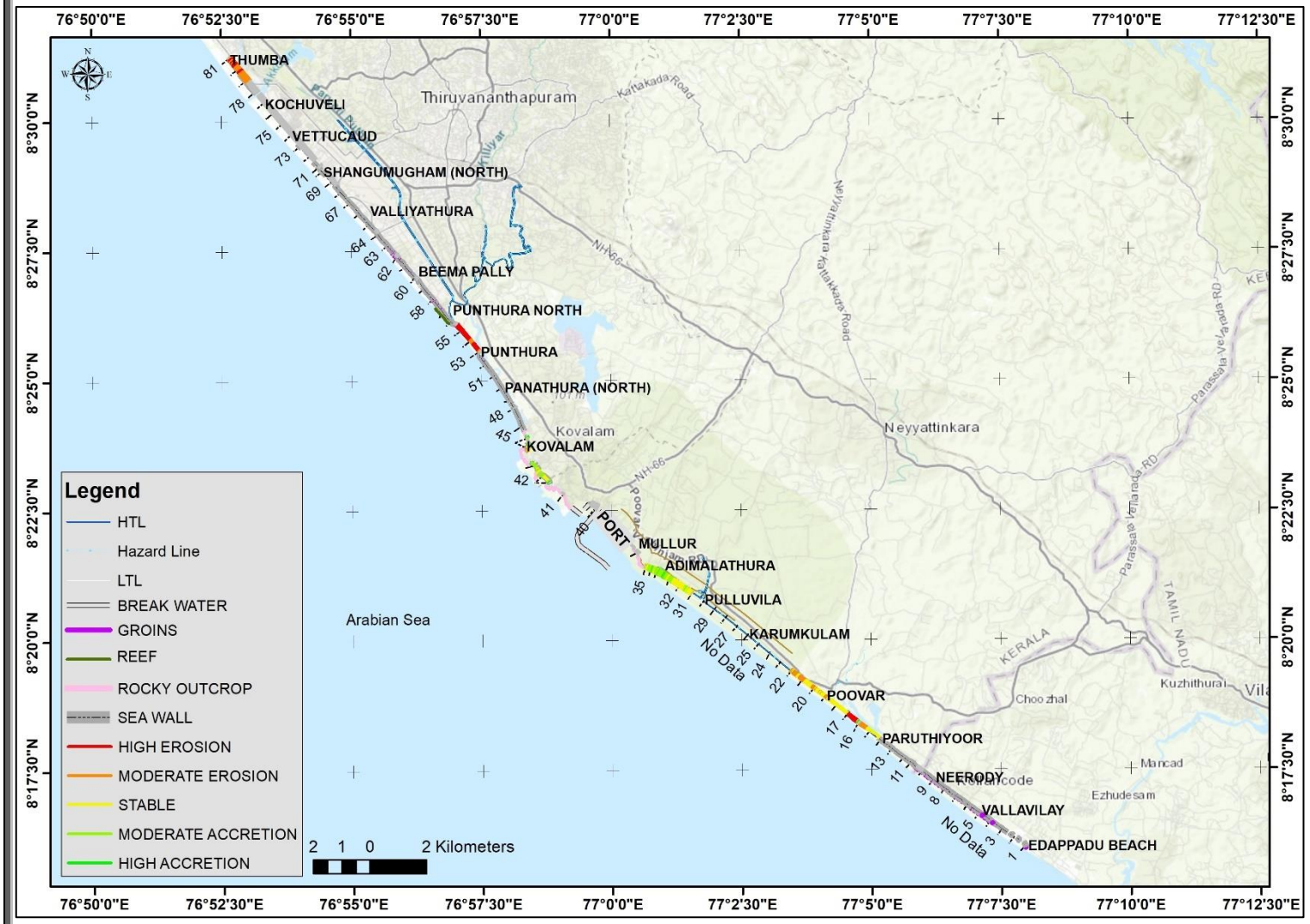


Figure A.67 Shoreline Change Map - May 2024 and May 2025

Shoreline comparison between May 2024 and May 2025

Accretion is noticed at Paruthiyoor (CSP14-15), Adimalathuta (CSP31-35), Kovalam (CSP42-45), while erosion is noticed at Poovar (CSP16-17), Punthuta (CSP53-55), Thumba (CSP80-81).

Figure A.68 Shoreline Change Map – September 2024 and September 2025

Shoreline comparison between September 2024 and September 2025

Accretion is noticed at Kovalam (CSP45), Punthura (CSP53), Shangumugham (CSP70-71), while erosion is noticed at Paruthiyoor to Poovar (CSP 14-22), Adimalathura (CSP31-36), Kovalam (CSP42-43), Punthura (CSP54-55), Valliyathura (CSP64), Shangumugham to Thumba (CSP68-69, 72-81).

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