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

ANNUAL REPORT

(October 2023 to September 2024)

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 includes a study on shoreline change assessment along the 40-km stretch of the Vizhinjam coast from October 2023 to September 2024, using high-resolution satellite images (0.5m spatial resolution), field shoreline and field-measured beach profile data.

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 2023 to September 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).

The shoreline changes using field-measured shoreline data from October 2023 to September 2024 shows accretion at Edapadu beach (CSP01, 03), Vallavilay to Neerody (CSP04-09), Azhimala (CSP35), Kovalam (CSP41-44), Punthura (CSP53-54, 57), Shangumugham (CSP68-69), Vettucaud (CSP72-74), Kochuveli (CSP75-76) and Valliyaveli (CSP78) while erosion at Poovar (CSP15-19, 21), Karumkulam (CSP22), Adimalathura (CSP-34), Mullur (CSP36-37), Kovalam (CSP45-46), Pannathura (CSP48), Punthura (CSP55,57), Valliyathura (CSP63,67), Shanmugham (CSP70-71), Kochuveli (CSP77), Thumba (CSP81)—no field data collected by AVPPL appointed survey agency from CSP23 to CSP30 due to local protest.

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. Due to rough sea conditions, the offshore survey was not carried out by the survey agency in any locations from September 2023 and May 2024 to September 2024. 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 before and after 2015 using high-resolution satellite images have also been compared. Shoreline trend analysis was also carried out for eight hotspot locations: Kochuveli, Valliyathura, Shangumugham, Punthura, Vizhinjam, Adimalathura, Poovar and Edapadu. Monthly, seasonal, annual, and intra-annual shoreline changes were assessed from October 2023 to September 2024. Shoreline change trends over the past two decades (2000-2024) 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.

Long-term trends (2000–2024) identified erosion hotspots at Shangumugham, Valliyathura, and Poovar South, whereas accretion was prominent at Vizhinjam, Adimalathura, and Poovar North. Climatic events, such as Cyclones Ockhi (2017) and Tauktae (2021), significantly impacted shoreline stability, causing severe erosion and altering sediment dynamics. Post-cyclone recovery patterns emphasized the role of structural interventions and natural sediment redistribution processes. The influence of dredging activities and breakwater construction from 2023 to 2024 had a significant impact on sediment distribution, and as such, the impacts are localised and confined to nearby areas. However, continuous monitoring is necessary to evaluate the scale of long-term effects on the coast.

The study highlights the dynamic nature of the Thiruvananthapuram coast, shaped by monsoon-driven currents and wave action. Accretion/ Erosion trends observed near structural interventions, such as groynes, indicate localised sediment recovery but also reveal downdrift erosion.

Further, the study requires continuous monitoring of shoreline dynamics through high-resolution satellite imagery and field-based observations to track ongoing changes and identify emerging trends, as well as conducting detailed investigations into sediment transport processes and evaluating the effectiveness of structural interventions in controlling erosion and accretion and fostering sustainable shoreline stabilization practices.

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) and for the year October 2022- September 2023 (SO No. 5702010119 dated 21/03/2023). 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, NGT-appointed expert committee and uploaded to the Kerala Coastal Zone Management Authority (KCZMA) website.

Subsequently, with reference to the mail dated 12/10/2023, NIOT has received the work order (SO No. 5702015202 dated 08/04/2024) to carry out the study on shoreline change analysis using beach profiles and high-resolution satellite images for the year October 2023 to September 2024. Accordingly, NIOT has procured the high-resolution satellite data (20km on either side of Vizhinjam port/ whichever available within 40km) through Indian Space Promotion and Authorisation Centre (INSPACe) and Indian satellite images procured from National Remote Sensing Centre (NRSC) and obtained field-measured data sets (beach profile) from AVPPL to study the shoreline changes analysis for 40 km stretch along Vizhinjam coast. This document reports the analysis and observation of the study on the shoreline change analysis carried out over a 40 km stretch, keeping Vizhinjam Port as a centre, using the available high-resolution satellite images and beach profile data from October 2023 to September 2024.

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 2023 to September 2024.

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 2023 to September 2024.

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 and Neyyar River (Poovar estuary). Geomorphologically, the south Kerala coast consists of coastal origin with younger coastal plains and denudational origin with a pediment pediplain complex. This study has been carried out to study the impact of the construction of the Port on the Vizhinjam coastal morphology. Thus, the long-term shoreline changes due to the construction of the Vizhinjam port facilities have been studied and submitted in the 2018 Annual Report, and

thereby, the annual monitoring and changes before and after 2015 have been reported. The development of a port involves various activities like dredging, reclamation, and construction of coastal structures such as breakwaters, groins, and jetties. Similarly, coastal protection and structures were introduced from 2010 to 2024 (Information on Coastal Infrastructures from Kerala Irrigation Department), and the structures were identified using high-resolution satellite images 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.

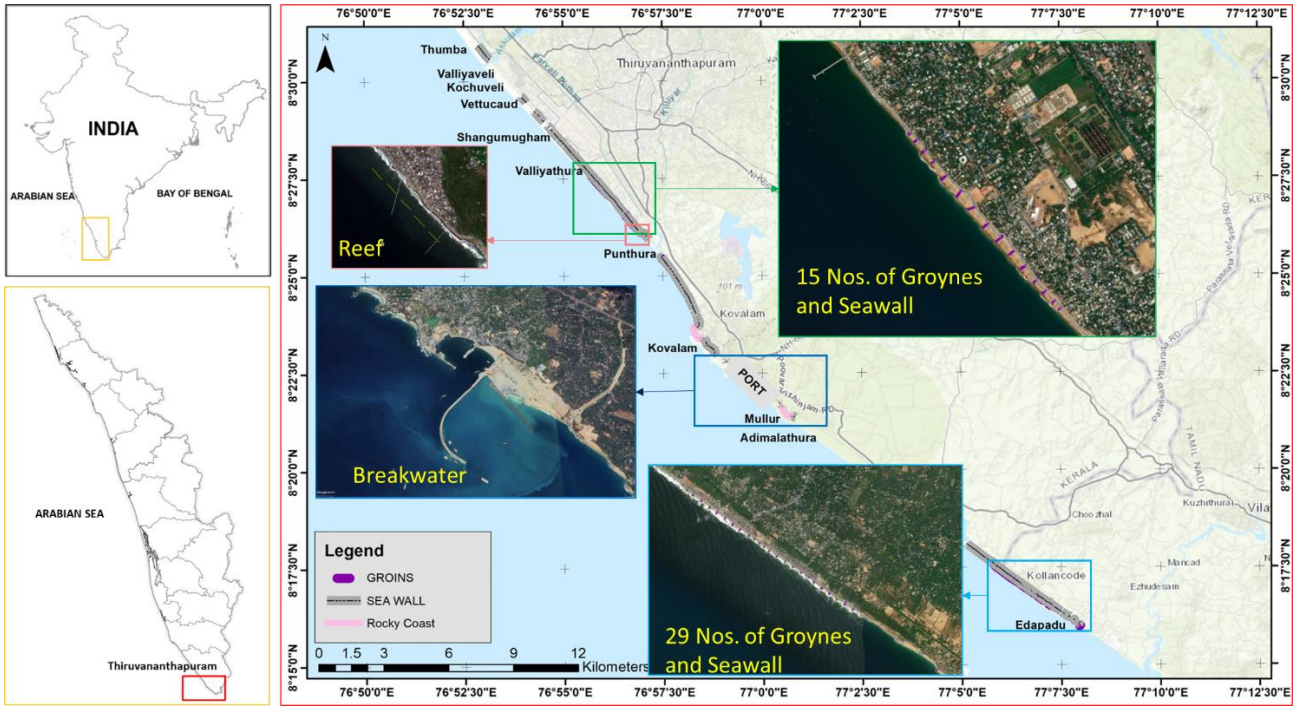

Figure 3.1 Location map depicting the coastal structures along the study area

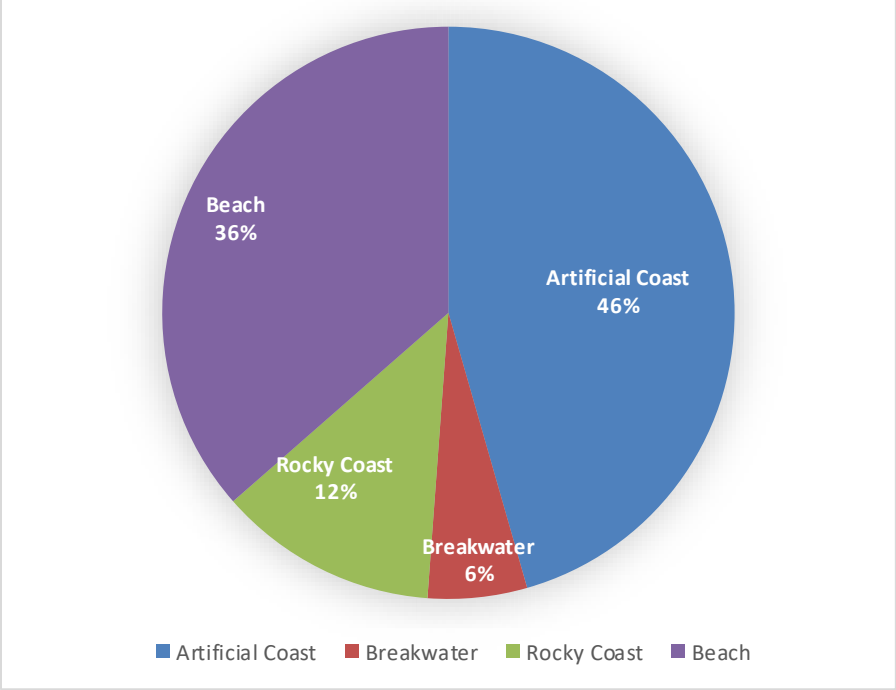

Figure 3.2 Pie Chart showing the percentage of natural and artificial coasts along the study area

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 have been constructed from 2020 to 2024 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. Table 3.2 lists the natural and Port events from 2015 and the corresponding wave data from Wave Rider Buoy. Cyclones Ockhi (December 2017) and Tauktae (May 2021) have had significant impacts on 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

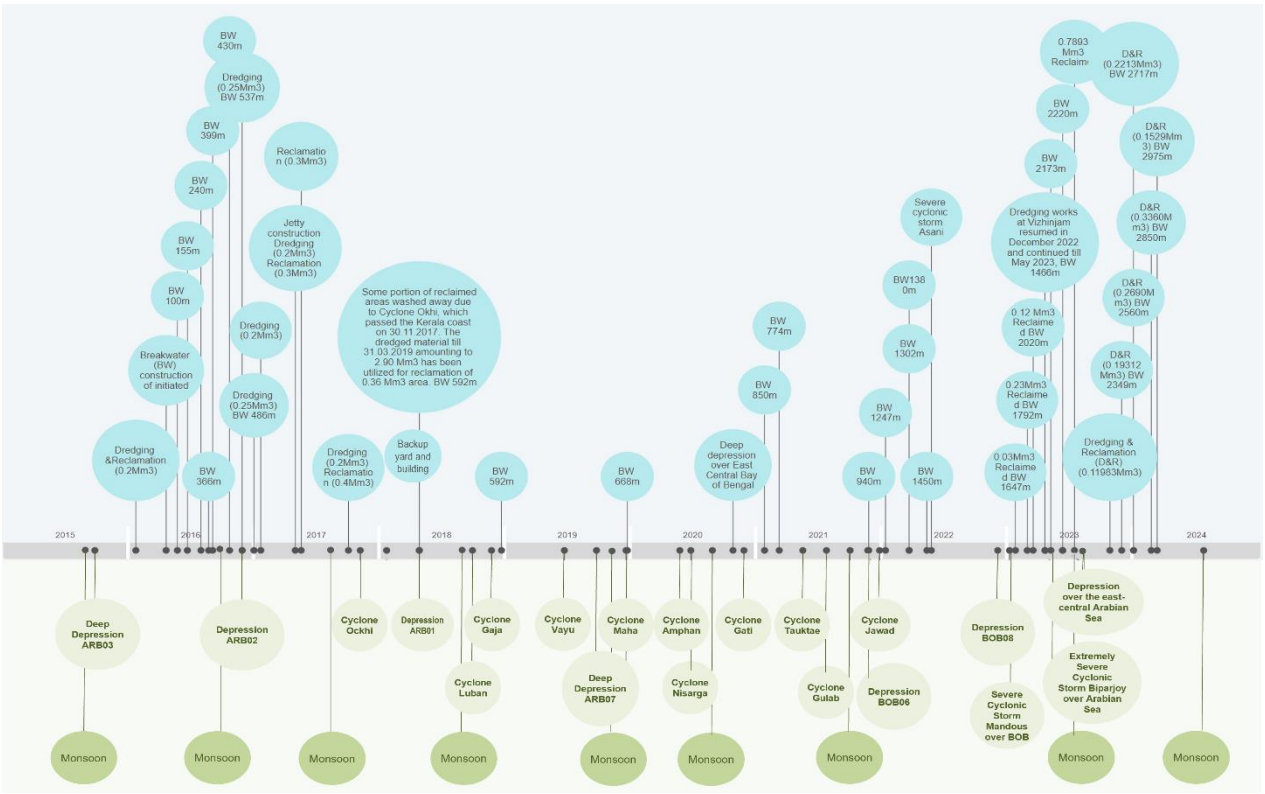

Figure 3.3 Timeline of Natural and Port events along the Vizhinjam coast

Table 3.2 Timeline of Natural and Port events along 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 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-November 7	Nov-19	Cyclone Maha		Maximum Hs-1.36m, Maximum Hmax-6.13m, Maximum Tp-16.7s(No Data During Cyclone Time)
2nd December	Nov-19	Deep Depression ARB07	No dredging and Reclamation	Maximum Hs-1.49m, Maximum Hmax-2.52m, Maximum Tp-18.2s

to 5th December				
	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		Maximum Hs-2.44m, Maximum Hmax-4.5m, Maximum Tp-20s
17th to 19th June 2020	Jun-20	Monsoon		
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	BW 940m	Maximum Hs- 2.87m Maximum Hmax-5.66m Maximum Tp- 10.0s

19th to 20th November 2021	Nov-21	Depression BoB 06		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 StormMandous 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 / Break Water 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 WRB Data from 24th August 2024

4. DATA & METHODS

4.1 Satellite images used

The input satellite images for the stretch of 20km on either side of Vizhinjam Port with the corresponding tide, coverage and resolution are listed in Table 3.1. The high-resolution satellite images of less than 1m have been procured from the vendors listed by the Indian National Space Promotion and Authorization Centre (InSPACe) and 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 2023 to September 2024.

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		
	01-10-2022	0.498	26.7		
	18-02-2023	0.604	30.8		
	26-10-2023	0.986	17.1		
	10-02-2024	0.669	14.5		
	28-02-2024	0.486	16.5		
	19-03-2024	0.581	15.0		
	14-04-2024	0.346	15.0		
	04-05-2024	0.861	22.0		
	01-06-2024	0.465	19.0		
	21-07-2024	0.634	25.0		
	01-08-2024	0.686	17.0		
	14-09-2024	0.612	22.0		
Kompsat3A	04-09-2024	0.391	40	(Multispectral)	0.5
	18-09-2024	0.592			
Satellogic	21-05-2023	0.573	30.8	(Multispectral)	0.7
	14-09-2023	0.611			
Cartosat 1	12-02-2011	0.283	10.2	PAN+Multispectral	1
Cartosat 2	13-12-2023	0.560	16.8		0.65
	12-03-2024	0.542	10.9		
	22-09-2024	0.493	16.7		
Cartosat 3	02-08-2024	0.679	6.5		0.3
Resourcesat2/ 2A	30-10-2023	0.750	40.0	LISS4	5
	11-11-2023	0.667			
	29-12-2023	0.453			
	15-02-2024	0.294			
	22-03-2024	0.840			
	03-04-2024	0.525			
	09-05-2024	0.688			
	25-08-2024	0.478			
Sentinel 2	10-10-2022	0.747		MSI	10
	17-02-2023	0.517			
	24-10-2023	0.814			
	14-12-2023	0.535			
	13-01-2024	0.546			
	07-02-2024	0.543			
	03-03-2024	0.329			
	07-04-2024	0.854			
	02-05-2024	0.588			
	11-06-2024	0.365			
	11-07-2024	0.572			
	25-08-2024	0.478			
	19-09-2024	0.547			

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 (Since 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 Kinetic) 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 monthly.

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 2023 to September 2024. 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 between September 2023 as well as from May 2024 to September 2024. 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 2023 and September 2024 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 2023 to September 2024 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, and October 2022 to September 2023 submitted to NGT Expert committees through VISL.

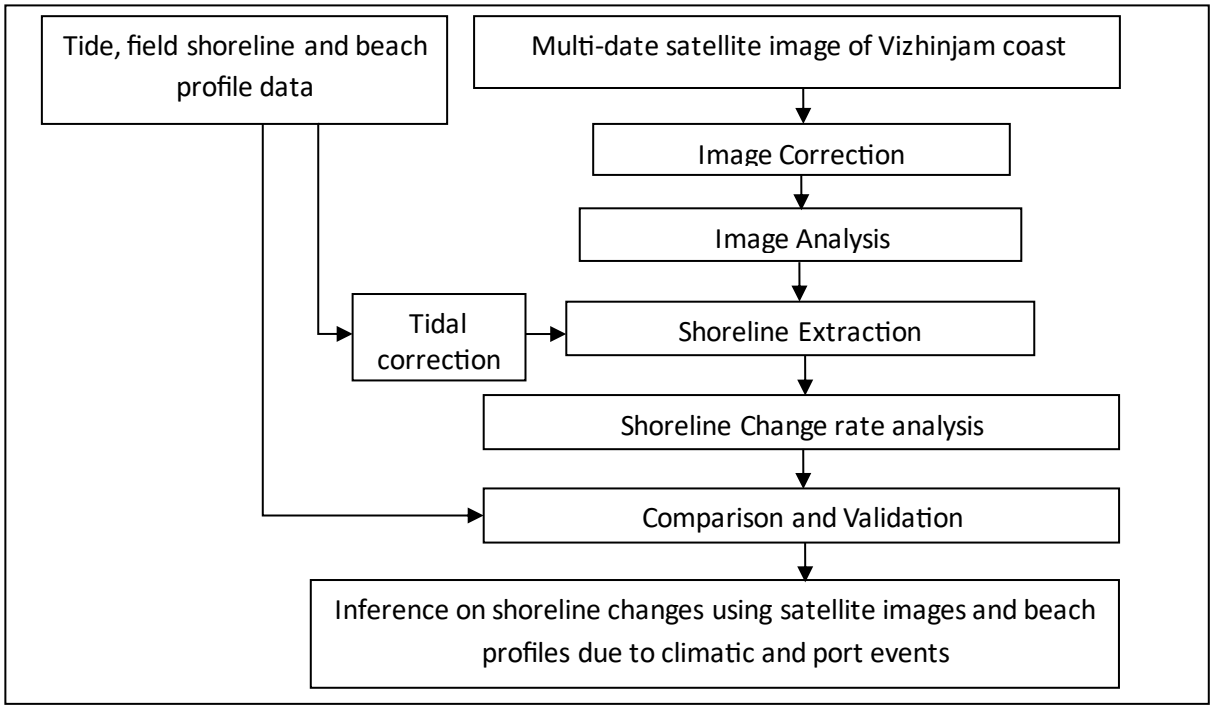

Figure 4.2 Flowchart of the methodology adopted

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.

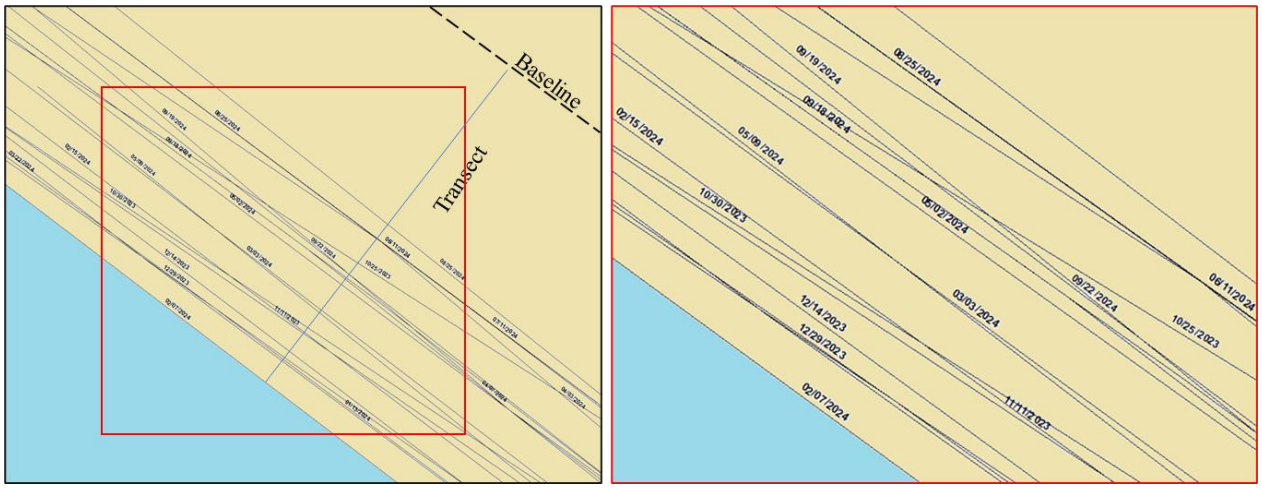

Figure 4.3 Estimation of Short-Term Shoreline Change (EPR)

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.

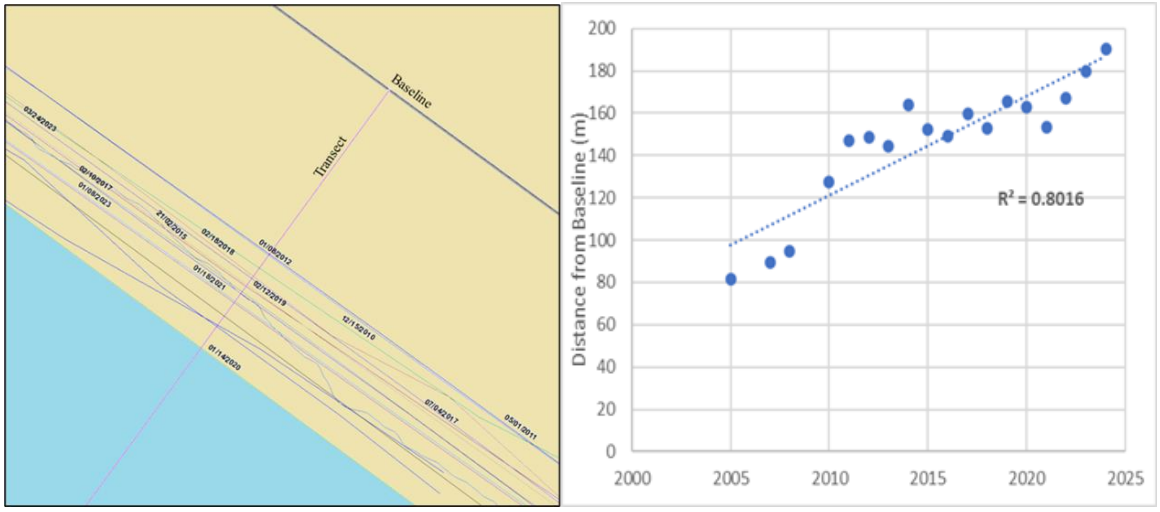

Figure 4.4 Estimation of Long-Term (LRR) Shoreline Change Analysis

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 Work Flow 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.

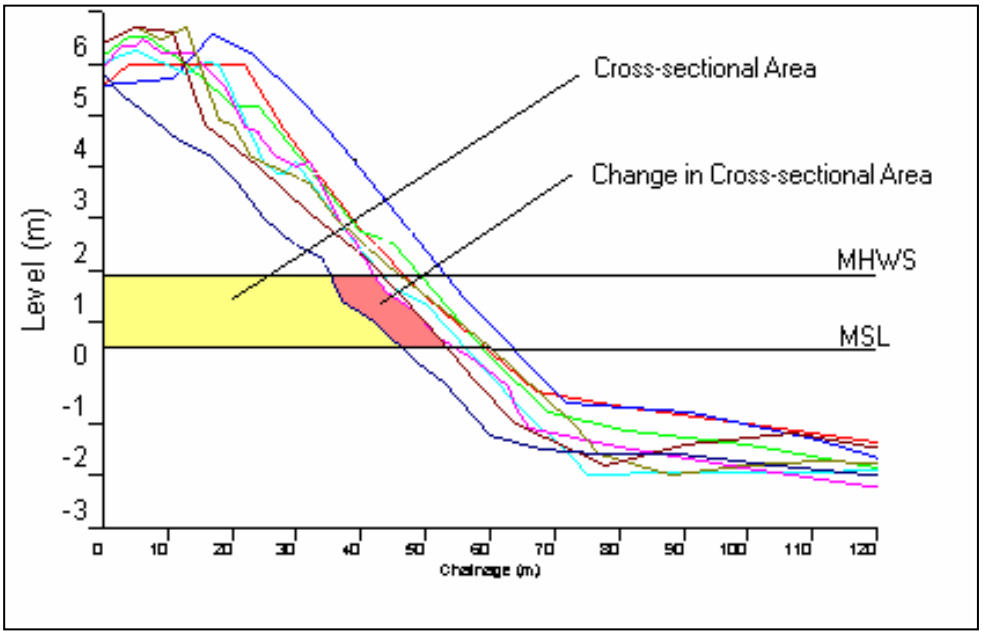

Figure 4.6 Profile Analysis by Level

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**).

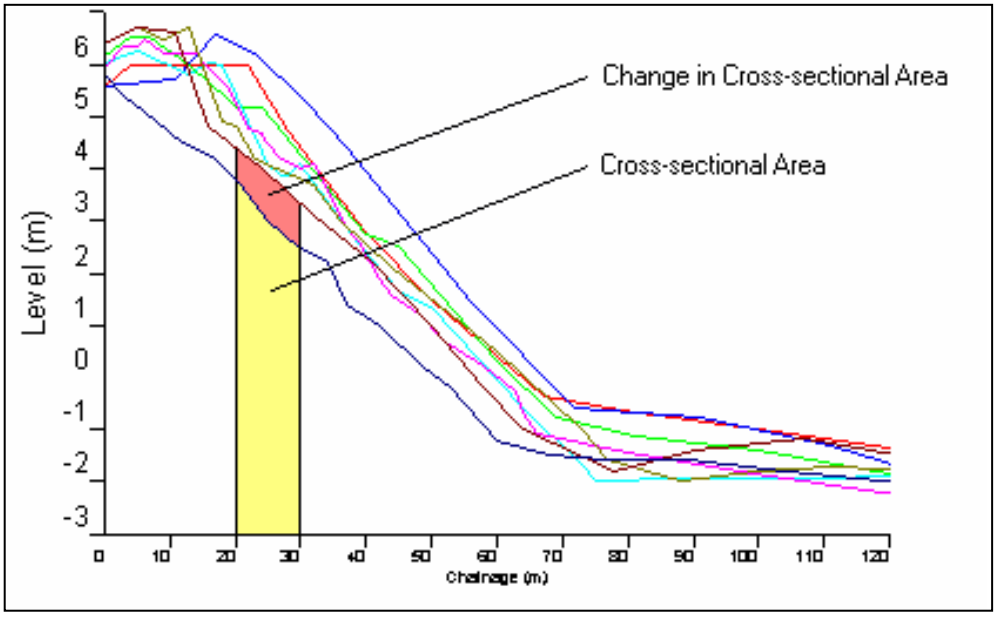

Figure 4.7 Profile Analysis by Chainage

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 2023 to September 2024 are listed in Table 4.3. Sediment samples were collected seasonally at the cross-shore profile locations. Water quality (Turbidity and TSS carried out at 4 locations for March 2023). Vetting of Reports on data analysis and model studies for Vizhinjam Port using data collected by AVPPL (October 2023 to September 2024) 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 2024 and periodic review and suggestions are being provided to the survey agency appointed by AVPPL. On 8th February 2024, the survey conducted by the designated survey agency underwent verification by engineers from the National Institute of Ocean Technology (NIOT). After the examination, 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 2023 to September 2024

Sl no.	Parameters	Post monsoon (October 2023 -January 2024)				Pre monsoon (Feb 2024-May 2024)				SW Monsoon (June 2024- September 2024)			
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	Wave (1 location)	×	×	×	✓	✓	✓	✓	✓	✓	✓	✓	×
2	Tide (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	Met (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	Current data from WRB	×	×	×	×	×	×	✓	✓	✓	✓	✓	×
5	Bathymetry	✓(Jan)				✓(Jun) Partially survey 34%				×			
6	Beach Profile (81 locations)	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*
7	Turbidity	×	×	×	×	×	×	×	×	×	×	×	×
8	Water sample (TSS, Salinity and Temp)	×				✓(May)				×			
9	Grain size(81 locations)	✓(Jan)				✓(May)				×			
10	LEO (81 locations)	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*
11	Shoreline monitoring	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*
12	Photo documentation	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*	✓*
13	Near Shore Survey	✓ (CSP68,69, 73,74)	×	×	×	×	×	✓ (CSP33,34, 73)	×	×	×	×	×
*(no data at 23-33), Buoy drifted on 4th October 2023 and redeployed on 21st December 2023, Buoy drifted on 24th August 2024 and redeployed on 8th October 2024													

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 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 respective to x and y coordinates
2. A data set which 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 has been 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 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.

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 ADCP's current data was analysed using standard oceanographic methods and analysis techniques using the software used by the surveying agency. These include standard visualisation techniques, pre- and post-calibration at the lab, time series, statistical methods, and numerical analysis. The ADCP quality control checks, correlation test, false target rejection test and error velocity test.

The data copied at buoy internal memory was downloaded at the end of retrieval and verified against the real-time data for any missing part. Wave data was processed using the manufacturer's software package after downloading to the field PC. Wave parameters like Significant wave height, period, maximum wave height and wave direction were tabulated against time. Data gaps, Spikes or improbable data were verified and removed. As the present directional wave rider buoy works based on the GPS principle, the calibration of the buoy is not required.

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 results submitted.

4.9 Tidal Observations

The Valeport Tidemaster Automatic Tide Gauge (ATG) was installed at the CoastGuard jetty inside the fishing harbour 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. On 28th May 2024, the ATG was relocated to the berth area inside the Vizhinjam Adani Seaport as the tide gauge which was installed at the Coast Guard Jetty, got damaged when a barge hit it. The AWS was relocated to the sub-station building on 3rd July 2024, as the Port Office building on which it was installed was being converted to an Immigration Check Post. 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 6.06m below the jetty top, corresponding to a correction factor of 2.373m. The tides observed are mixed semi-diurnal. The tide observation from October 2023 to September 2024 is presented below.

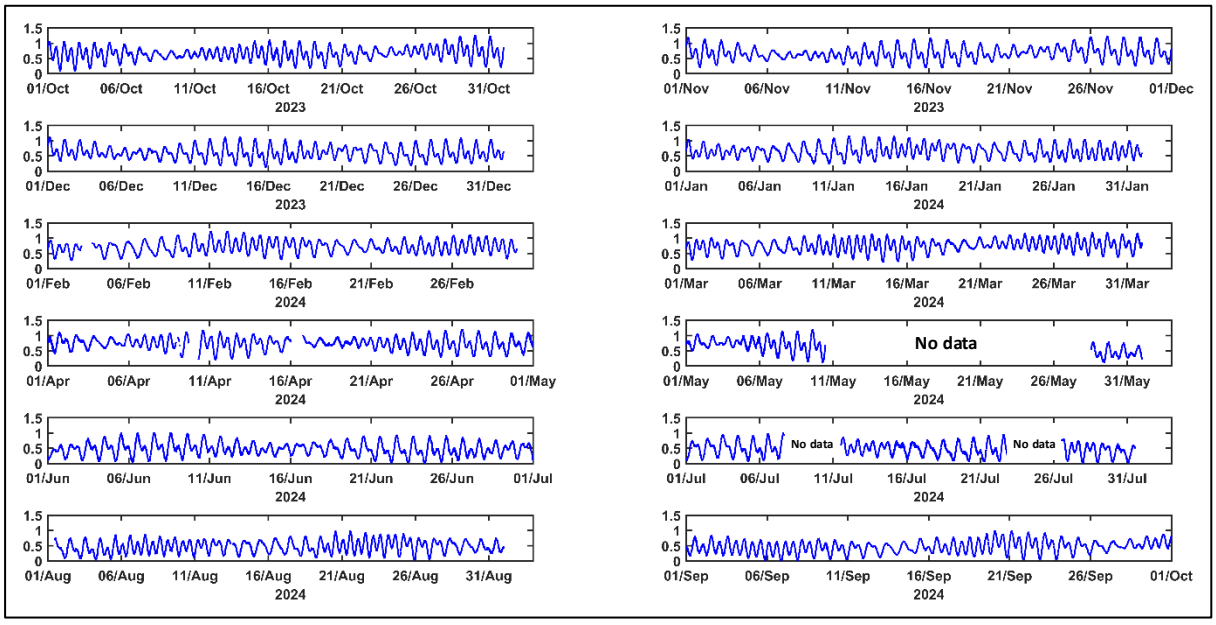

Figure 4.8 Tide observation from October 2023 to September 2024.

4.10 Wave Observations

Time series for the different wave parameters- Hs, Tp and Dir, during the observation period from October 2023 to September 2024 are given in Figure 4.9. Significant data gaps exist due to WRB drift from its location: on 4th October 2023, the buoy drifted and redeployed on 21st December 2023. Further, the buoy drifted on 24th August 2024 and was redeployed on 8th October 2024. During the fair-weather season, the sea state remains relatively calm, with an average Hs of 0.75m. The maximum Hs of 1.74 m was observed on 31st March 2024. In contrast, the Hs during

the monsoon seasons is higher, with an average of 1.78 m and a maximum of 3.30 m reported on 21st August 2024. The pre-monsoon season is characterised by moderate sea conditions, with an average Hs of 1.21 m, but a maximum of 3.35 m) was observed on 30th May 2024 during Severe Cyclonic Storm Remal in the BoB. The minimum Hs observed during the study period was 0.38 m on 19th January 2024. 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 4.26 s (during the pre-monsoon season) and 5.56 s (during the monsoon season).

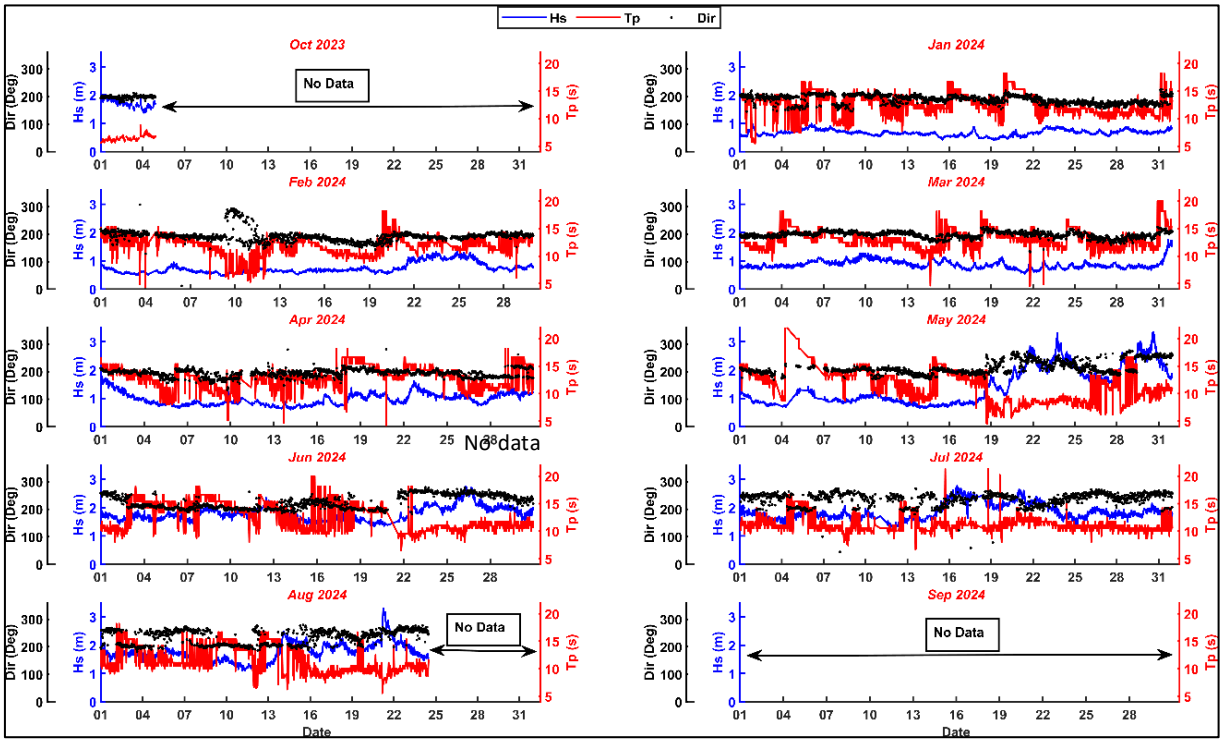

Figure 4.9 Wave observation from October 2023 to September 2024.

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 2023 to September 2024 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), 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 2023 to September 2024, and beach volume changes between October 2022-October 2023, February 2023- February 2024, May 2023-May 2024 and September 2023-September 2024 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 2023 to September 2024, it was found that beaches exhibited 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) while 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). There is no data from CSP23-30. Due to rough sea conditions, the offshore survey was not carried out in any locations from September 2023 and May 2023 to September 2024. 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 2023 to September 2024 shows 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)while accretion is noticed 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).

The shoreline changes using field shoreline data from October 2023 to September 2024 shows erosion at Poovar (CSP15-19, 21), Karumkulam (CSP22), Adimalathura (CSP-34), Mullur (CSP36-37), Kovalam (CSP45-46), Pannathura (CSP48), Punthura (CSP55,57), Valliyathura (CSP63,67), Shanmugham (CSP70-71), Kochuveli (CSP77), Thumba (CSP81) while accretion is noticed at Edapadu beach (CSP01, 03), Vallavilay to Neerody (CSP04-09), Azhimala (CSP35), Kovalam (CSP41-44), Punthura (CSP53-54, 57), Shangumugham (CSP68-69), Vettucaud (CSP72-74), Kochuveli (CSP75-76) and Valliyaveli (CSP78)—no field data from CSP23 to CSP30.

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 2024 using high-resolution satellite images shows erosion at Poovar South (CSP14-17), Adimalathura (CSP32-33), Kovalam (CSP44), Valliyathura to Kochuveli (CSP63-76) and Thumba (CSP79-80) while Poovar North to Pullavila (CSP18-32), Punthura (CSP53-55) shows stable. Figure 5.1 shows the shoreline change results from 2012 to 2015 and 2015 to 2024, 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 2024. 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 are listed in Table 5.1.

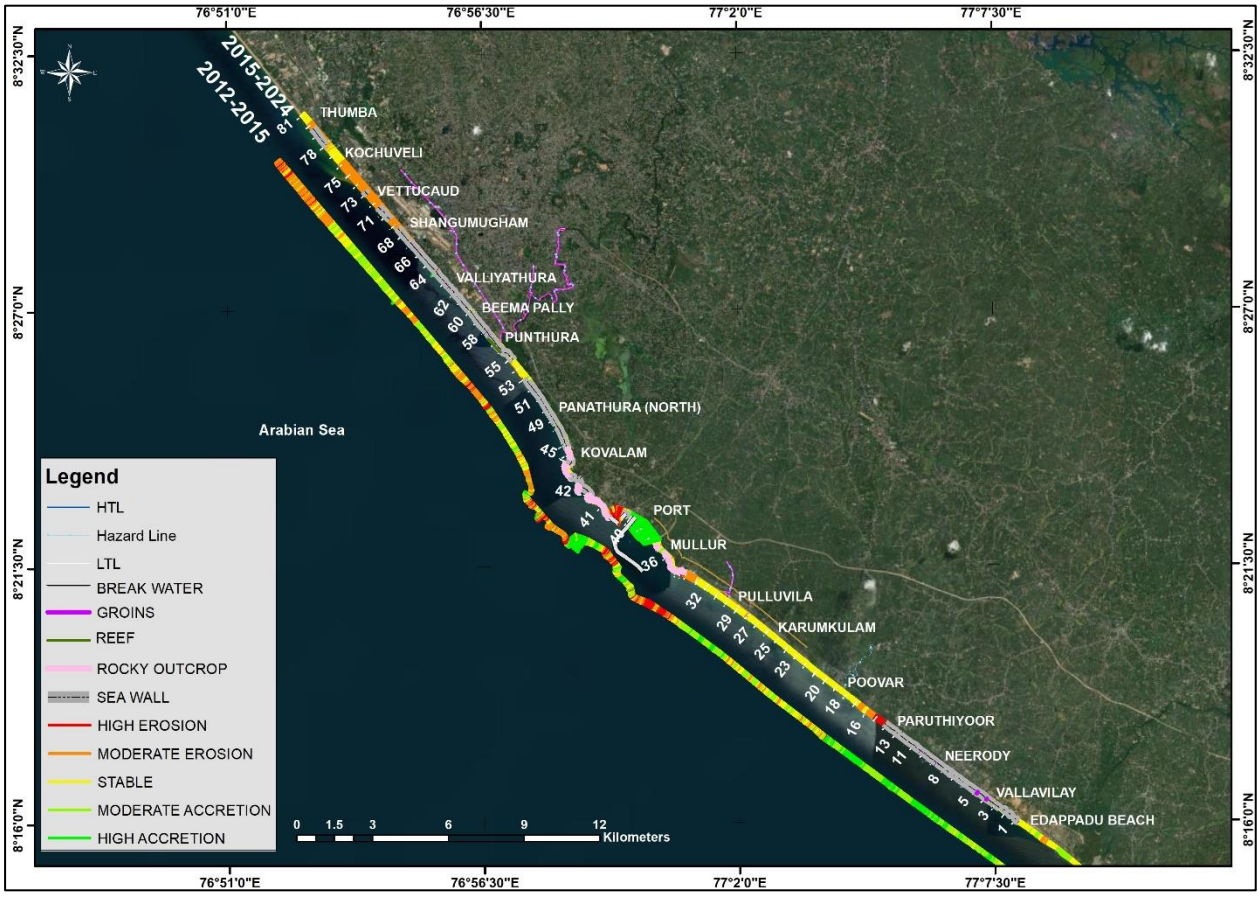

Figure 5.1 Shoreline Change Analysis for the period 2012 to 2015 and 2015 to 2024 using high-resolution satellite images

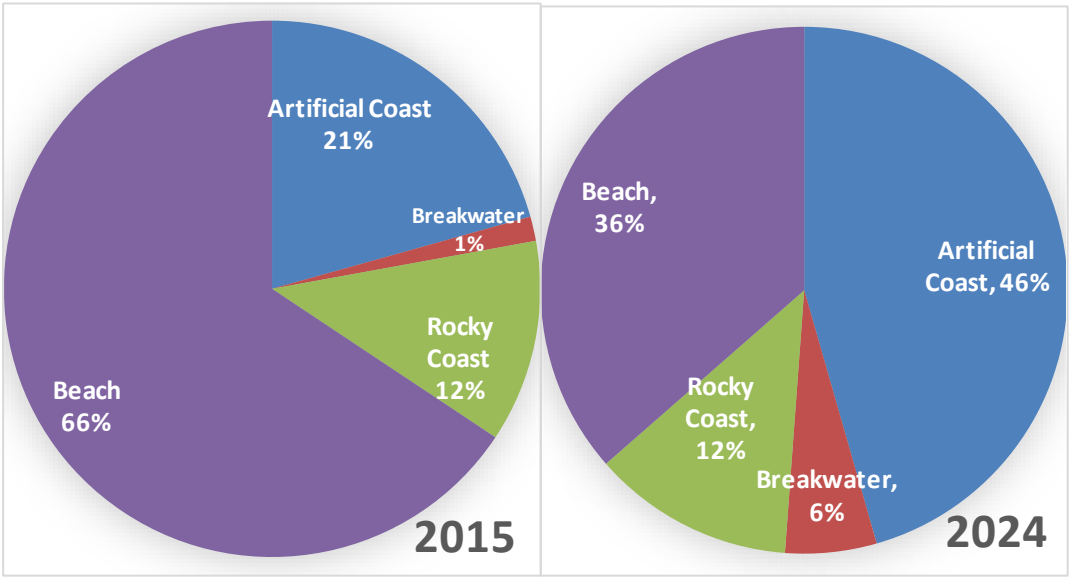

Figure 5.2 Pie chart showing artificial coast (seawall, groynes), rocky coast, breakwater and beach in 2015 and 2024.

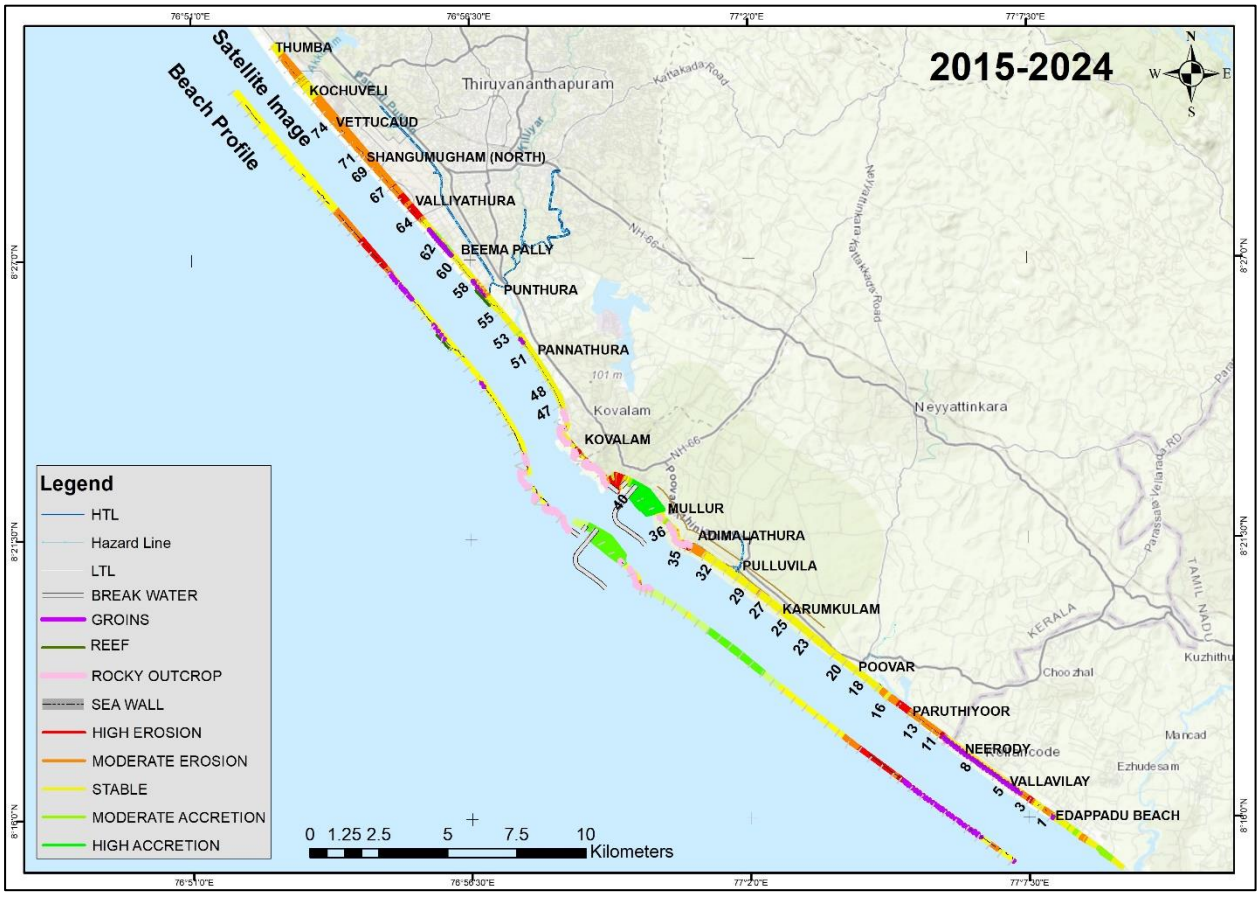

Figure 5.3 Shoreline Change Analysis for the period February 2015 to February 2024 using high-resolution satellite images and beach profile (onshore) data

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 2024.

	From Satellite image analysis	From Beach profile analysis-Onshore
Erosion spots	Edapadu beach (CSP01,03), Poovar (CSP14-15), Azhimala (CSP34-35), Kovalam (CSP44), Punthura (CSP57), Valliyathura to Shangumugham (CSP63-75), Thumba (CSP79-80)	Edappadu Beach (CSP03), Poovar (CSP11-16), Azhimala (CSP 35), Kovalam (CSP42), Valiyathura to Shangumugham (CSP63-69)
Accretion spots	Mullur (CSP36-37), Panathura north (CSP53), Cheriyathura (CSP61-62)	Vallavilay to Pozhiyoor (CSP06-10), Adimalathura to Karumkulam (CSP23-34), Cheriyathura (CSP61-62)
Stable spots	Edapadu beach (CSP02), Vallavilay to Pozhiyoor (CSP04-10), Poovar to Adimalathura (CSP16-32), (CSP43-52), Beemapally (CSP58-60), Valliyaveli and Thumba (CSP77-78,81)	Edapadu beach (CSP01-02), Vallavilay (CSP04-05), Poovar to Karumkulam (CSP17-22), Kovalam to Beemapally (CSP43-60), Shangumugham to Thumba (CSP70-81)

The trend analysis from 2000 to 2024 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 2015-2024) as shown in Table 5.2 and yearly erosion spots from 2018 to 2024 in Table 5.3.

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

2000-2005	2005-2010	2010-2015	2015-2020	2020-2024
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
Kochuveli	Thumba to Vettucaud	Kochuveli Cheriyathura	Thumba to Kochuveli	Thumba to Kochuveli	Thumba to Kochuveli
Shangumugham	Shangumugham	Shangumugham	-	Shangumugham	Shangumugham
Valliyathura	Valliyathura	Valliyathura	Valliyathura	-	Valliyathura
Punthura	Punthura	Punthura	Punthura	-	Punthura
Pulluvila to Edapadu	Karumkulam to Edapadu	Pulluvila	-	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 2024 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. Post-Ockhi, groynes along the Thiruvananthapuram coast helped accumulate sediment on their updrift sides. However, sediment starvation occurred downdrift, exacerbating erosion in some areas. Similar patterns were observed, with groynes facilitating localised sediment recovery, but the rapid wave action during Tauktae left minimal sediment available for natural replenishment in downdrift zones. Post-Ockhi and Tauktae seawalls caused increased turbulence at their base, limiting sediment deposition in front of the structures, and may have shifted sediments to deeper offshore zones. Beaches without structures gradually regained sediments during calmer post-cyclone conditions.

During this annual study period from October 2023 to September 2024, Indian National Centre for Ocean Information Services (INCOIS) warning was issued on 3rd May 2024, on long period swells combined with high tide conditions causing coastal flooding from 4th to 5th May 2024 and Indian Meteorological Department (IMD) and INCOIS have issued an advisory for the Thiruvananthapuram coast, covering the stretch from Kappil to Poovar. Forecasts indicate surface ocean currents with speeds ranging from 0.5 to 0.7 m/s between 16:00 hours on August 31, 2024, and 04:00 hours on September 1, 2024. High waves, reaching heights of 2.3 to 2.4 meters, were expected from 17:30 hours on August 31, 2024, to 23:30 hours on September 2, 2024. Additionally, swell waves with periods of 12.0-13.0 seconds and heights of 1.7-1.8 meters were anticipated between 17:30 hours on August 31, 2024, and 11:30 hours on September 2, 2024. The impact of the swell and high wave energy on the coast is seen in the monthly shoreline changes of June 2024.

The analysis of shoreline changes along the Vizhinjam coast highlights the significant influence of seasonal variations driven by monsoon currents, wave characteristics, and wind patterns. From December 2023 to September 2024, ocean currents predominantly flowed southeastward,

influenced by the northeast and southwest monsoons. Peak current speeds during January (98.1 cm/s) and July (91.2 cm/s) reflected high-energy conditions, while slower currents in March and April suggested transitional phases. These variations impact sediment transport and shoreline dynamics, with strong monsoonal currents contributing to erosion near coastal structures. The absence of data in September 2024 leaves uncertainty regarding post-monsoon recovery, underscoring the need for continuous monitoring and strategic shoreline management.

Wave data from December 2023 to August 2024 revealed seasonal changes driven by monsoon activity. Wave heights ranged from 0.99 m in January to a peak of 3.35 m in May, indicating higher wave energy during the southwest monsoon. Wave direction shifted from south-southwest in pre-monsoon months to southwest during the monsoon, reflecting the influence of wind-driven swells. Shorter wave periods during May 2024 – August 2024 suggested steep, high-energy waves, while longer periods before the monsoon indicated swell-dominated waves from distant storms. These variations highlight the high-energy nature of the coast during the monsoon, contributing to erosion, sediment transport, and pressure on coastal structures, requiring mitigation measures to protect shoreline stability.

Wind patterns also play a crucial role in shaping coastal processes. Landward winds showed moderate to high speeds, peaking at 7.92 m/s in October, with directionality from the northeast to east. These winds contributed to stable conditions during non-monsoon months. Conversely, stronger seaward winds, peaking at 13.58 m/s in May and June, intensified wave energy and erosion during the monsoon. Seasonal wind shifts exacerbated erosion risks during the monsoon while promoting stabilization during calmer post-monsoon periods. This seasonal variability in wind strength and direction directly influenced sediment transport and shoreline changes, emphasizing the need for proactive coastal management strategies.

Alongshore currents further influenced sediment dynamics. Northward-directed currents during non-monsoon months (October–May) recorded higher speeds, particularly at Poovar Beach South and Vettucaud, contributing to northward sediment transport. In contrast, southward currents during the monsoon (June–September) were less intense, promoting relative stability. These variations caused erosion in northern areas due to stronger northward currents and more stable conditions in southern regions, emphasizing the complex interplay between currents and shoreline processes.

Sediment analysis in April 2024 revealed a dominance of sand, with median grain sizes indicating coarse and medium sand fractions. Coarser sand samples were associated with higher-energy areas, while medium sand reflected calmer conditions. Seasonal sediment composition shifts aligned with wave energy changes and monsoonal influences. Sampling limitations due to inaccessible locations and local protests left data gaps, highlighting challenges in monitoring sediment transport patterns. The results emphasize the dynamic nature of sediment deposition and erosion, shaped by hydrodynamic forces and seasonal changes.

Rainfall data further corroborated these patterns, with heavy monsoon rainfall (May–July) contributing to increased runoff and sediment flux, amplifying erosion risks. Conversely, lower rainfall during fair-weather months (January–March) promoted accretion and shoreline stabilization. These hydrological patterns directly influenced sediment availability and transport, impacting erosion and deposition trends.

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.

Further, the dredging activities that took place from October 2023 to March 2024 , particularly at CSPs 38, 39, and 40 by using a Cutter Suction Dredger (CSD) and at CSP 36 (March 2024), along with the Trailing Suction Hopper Dredger (TSHD) operations between CSP 30 to 35 during January and February 2024. No dredging carried out from April to September 2024. Dredging leads to removing finer sediments and replacing them with coarser materials, as seen in the beach sample data. The increased presence of coarser sand, especially during this period, suggests that dredging materials were likely deposited on the beach, altering its texture and possibly contributing to changes in beach morphology and sediment characteristics. This could significantly affect coastal erosion/accretion, sediment transport, and shoreline stability. Rainfall patterns and seasonal changes in wave activities might have further influenced the shoreline. The construction of a breakwater from 2349m to 2975m in length was completed from October 2023 to March 2024, thereby completing the entire port breakwater. While the most immediate effects are confined to a few kilometres around the Port site, the longer-term redistribution of sediments and influence on coastal morphology requires continuous monitoring and sediment analysis to assess these impacts and inform coastal management strategies.

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 highlight the need for continuous monitoring, sediment management, and erosion control strategies to safeguard the coast against long-term changes.

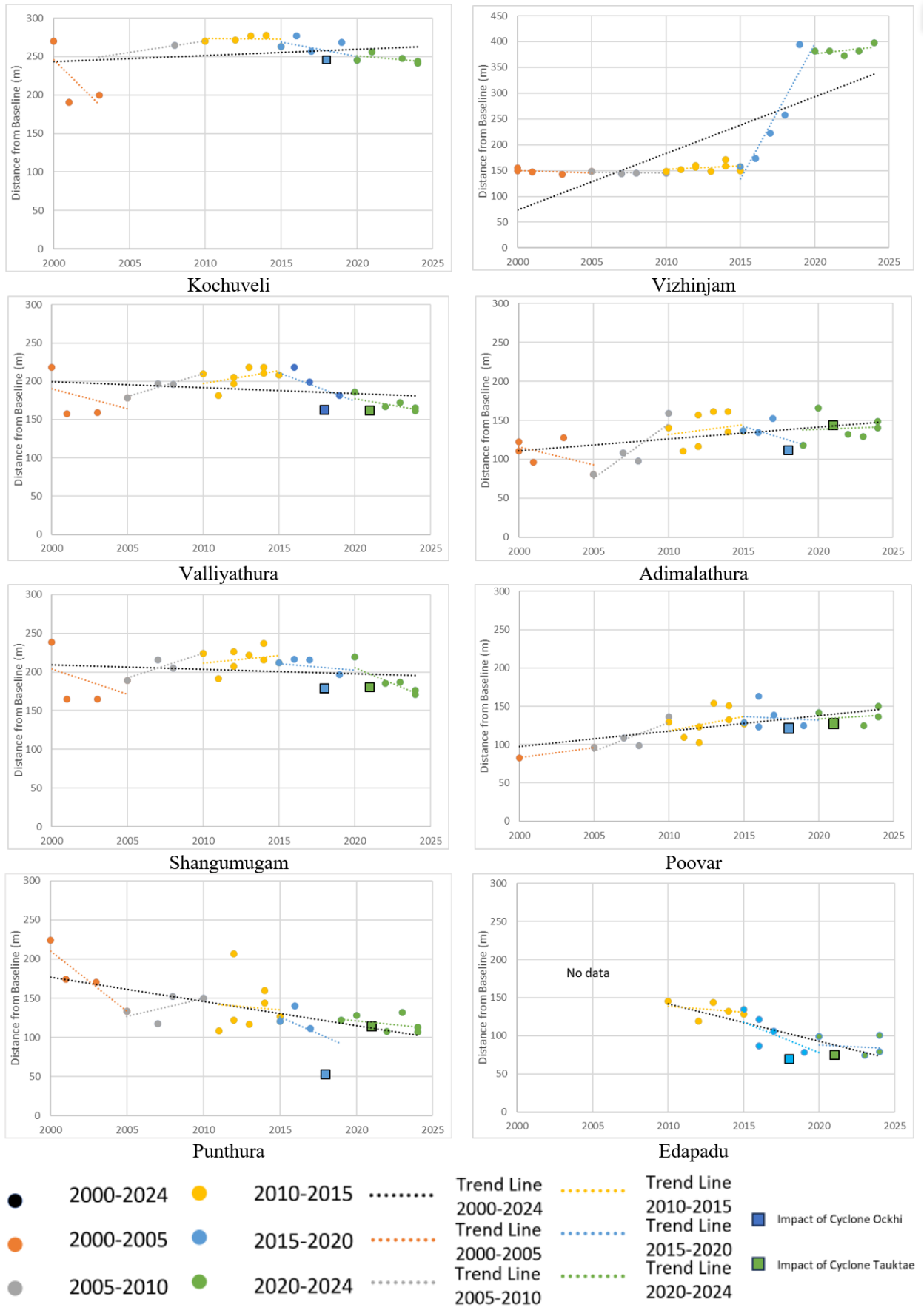

Figure 5.4 Trend analysis of shoreline change distance from baseline from 2000 to 2024 and trends before and after 2015

Validation and Comparison

The shoreline change was validated by comparing shoreline changes derived from two months (February 2023 to February 2024) of satellite data with those obtained from available beach profile measurements and field-collected shoreline data (35 profiles out of 81). The beach profile data at every 500m interval and field shoreline data collected using the Digital Global Positioning System (DGPS) are used for validation. The Shoreline change calculated from the satellite images for the two months is compared with the shoreline derived from the field data of the corresponding tide level of beach profile data, shown in Figure 5.5. The regression coefficient (R2) of 0.872 is achieved when compared with the shoreline change derived from the beach profile data, whereas 0.96 is achieved with the field shoreline data. This comparison evaluates the accuracy of capturing shoreline dynamics.

Several institutes and organizations have conducted shoreline change analysis studies along the Thiruvananthapuram coast, utilizing satellite imagery and tools such as the Digital Shoreline Analysis System (DSAS) are listed in Table 5.4. SAC (2014) analyzed High Water Line (HWL) data from 1989-1991 and 2004-2006 while SAC (2021) report studied 2004-2006 and 2014-2016, incorporating field observations for accuracy. INCOIS (2012) used Landsat TM and IRS P6 LISS III imagery (1992-2011) to estimate shoreline change rates, classifying changes into categories ranging from high erosion (<-5m/year) to high accretion (>5m/year). NCSCM (2010) conducted a 38-year study (1972-2010) and categorized 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 2024, 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, emphasizing the need for ongoing monitoring and targeted coastal management strategies to address erosion and stabilize vulnerable areas.

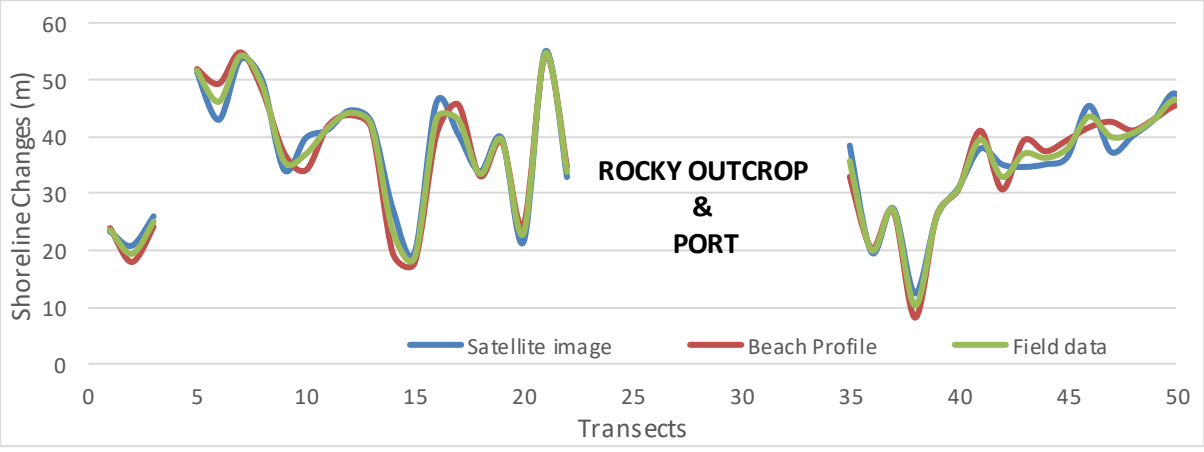

Figure 5.5 Comparison of shoreline changes estimated from the satellite images, beach profiles and field data at 500m intervals.

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 1992-2011 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, seasons from October 2023 to September 2024

Month Year	Erosion/ Accretion	From Satellite image analysis	From Beach profile analysis-Onshore	From Field Shoreline analysis
October 2023	Erosion spots	Edappadu beach (CSP01), Vallavilay (CSP04), Poovar (CSP16-18), Karumkulam (CSP25), Mullur (CSP36-37), Kovalam (CSP45-46), Panathura (CSP49), Punthura (CSP53-54, 57), Valliyathura (CSP64-65), Shangumugham (CSP68-69), Vettucaud to Thumba (CSP74-81)	Neerody (CSP09), Poovar south (CSP15,17), Valiyathura (CSP64A), the area from Shangumugham south to Shangumugham north (CSP68-71), and from Vettucaud to Thumba (CSP73-81).	Edappadu beach (CSP01), Pozhiyur (CSP10), Poovar beach (CSP16), Kovalam, (CSP 42,44,46), Punthura (CSP53-54), Valliyathura (CSP64) and Valliyaveli (CSP78).
	Accretion spots	Edapadu (CSP02), Vallavilay (CSP05), Neerody (CSP07), Pozhiyur (CSP11-12), Poovar (CSP15-16), Poovar North to Karumkulam (CSP19-24), Pulluvila to Adimalathura (CSP27-34), Kovalam (CSP42-44), Punthura (CSP55-56), Beemapally to Cheriyathura (CSP59-62), Vettucaud (CSP72-73).	Edappadu beach (CSP02), Vallavilay (04-05), Neerody (CSP07,08), Pozhiyoor (CSP10), the stretch from Poovar to Karumkulam (CSP18-22), Mullur (CSP36,37), Kovalam (CSP40A), Kovalam (CSP43-46), Punthura (CSP53,54), Beemapally (CSP60), Cheriyathura (CSP62), and Vettucaud (CSP72).	Vallavilay (CSP05), Poovar beach (CSP15, 18-19), Mullur (CSP36-38), Punthura (CSP55), Beemapally (CSP60), Cheriyathura (CSP62), Valliyathura (CSP67), Shanguham to Kochuveli (CSP67-77) and Thumba (CSP81). No data from CSP23 to CSP35.
November 2023	Erosion spots	Pannathura (CSP48, 51), Punthura (CSP54-56), Valiyathura (CSP 63-64, 67), Kochuveli (CSP 76), Valiyaveli (CSP79), and Thumba (CSP80-81)	Edappadu beach (CSP02), Pozhiyoor (CSP10), Poovar (CSP19), Karumkulam (CSP22), Kovalam (CSP45-46), Punthura (CSP54), Beemapally (CSP60), Cheriyathura (CSP62), Vettucaud (CSP72,74), and the section from Kochuveli to Thumba (CSP76-81).	Poovar (CSP15, 18), Mullur (CSP36-37), Punthura (CSP53-54). No data from CSP23 to CSP35.
	Accretion spots	Edapadu to Adimalathura (CSP01-35), Kovalam (CSP42-44), Punthura (CSP57), Beemapally (CSP59-60), Cheriyathura (CSP 61-62), Shangumugham (CSP68-69),	Vallavilay (04-05), Neerody (CSP07-09), Poovar south (CSP15), Poovar north (CSP20-21), Adimalathura (CSP34), the stretch from Adimalathura to Mullur (CSP35A-37), Kovalam (CSP40A),	Edapadu (CSP02), Vallavilay to Neerody (CSP04-09), Pozhiyur (CSP10), Poovar (CSP16, 20-21), Karumkulam (CSP22), Adimalathura (CSP34), Azhimala

		Kochuveli (CSP77), Valiyaveli (CSP78).	Kovalam (CSP42-44), Punthura (CSP53), Valiyathura (CSP64A), the area from Shangumugham south to Shangumugham north (CSP68-71), Vettucaud (CSP73), and Kochuveli (CSP75).	(CSP35), Kovalam (CSP42-44, 46), Beemapally (CSP58), Cheriyathura (CSP61-62), Valliyathura to Valliyaveli (CSP67-78).
December 2023	Erosion	Edapadu (CSP01), Neerody (CSP08-09), Pozhiyur (CSP11-12), Paruthiyoor (CSP14), Poovar South (CSP15-16), Poovar North (CSP20), Pulluvila (CSP27), Mullur (CSP36), Beemapally (CSP60), Valliyathura (CSP66), Shangumugham (CSP68-71), Vettucaud (CSP72, 74), Thumba (CSP79-81)	Vallavilay (CSP05), Neerody (CSP07-08), Poovar south (CSP15), Poovar South to Poovar (CSP17-18), Kovalam (CSP40A), Kovalam (CSP43,45,46), Punthura (CSP55), Cheriyathura (CSP62), Valliyathura to Shangumugham south (CSP67-69), Shangumugham north (CSP71), Vettucaud (CSP73), Kochuveli (CSP75), Valiyaveli (CSP78).	Vallavilay (CSP04), Poovar (CSP15-16), Cheriyathura (CSP61), Valliyathura to Shangumugham (CSP67-70), Kochuveli (CSP76).
	Accretion spots	Edapadu (CSP03), Vallavilay (CSP04-06) Pulluvila to Adimalathura (CSP28-34), Azhimala (CSP35), Mullur (CSP37), Kovalam (CSP42-47), Pannathura (CSP50-52), Punthura (CSP53-54), Vettucaud (CSP73), Kochuveli (CSP75), Valliyaveli (CSP78).	Edappadu beach (CSP02), Vallavilay (CSP04), Neerody to Pozhiyoor (CSP09-10), Poovar south (CSP16), Poovar to Karumkulam (CSP19-22), Kovalam (CSP42,44), Punthura (CSP53), Beemapally (CSP60), Valliyathura (CSP64A), Shangumugham north (CSP70), Vettucaud (CSP72,74), Kochuveli (CSP76,77), Valiyaveli to Thumba (CSP79-81).	Edapadu (CSP02), Neerody (CSP07), Poovar (CSP17-18), Adimalathura (CSP34), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP42-43), Punthura (CSP54), Valliyaveli (CSP78).
January 2024	Erosion spots	Edapadu (CSP02-03), Neerody (CSP07), Poovar (CSP17), Karumkulam (CSP22-23), Mullur (CSP37), Pannathura (CSP48-52), Punthura (CSP53), Valliyathura (CSP63, 67), Shangumugham (CSP68-69), Thumba (CSP80)	Neerody (CSP09), Poovar North (CSP21), Mullur (CSP37), Kovalam (CSP40A), in Kovalam (CSP42-45), from Shangumugham South to Vettucaud (CSP69-72), between Vettucaud and Kochuveli (CSP74-77), and from Valiyaveli to Thumba (CSP79-81).	Poovar (CSP16-18)
	Accretion spots	Edapadu (CSP01), Vallavilay (CSP04-06), Neerody (CSP08-09), Pozhiyur (CSP11), Poovar (CSP15-21), Karumkulam (CSP25-26), Pulluvila to Adimalathura (CSP27-34),	Edappadu beach (CSP02), Vallavilay (CSP04-05), Neerody (CSP07-08), Pozhiyoor (CSP10), between Poovar South and Poovar North (CSP15-20), Karumkulam (CSP22), from Adimalathura	Edapadu (CSP01), Vallavilay (CSP04), Adimalathura (CSP33-34), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP44-46), Punthura (CSP53), Beemapally to

		Azhimala (CSP35), Kovalam (CSP41-47), Pannathura (CSP48-52), Punthura (CSP55-56), Beemapally to Cheriyathura (CSP59-61), Valliyathura (CSP66), Vettucaud (CSP73).	to Mullur (CSP31-36), Kovalam (CSP46), Punthura (CSP55), Beemapally (CSP60), Cheriyathura (CSP62), Valliyathura (CSP64A), from Valliyathura to Shangumugham South (CSP67-68), Vettucaud (CSP73), and Valiyaveli (CSP78).	Cheriyathura (CSP60-61), Valliyathura to Thumba (CSP67-81).
February 2024	Erosion spots	Edapadu (CSP01,03), Vallavilay (CSP04-05), Neerody (CSP08), Pozhiyoor (CSP11-12), Poovar (CSP15), Pulluvila (CSP27), Mullur (CSP36), Kovalam (CSP44-47), Pannathura (CSP48,50), Punthura (CSP53), Cheriyathura (CSP61), Shangumugham (CSP71), Vettucaud (CSP72), Valliyaveli (CSP79), Thumba (CSP80).	Edappadu beach (CSP02), Vallavilay (CSP04-05), the segment from Neerody to Pozhiyoor (CSP08-10), Poovar South (CSP16), Poovar (CSP18-19), the area from Poovar North to Karumkulam (CSP21-22), Adimalathura (CSP33), Mullur (CSP36), Kovalam (CSP40A,42,45), Beemapally (CSP60), Valliyathura (CSP64A), the stretch from Shangumugham South to North (CSP68-71), Vettucaud (CSP73), and Thumba (CSP81).	Vallavilay (CSP04), Punthura (CSP53), Cheriyathura (CSP61-62), Valliyathura (CSP63), Kochuveli (CSP75, 77), Valliyaveli (CSP78-79), Thumba (CSP81).
	Accretion spots	Neerody (CSP07), Pozhiyur (CSP10), Poovar (CSP18), Karumkulam (CSP22-24), Pulluvila (CSP29), Adimalathura (CSP33), Kovalam (CSP41-43), Punthura (CSP54,57), Cheriyathura (CSP62), Valliyathura (CSP63,66), Shangumugham (CSP68-69), Valliyaveli (CSP78), Thumba (CSP81).	Neerody (CSP07), Poovar South (CSP15,17), Poovar North (CSP20), Adimalathura (CSP31-32), the stretch from Adimalathura to Azhimala (CSP34-35A), Mullur (CSP37), Kovalam (CSP43-44,46), Punthura (CSP54,55), Cheriyathura (CSP62), Valliyathura (CSP67), Shangumugham South (CSP69), Vettucaud (CSP72), and the area from Vettucaud to Thumba (CSP74-80).	Poovar (CSP18), Adimalathura (CSP34), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP41-43), Punthura (CSP54-56).
March 2024	Erosion spots	Poovar (CSP17-19), Pulluvila (CSP29), Adimalathura (CSP31), Mullur (CSP33-34), Kovalam (CSP44-47), Pannathura (CSP51), Punthura (CSP53-56), Beemapally (CSP60), Valliyathura (CSP64,66), Vettucaud (CSP73-74)	Poovar south (CSP17), Adimalathura (CSP32-33), Azhimala to Mullur (CSP35A-36), Kovalam (CSP44), Punthura (CSP55), Beemapally (CSP60), Valliyathura (CSP67), Shangumugham north to Vettucaud (CSP71-72), Kochuveli (CSP75), Valiyaveli (CSP78), Thumba (CSP80-81).	Poovar (CSP15,18), Punthura (CSP57)

	Accretion spots	Poovar (CSP17-19), Pulluvila (CSP29), Adimalathura (CSP31), Mullur (CSP33-34), Kovalam (CSP44-47), Pannathura (CSP51), Punthura (CSP53-56), Beemapally (CSP60), Valliyathura (CSP64,66), Vettucaud (CSP73-74)	Edappadu beach (CSP02), Vallavilay (CSP04-05), Neerody to Pozhiyoor (CSP09-10), Poovar South (CSP15-16), Poovar to Karumkulam (CSP18-22), Adimalathura (CSP31), Adimalathura to Azhimala (CSP34-35), Mullur (CSP37), Kovalam (CSP40A,42-43,45-46), Punthura (CSP54), Cheriyathura (CSP62), Valliyathura (CSP64A), Shangumugham south to Shangumugham north (CSP68-70), Vettucaud (CSP73-74), Kochuveli (CSP76-77), Valiyaveli (CSP79).	Edappadu beach to Poovar (CSP01-14, 20-21), Adimalathura (CSP33-34), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP42-44), Punthura (CSP54-55), Beemapally to Cheriyathura (CSP60-62), Valliyathura to Valiyaveli (CSP67-79)
April 2024	Erosion spots	Edappadu beach (CSP01-02), Vallavilay (CSP04-06), Paruthiyoor (CSP13-14), Poovar (CSP15-21), Karumkulam (CSP23-26), Adimalathura (CSP31,34), Azhimala (CSP35), Mullur (CSP37), Kovalam (CSP41,44-46), Pannathura (CSP48-50), Punthura (CSP53-56), Beemapally (CSP58,60), Cheriyathura (CSP61-62), Valiyathura (CSP64-67), Shangumugham (CSP68-71), Vettucaud (CSP72-74), Kochuveli (CSP75), Kochuveli to Valiyaveli (CSP77-79) and CSP80 (Thumba).	Pozhiyoor (CSP10), Poovar South (CSP15), Poovar South to Poovar (CSP17-18), Azhimala (CSP35), Kovalam (CSP46), Beemapally (CSP60), Valliyathura (CSP64A), Valliyathura to Shangumugham south (CSP67-68), Kochuveli (CSP77).	Poovar (CSP15-18), Adimalathura (CSP34), Azhimala (CSP35), Kovalam (CSP43-46), Punthura (CSP53-54), Valiyaveli to Thumba (CSP79-81).
	Accretion spots	Edappadu Beach (CSP03), Neerody (CSP07,09), Pozhiyoor (CSP10-11), Karumkulam (CSP22), Adimalathura (CSP32-33), Mullur (CSP36), Kovalam (CSP47), Punthura (CSP57), Thumba (CSP81).	Neerody (CSP09), Poovar South (CSP16), Poovar to Karumkulam (CSP19-22), Adimalathura (CSP31-32,34), Kovalam (CSP42-45), Punthura (CSP53-55), Cheriyathura (CSP62), Shangumugham south to north (CSP68-71), Vettucaud to Kochuveli (CSP73-75), Valiyaveli to Thumba (CSP78-81).	Adimalathura (CSP33)
May 2024	Erosion spots	Edappadu beach to Pozhiyoor (CSP01-10), Poovar south (CSP17),	Pozhiyoor (CSP10), Poovar north (CSP21), Adimalathura (CSP34), Azhimala	Poovar (CSP16, 18-21), Adimalathura (CSP34), Mullur

		Poovar (CSP19), Mullur (CSP36-37), Kovalam (CSP41,47), Panathura north (CSP51-52), Punthura (CSP53-57), Shangumugham (CSP69-71), and Vettucaud to Thumba (CSP72-80).	(CSP35A), Kovalam (CSP42,45-46), Valliyathura (CSP64A), Valliyathura to Shangumugham south (CSP67-68), Shangumugham north (CSP70), Vettucaud (CSP74), Valiyaveli (CSP78), Thumba (CSP81).	(CSP36-37), Kovalam (CSP43-46), Punthura (CSP53-55), Shangumugham to Thumba (CSP69, 71-81)
	Accretion spots	Poovar North (CSP15-21), Karumkulam (CSP22,23,26), Pulluvila (CSP27-30), Adimalathura (CSP31-34), Kovalam (CSP44,46), Panathura (CSP48-49), Valiyathura (CSP64, 65, 67), Shangumugham (CSP68).	Neerody (CSP09), Poovar South (CSP15), Poovar south Poovar north (CSP17-20), Karumkulam (CSP22), Adimalathura (CSP31-32), Azhimala (CSP35), Kovalam (CSP43-44), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham south (CSP69), Shangumugham north (CSP71), Kochuveli (CSP75,77), Valiyaveli to Thumba (CSP79-80).	Poovar (CSP15, 17), Adimalathura (CSP31-33), Azhimala (CSP35), Kovalam (CSP41)
June 2024	Erosion spots	Edappadu beach (CSP02), Neerody (CSP08,09), Pozhiyoor (CSP10), Poovar (CSP15-16, 18-21), Karumkulam (CSP22-26), Pulluvila (CSP27-30), Adimalathura (CSP31-34), Azhimala (CSP35), Kovalam (CSP41-46), Panathura (CSP48, 50), Punthura (CSP53,55), Beemapally (CSP58, 60), Cheriyathura (CSP61-62), Shangumugham (CSP68, 70), Vettucaud to Thumba (CSP72-81).	Pozhiyoor (CSP10), the area from Poovar south to Poovar (CSP15-19), Mullur (CSP36-37), Kovalam (CSP40A), Kovalam (CSP42), Panathura north (CSP52), Shangumugham north (CSP71), and the stretch from Kochuveli to Valiyaveli (CSP76-77).	Poovar (CSP15-16), Adimalathura (CSP31-34), Mullur (CSP36-37), Kovalam (CSP42-45), Punthura (CSP53-55), Shangumugham (CSP69), Vettucaud (CSP74), Kochuveli (CSP77), Valiyaveli (CSP78).
	Accretion spots	Edappadu beach (CSP01), Vallavilay (CSP06), Mullur (CSP36-37), Pannathura (CSP49, 51), Valliyathura (CSP63, 67).	Poovar north to Karumkulam (CSP20-22), Kovalam (CSP43), Punthura (CSP53), Shangumugham south (CSP69), Vettucaud to Kochuveli (CSP74-75), Valiyaveli (CSP78), and Thumba (CSP80-81).	Poovar (CSP17-21)
July 2024	Erosion spots	Vallavilay (CSP04, 06), Neerody (CSP08,09), Poovar (CSP21), Adimalathura (CSP33-34), Mullur (CSP36-37), Kovalam (CSP45),	Adimalathura (CSP34), Mullur (CSP36-37), Kovalam (CSP40A,42-45), Punthura (CSP54,55), Beemapally (CSP60), Shangumugham North (CSP70), Vettucaud	Poovar (CSP18-21), Adimalathura (CSP31-34), Kovalam (CSP42), Punthura (CSP57)

		Punthura (CSP57), Beemapally (CSP58, 60), Cheriyathura (CSP62), Valliyathura (CSP63-64, 67), Shangumugham (CSP69), Vettucaud (CSP73-74) and Valiyaveli (CSP78).	(CSP73), Kochuveli to Valiyaveli (CSP75-78).	
	Accretion spots	Edappadu beach (CSP01-03), Pozhiyoor (CSP12), Poovar (CSP15-16, 19-20), Kovalam (CSP41-43, 46-47), Pannathura (CSP 48, 50, 52), Punthura (CSP53-55), Valliyathura (CSP65-66), Shangumugham (CSP70-71),	Pozhiyoor (CSP10), Poovar south to Karumkulam (CSP17-22), Punthura (CSP53), Cheriyathura (CSP62), Valiyathura (CSP64A), Shangumugham south (CSP69), Vettucaud (CSP74), Valiyaveli to Thumba (CSP79-81).	Poovar (CSP15-16), Punthura (CSP53-54)
August 2024	Erosion spots	Vallavilay (CSP04-05), Neerody (CSP07, 09), Karumkulam (CSP22), Adimalathura (CSP31-34), Kovalam (CSP47), Panathura (CSP48-50), Punthura (CSP53-55), Cheriyathura (CSP61-62), Shangumugham (CSP70), Thumba (CSP80).	Poovar to Karumkulam (CSP19-22), Adimalathura (CSP32-34), Mullur (CSP36-37), Kovalam (CSP42-43,45), Valiyathura (CSP64A), Shangumugham south to north (CSP69,70).	Adimalathura (CSP33-34), Mullur (CSP36), Kovalam (CSP45), Punthura (CSP55), Kochuveli (CSP76-77).
	Accretion spots	Edappadu Beach (CSP01-03), Pozhiyoor (CSP10), Poovar (CSP17), Mullur (CSP37), Beemapally (CSP58-60), Shangumugham South (CSP68), Vettucaud (CSP73), Kochuveli (CSP75) and Valiyaveli (CSP79).	Pozhiyoor (CSP10), Poovar south (CSP15,17), Poovar (CSP18), Adimalathura (CSP31), Kovalam (CSP40A,44), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), Vettucaud to Thumba (CSP72-81).	Poovar (CSP15-21), Vettucaud (CSP72), Valiyaveli (CSP79) and Thumba (CSP80)
September 2024	Erosion spots	Edappadu Beach (CSP01, 03), Mullur (CSP36-37), Kovalam (CSP41), Panathura (CSP50-51), Beemapally (CSP58-59), Valliyathura (CSP63, 65-66), Shangumugham north (CSP68).	Southern Poovar (CSP15,17), Adimalathura (CSP31,33), Kovalam (CSP40A,44), Beemapally (CSP60), Vettucaud (CSP72), Kochuveli (CSP76-77), and Thumba (CSP80).	No data from CSP01-10, 56-67.
	Accretion spots	Poovar (CSP15-20), Karumkulam (CSP22,26), Pulluvila (CSP29-30), Adimalathura (CSP32-35), Kovalam (CSP46), Panathura (CSP49), Punthura (CSP53-55),	Southern Poovar (CSP16), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP34), Mullur (CSP36,37), Kovalam (CSP42-43,45-46), Punthura (CSP53-55), Cheriyathura (CSP62), the area extending	Poovar (CSP15-20), Karumkulam (CSP22,26), Pulluvila (CSP29-30), Adimalathura (CSP32-35), Kovalam (CSP46), Panathura (CSP49), Punthura (CSP53-55),

		Shangumugham to Thumba (CSP69-80).	from Shangumugham south to north (CSP69-71), Vettucaud to Kochuveli (CSP73-75), Valiyaveli (CSP78-79), and Thumba (CSP81).	Shangumugham to Thumba (CSP68-80).
Post-monsoon (October 2023-November 2023)	Erosion spots	Pannathura (CSP48, 51), Punthura (CSP54-56), Valiyathura (CSP 63-64, 67), Kochuveli (CSP 76), Valiyaveli (CSP79), and Thumba (CSP80-81)	Edappadu beach (CSP02), Pozhiyoor (CSP10), Poovar (CSP19), Karumkulam (CSP22), Kovalam (CSP45-46), Punthura (CSP54), Beemapally (CSP60), Cheriyathura (CSP62), Vettucaud (CSP72,74), and the section from Kochuveli to Thumba (CSP76-81).	Poovar (CSP15, 18), Mullur (CSP36-37), Punthura (CSP53-54). No data from CSP23 to CSP35.
	Accretion spots	Edapadu to Adimalathura (CSP01-35), Kovalam (CSP42-44), Punthura (CSP57), Beemapally (CSP59-60), Cheriyathura (CSP 61-62), Shangumugham (CSP68-69), Kochuveli (CSP77), Valiyaveli (CSP78).	Vallavilay (04-05), Neerody (CSP07-09), Poovar south (CSP15), Poovar north (CSP20-21), Adimalathura (CSP34), the stretch from Adimalathura to Mullur (CSP35A-37), Kovalam (CSP40A), Kovalam (CSP42-44), Punthura (CSP53), Valiyathura (CSP64A), the area from Shangumugham south to Shangumugham north (CSP68-71), Vettucaud (CSP73), and Kochuveli (CSP75).	Edapadu (CSP02), Vallavilay to Neerody (CSP04-09), Pozhiyur (CSP10), Poovar (CSP16, 20-21), Karumkulam (CSP22), Adimalathura (CSP34), Azhimala (CSP35), Kovalam (CSP42-44, 46), Beemapally (CSP58), Cheriyathura (CSP61-62), Valliyathura to Valliyaveli (CSP67-78).
Fairweather (Dec 2023 to March 2024)	Erosion spots	Poovar (CSP16-18), Karumkulam (CSP22-23), Adimalathura (CSP34), Mullur (CSP37), Punthura (CSP 57), Valliyathura (CSP64), Shangumugam (CSP67-69), Vettucaud to Kochuveli (CSP73-77), Thumba (80-81).	Neerody (CSP09), Poovar South to Poovar (CSP15-18), Port reclamation area (CSP40A), Kovalam (CSP42 and 44-45), Punthura (CSP53), Shangumugham to Vettucaud (CSP69-72), Kochuveli (CSP75-77), Valiyaveli (CSP79), and Thumba (CSP81).	Poovar (CSP15-20), Adimalathura (CSP31), Punthura (CSP54).
	Accretion spots	Edapadu (CSP02), Poovar to Karumkulam (CSP19-22), Pullavila to Adimalathura(CSP24-31, 33), Punthura to Valliyathura (CSP57-61), Shangumugham (CSP70-71), Vettucaud (CSP73), Valliyaveli (CSP78),	Edappadu Beach (CSP02), Vallavilay (CSP04-05), Pozhiyoor (CSP10), Poovar to Karumkulam (CSP19-22), Adimalathura (CSP31-33), Azhimala to Mullur (CSP35-37), Kovalam (CSP43 and 46), Punthura (CSP55), Beemapally (CSP60), Cheriyathura (CSP62), Valiyathura (CSP64A), Valiyathura to Shangumugham	Adimalathura (CSP34), Mullur (CSP37), Vettucaud to Kochuveli (CSP73-77), Thumba (80-81).

			(CSP67-68), Vettucaud (CSP73-74), Valiyaveli (CSP78), Thurmba (CSP 80).	
Pre-Monsoon (April 2024-May 2024)	Erosion spots	Edappadu beach to Pozhiyoor (CSP01-10), Poovar south (CSP17), Poovar (CSP19), Mullur (CSP36-37), Kovalam (CSP41,47), Panathura north (CSP51-52), Punthura (CSP53-57), Shangumugham (CSP69-71), and Vettucaud to Thumba (CSP72-80).	Pozhiyoor (CSP10), Poovar North (CSP21), Adimalathura (CSP34), Azhimala (CSP35A), Kovalam (CSP42,45-46), Valliyathura (CSP64A), the stretch from Valliyathura to Shangumugham South (CSP67-68), Shangumugham North (CSP70), Vettucaud (CSP74), Valiyaveli (CSP78), and Thumba (CSP81).	Poovar (CSP16, 18-21), Adimalathura (CSP34), Mullur (CSP36-37), Kovalam (CSP43-46), Punthura (CSP53-55), Shangumugham to Thumba (CSP69, 71-81)
	Accretion spots	Poovar North (CSP15-21), Karumkulam (CSP22,23,26), Pulluvila (CSP27-30), Adimalathura (CSP31-34), Kovalam (CSP44,46), Panathura (CSP48-49), Valiyathura (CSP64, 65, 67), Shangumugham (CSP68).	Neerody (CSP09), Poovar South (CSP15), Poovar North (CSP17-20), Karumkulam (CSP22), Adimalathura (CSP31-32), Azhimala (CSP35), Kovalam (CSP43-44), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham South (CSP69), Shangumugham North (CSP71), Kochuveli (CSP75,77), and from Valiyaveli to Thumba (CSP79-80).	Poovar (CSP15, 17), Adimalathura (CSP31-33), Azhimala (CSP35), Kovalam (CSP41)
Monsoon (June2024-September 2024)	Erosion spots	Edapadu Beach (CSP01, 03), Adimalathura to Poovar (CSP20-34, 16), Kovalam (CSP42-45), Valliyathura (CSP65-66), Thumba (CSP80-81).	North Poovar to Kaumkulam (CSP21-22), Adimalathura (CSP31-34), Mullur (CSP36-37), Kovalam (CSP42-45), Punthura (CSP55), Shangumugham north (CSP70), and Kochuveli (CSP77).	Poovar (CSP16), Adimalathura to Mullur (CSP31-36), Punthura (CSP55)
	Accretion spots	Edapadu beach (CSP02), Poovar (CSP14-15, 17), Mullur (CSP37), Punthura (CSP 53-55), Shangumugham to Vettucaud (CSP66-73).	South Poovar to north Poovar (CSP17-20), the port reclamation area (CSP40A), Punthura (CSP53-54), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham south (CSP69), Shangumugham north (CSP71), Vettucaud to Kochuveli (CSP73-76), and Valiyaveli to Thumba (CSP78-81).	Poovar (CSP14-15, 17-22), Mullur (CSP37), Punthura (CSP 53-54), Shangumugham to Thumba (CSP66-81).
Overall change (October	Erosion spots	Pozhiyoor (CSP11-12), Poovar (CSP15, 18, 20-21), Karumkulam (CSP23-24), Pulluvila (CSP30),	Poovar south (CSP15), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP34), Mullur (CSP37), Kovalam	Poovar (CSP15-19, 21), Karumkulam (CSP22), Adimalathura (CSP-34), Mullur

2023-September 2024)		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).	(CSP42-43, 45-46), Punthura (CSP54), Beemapally (CSP60), Vettucaud (CSP72-73), Kochuveli (CSP77), and Valiyaveli (CSP79).	(CSP36-37), Kovalam (CSp45-46), Pannathura (CSP48), Punthura (CSP55,57), Valliyathura (CSP63,67), Shanmugham (CSP70-71), Kochuveli (CSP77), Thumba (CSP81)
	Accretion spots	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)	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).	Edapadu beach (CSP01, 03), Vallavilay to Neerody (CSP04-09), Azhimala (CSP35), Kovalam (CSP41-44), Punthura (CSP53-54, 57), Shangumugham (CSP68-69), Vettucaud (CSP72-74), Kochuveli (CSP75-76) and Valliyaveli (CSP78)
October 2022-October 2023	Erosion spots	Poovar (CSP16-17), Karumkulam (CSP25-26), Pulluvila (CSP28), Mullur (CSP37), Kovalam (CSP45), Punthura (CSP53,57), Valliyathura (CSP66)and Thumba (CSP 78-81)	Thumba (CSP81), Vettucaud (CSP72-73), Changumugham (CSP68-70), Neerody (CSP09), Kochuveli (CSP75), and Shanghaimugham (CSP44).	Shangumugham (CSP68-71), Thumba (CSP 78-79)
	Accretion spots	EdapaduBeach(CSP02), Poovar (CSP18-24), Adimalathura to Pulluvila (CSP 29-34), Panathura North (CSP51), Punthura (CSP53-54) and Vettucaud (CSP69-75).	Beaches at Edappadu Beach (CSP02), Vallavilay (04-05), Neerody (CSP07-08), Pozhiyoor (CSP10), Kovalam (CSP42-43 and 45-46), Cheriyathura (CSP62), Shangumugham (CSP71), Vettucaud (CSP74), Kochuveli to Thumba (CSP76-80).	Vettucaud (CSP69-75) and Thumba (CSP 80-81)
February 2023-February 2024	Erosion spots	Poovar (CSP13-19), Punthura (CSP 53-54), Shangumugamto Valliyathura (CSP65-71), Kochuveli (CSP75) and Thumba (CSP79-81).	Poovar South (CSP16-17), Adimalathura (CSP31-34), Azhimala to Mullur (CSP35A-37), Kovalam (CSP42 AND 44-46), Punthura (CSP54-55), Beemapally (CSP60), Valiyathura to Vettucaud (CSP67-72) and Vettucaud to Thumba (CSP74-81).	Poovar (CSP13-18), Mullur (CSP36), Punthura (CSP 53), and Thumba (CSP80).
	Accretion spots	Edapadubeach(CSP02), Poovar to Adimalthura (CSP20-34), Mullur (CSP37), Punthura to Valliyathura	Edappadu Beach (CSP02), Vallavilay (04-05), Neerody to Pozhiyoor (CSP07-10), Poovar south (CSP15), Poovar to	Poovar (CSP19-22), Admalathura (CSP31-35), Shangumugham to Thumba (CSP68-79,81)

		(CSP55-64), Vettucaud (CSP73), and Valliyaveli (CSP79)	Karumkulam (CSP18-22), Port reclamation area (CSP40A), Kovalam (CSP43), Cheriyathura (CSP62), and Vettucaud (CSP73).	
May 2023-May 2024	Erosion spots	Edapadu beach (CSP01, 03), (CSP04-10), Poovar to Pulluvila (CSP13-26), Mullur (CSP35), Kovalam (CSP42,44,45), Pannathura (CSP48-49, 51-52), Punthura (CSP53-55), Cheriyathura (CSP61-62), Valliyathura (CSP63-64, 66), Vettucaud (CSP73-74), Kochuveli (CSP76-77).	Poovar South (CSP15,17), Poovar (CSP18), Poovar North (CSP21), the area from Adimalathura to Mullur (CSP33-36), Kovalam (CSP42-46), Beemapally (CSP60), Cheriyathura (CSP62), and from Valiyathura to Thumba (CSP67-81).	Poovar (CSP13-22), Mullur (CSP35), Kovalam (CSP42,44,45), Punthura (CSP53-55), Shangumugham to Thumba (CSP68-81).
	Accretion spots	EdapaduBeach(CSP02), Pulluvila to Adimalathura (CSP27-34), Mullur (CSP37), Shangumugham north (CSP68-71), and Thumba (CSP80-81).	Neerody to Pozhiyoor (CSP09-10), Poovar to Poovar North (CSP19-20), Karumkulam (CSP22), Mullur (CSP37), the port reclamation area (CSP40A), and Punthura (CSP53-55).	Adimalathura (CSP32-34)
September 2023-September 2024	Erosion spots	Pozhiyoor to Karumkulam (CSP10-23), Pullavila (CSP30), Adimalathura to Mullur (CSP33-36), Pannathura (CSP47-50), Valliyathura to Shangumugham (CSP64-69), Vettucaud to Kochuveli (CSP74-77), Thumba (CSP80).	Poovar south (CSP15), Poovar (CSP18-19), Karumkulam (CSP22), Mullur (CSP37), Kovalam (CSP42-43, 45-46), Punthura (CSP54-55), Valiyathura (CSP67), Vettucaud (CSP73), Kochuveli (CSP77), and the stretch from Valiyathura to Thumba (CSP79-81).	Poovar (14-18, 22), Mullur (CSP36), Punthura (CSP54-55)
	Accretion spots	Edappadu beach to Neerody (CSP01-09), Pulluvila to Adimalathura (CSP26-33), Kovalam (CSP40-44), Shangumugham north to Vettucaud (CSP71-73), Valiyaveli (CSP78-79).	Poovar south (CSP16-17), Poovar north (CSP20-21), Mullur (CSP36), the port reclamation area (CSP40A), Punthura (CSP53), Beemapally (CSP60), Cheriyathura (CSP62), the southern section of Shangumugham to Vettucaud (CSP68-72), the stretch from Vettucaud to Kochuveli (CSP74-76), and Valiyaveli (CSP78).	Poovar (CSP20), Shangumugham (CSP69), Vettucaud (CSP72-73), Kochuveli (CSP75-76), Valiyaveli (CSP78-79).

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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 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 surveys took place at CSP01-11, 35A, and CSP64A in September 2024. Additionally, there were no onshore surveys at CSP16 and CSP31-33, 35,67 in October 2023. In October 2023, CSP55 detected inaccuracies in the onshore data. Due to rough sea conditions, no offshore survey was carried out in September 2024. Hence, offshore beach profile analysis was not carried out from October 2023 to September 2024.

The overall shoreline changes using satellite images from October 2023 to September 2024 shows 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) while erosion at Poovar (CSP15), Pulluvila (CSP27), Karumkulam (CSP24), Mullur (CSP36-37), Punthura (CSP56), Valiyathura (CSP65), Shangumugham (CSP69), and Thumba (CSP80); for the period from October 2023 to September 2024.

This study analyzed 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 2023 to September 2024. Shoreline change trends over the past two decades (2000-2024) 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.

Key observations highlighted significant spatial and temporal variations in shoreline dynamics. Beach profile analysis from October 2023 to September 2024 revealed erosion at Poovar South, Kovalam, and Valiyaveli, while accretion occurred at Mullur, Kovalam, and Shangumugham. Satellite image analysis supported these findings, showing erosion at Edapadu, Poovar, Adimalathura, and Valiyathura, with accretion at Mullur, Kovalam, and Kochuveli. Field data corroborated the satellite-based observations, providing further validation.

Long-term trends (2000-2024) identified persistent erosion hotspots at Shangumugham, Valliyathura, and Poovar South, whereas accretion was prominent at Vizhinjam, Adimalathura, and Poovar North. Climatic events, such as Cyclones Ockhi (2017) and Tauktae (2021), significantly impacted shoreline stability, causing severe erosion and altering sediment dynamics. Post-cyclone

recovery patterns emphasized the role of structural interventions and natural sediment redistribution processes. The influence of dredging activities and breakwater construction from 2023 to 2024 had a significant impact on sediment distribution, and as such, the impacts are localized and confined to nearby areas. However, continuous monitoring is necessary to evaluate the scale of long-term effects on the coast.

The study highlights the dynamic nature of the Thiruvananthapuram coast, shaped by monsoon-driven currents and wave action. Accretion/ Erosion trends observed near structural interventions, such as groynes, indicate localised sediment recovery but also reveal downdrift erosion.

Further, the study requires continuous monitoring of shoreline dynamics through high-resolution satellite imagery and field-based observations to track ongoing changes and identify emerging trends, as well as conducting detailed investigations into sediment transport processes and evaluating the effectiveness of structural interventions in controlling erosion and accretion and fostering sustainable shoreline stabilization practices.

Table 6.1. **Summary and significant findings of 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 2000-2018 and annual variation for the years 2015-2016, 2016-2017, and 2017-18. • Erosion spots are Valliyathura, Punthura,and Neerody toEdapadu 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 show that these sites along the Vizhinjam coast have undergone erosion for a long time.
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 noticed at Kochuveli, Shangumugham, Valliyathura, Cheriyathura, Punthura, Mullur, Pulluvila and accretion at Thumba, Vettucaud and

		Shangumugham, Punthura, Adimalathura, Karumkulam, Poovar and Edapadu beach. • From beach volume change analysis, erosion is noticed at Thumba, Vettucaud to Kochuveli, Valliyathura, Pannathura to Punthura, Kovalam, Mullur, Pulluvila to Adimalathura, Karumkulam and Poovar and accretions 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). • Trend analysis comparison of beach volume change (onshore) and shoreline change using satellite images (February to February) from 2015 to 2021 has been 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 (CSP51-53), Valliyathura (CSP 64,66), Thumba to Kochuveli (CSP 75-81), while accretion 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 observed at Shangumugham South (CSP69), Vettucaud (CSP74) and Kochuveli to Valiyaveli (CSP76-78) were erosion spots. The beach got accretion at Edappadu Beach (CSP02), Kovalam (CSP42,43), Panathura North (CSP52), Shangumugham North (CSP70-71), Vettucaud (CSP73), Kochuveli (CSP75) and Thumba (CSP80-81).

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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) has been taken into account for shoreline change estimation using satellite images. The result of the shoreline change analysis carried out from October 2023 to September 2024 has 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), 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 2023 to September 2024, and beach volume changes between October 2022-October 2023, February 2023- February 2024, May 2023-May 2024 and September 2023-September 2024 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.

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 CSP23-30 were not conducted from September 2023 to September 2024. There were no offshore surveys in September 2023 and from May 2024 to September 2024 at any locations because of adverse weather conditions.

A.1.1 Monthly Beach Volume variations for October 2023 to September 2024 for the onshore profiles

This report contains the monthly beach volume changes from October 2023 to September 2024 and has been represented graphically in **Figures A.1 to A.12** and **Table A.1.**

In September 2023, no onshore survey was conducted at CSP31-35A; in October 2023, there were no surveys performed at CSP16, CSP31-33,35,67; during November 2023, there were no surveys at CSP31-33 and CSP35; in December 2023, there were no

surveys at CSP34 and CSP54; in February 2024, no survey occurred at CSP53; from March to September 2024, CSP07-08 had no surveys conducted; in the period from April 2024 to September 2024, there were no surveys at CSP02, CSP04, CSP05, CSP07, and CSP08; in April 2024, there were no surveys at CSP40A and CSP76; between May 2024 and July 2024, there was no data recorded for CSP16; at CSP09, no survey was undertaken from June 2024 to September 2024, while CSP35A had no surveys conducted in the same period; there was no data available for CSP46 in June and July 2024; there was no data for CSP67 during June, July, and August 2024; for CSP68, no data was recorded in June 2024 and July 2024.

In October 2023, CSP55 was identified as erroneous on the onshore. Therefore, these profiles were excluded from the analysis for October 2023. Accretion was observed at Edappadu beach (CSP02), Vallavilay (04-05), Neerody (CSP07,08), Pozhiyoor (CSP10), the stretch from Poovar to Karumkulam (CSP18-22), Mullur (CSP36,37), Kovalam (CSP40A), Kovalam (CSP43-46), Punthura (CSP53,54), Beemapally (CSP60), Cheriyathura (CSP62), and Vettucaud (CSP72). Erosion was noted at Neerody (CSP09), Poovar south (CSP15,17), Valiyathura (CSP64A), the area from Shangumugham south to Shangumugham north (CSP68-71), and from Vettucaud to Thumba (CSP73-81).

In November 2023, deposition was observed at Vallavilay (04-05), Neerody (CSP07-09), Poovar south (CSP15), Poovar north (CSP20-21), Adimalathura (CSP34), the stretch from Adimalathura to Mullur (CSP35A-37), Kovalam (CSP40A), Kovalam (CSP42-44), Punthura (CSP53), Valiyathura (CSP64A), the area from Shangumugham south to Shangumugham north (CSP68-71), Vettucaud (CSP73), and Kochuveli (CSP75). Erosion was reported at Edappadu beach (CSP02), Pozhiyoor (CSP10), Poovar (CSP19), Karumkulam (CSP22), Kovalam (CSP45-46), Punthura (CSP54), Beemapally (CSP60), Cheriyathura (CSP62), Vettucaud (CSP72,74), and the section from Kochuveli to Thumba (CSP76-81).

Accretion occurred in December 2023 at the following sites: Edappadu beach (CSP02), Vallavilay (CSP04), the area from Neerody to Pozhiyoor (CSP09-10), Poovar south (CSP16), the stretch from Poovar to Karumkulam (CSP19-22), Kovalam (CSP42,44), Punthura (CSP53), Beemapally (CSP60), Valliyathura (CSP64A), the northern part of Shangumugham (CSP70), Vettucaud (CSP72,74), Kochuveli (CSP76,77), and the area from Valiyaveli to Thumba (CSP79-81). Erosion was noted in December 2023 at the

following locations: Vallavilay (CSP05), Neerody (CSP07-08), Poovar south (CSP15), the area from Poovar South to Poovar (CSP17-18), Kovalam (CSP40A), Kovalam (CSP43,45,46), Punthura (CSP55), Cheriyathura (CSP62), the section from Valliyathura to Shangumugham south (CSP67-69), the northern part of Shangumugham (CSP71), Vettucaud (CSP73), Kochuveli (CSP75), and Valiyaveli (CSP78).

In January 2024, an error was identified in the profile at CSP53. Accretion was observed at several locations, including Edappadu beach (CSP02), Vallavilay (CSP04-05), Neerody (CSP07-08), Pozhiyoor (CSP10), between Poovar South and Poovar North (CSP15-20), Karumkulam (CSP22), from Adimalathura to Mullur (CSP31-36), Kovalam (CSP46), Punthura (CSP55), Beemapally (CSP60), Cheriyathura (CSP62), Valliyathura (CSP64A), from Valliyathura to Shangumugham South (CSP67-68), Vettucaud (CSP73), and Valiyaveli (CSP78) in January 2024. Erosion was detected at Neerody (CSP09), Poovar North (CSP21), Mullur (CSP37), Kovalam (CSP40A), in Kovalam (CSP42-45), from Shangumugham South to Vettucaud (CSP69-72), between Vettucaud and Kochuveli (CSP74-77), and from Valiyaveli to Thumba (CSP79-81) in January 2024.

In February 2024, accretion was observed at several beaches including Neerody (CSP07), Poovar South (CSP15,17), Poovar North (CSP20), Adimalathura (CSP31-32), the stretch from Adimalathura to Azhimala (CSP34-35A), Mullur (CSP37), Kovalam (CSP43-44,46), Punthura (CSP54,55), Cheriyathura (CSP62), Valliyathura (CSP67), Shangumugham South (CSP69), Vettucaud (CSP72), and the area from Vettucaud to Thumba (CSP74-80). Erosion, on the other hand, was reported at Edappadu beach (CSP02), Vallavilay (CSP04-05), the segment from Neerody to Pozhiyoor (CSP08-10), Poovar South (CSP16), Poovar (CSP18-19), the area from Poovar North to Karumkulam (CSP21-22), Adimalathura (CSP33), Mullur (CSP36), Kovalam (CSP40A,42,45), Beemapally (CSP60), Valliyathura (CSP64A), the stretch from Shangumugham South to North (CSP68-71), Vettucaud (CSP73), and Thumba (CSP81).

In March 2024, there was an accumulation observed at Edappadu beach (CSP02), Vallavilay (CSP04-05), from Neerody to Pozhiyoor (CSP09-10), Poovar South (CSP15-16), along Poovar to Karumkulam (CSP18-22), at Adimalathura (CSP31), between Adimalathura and Azhimala (CSP34-35), Mullur (CSP37), Kovalam (CSP40A,42-43,45-46), Punthura (CSP54), Cheriyathura (CSP62), Valliyathura (CSP64A), from Shangumugham south to Shangumugham north (CSP68-70), Vettucaud (CSP73-74),

Kochuveli (CSP76-77), and Valiyaveli (CSP79). Conversely, erosion was noted at Poovar south (CSP17), Adimalathura (CSP32-33), from Azhimala to Mullur (CSP35A-36), Kovalam (CSP44), Punthura (CSP55), Beemapally (CSP60), Valliyathura (CSP67), from Shangumugham north to Vettucaud (CSP71-72), Kochuveli (CSP75), Valiyaveli (CSP78), and Thumba (CSP80-81).

A faulty profile has been identified at CSP72, leading to its exclusion from the April 2024 analysis. In April 2024, accretion was noted at Neerody (CSP09), Poovar South (CSP16), the area from Poovar to Karumkulam (CSP19-22), Adimalathura (CSP31-32,34), Kovalam (CSP42-45), Punthura (CSP53-55), Cheriyathura (CSP62), from Shangumugham south to north (CSP68-71), Vettucaud to Kochuveli (CSP73-75), and from Valiyaveli to Thumba (CSP78-81). Erosion was recorded at Pozhiyoor (CSP10), Poovar South (CSP15), from Poovar South to Poovar (CSP17-18), Azhimala (CSP35), Kovalam (CSP46), Beemapally (CSP60), Valliyathura (CSP64A), from Valliyathura to Shangumugham south (CSP67-68), and Kochuveli (CSP77).

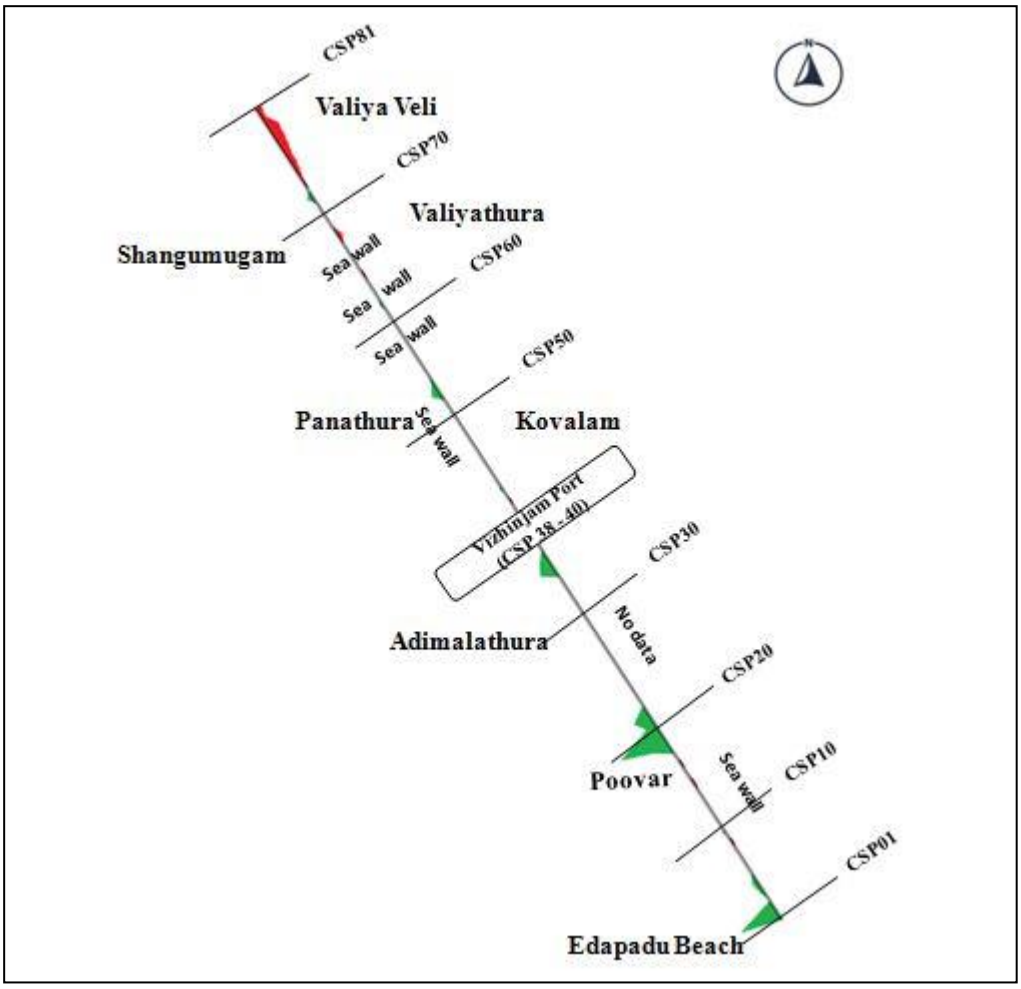
In May 2024, accretion was noted at Neerody (CSP09), Poovar South (CSP15), Poovar North (CSP17-20), Karumkulam (CSP22), Adimalathura (CSP31-32), Azhimala (CSP35), Kovalam (CSP43-44), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham South (CSP69), Shangumugham North (CSP71), Kochuveli (CSP75,77), and from Valiyaveli to Thumba (CSP79-80). Erosion was recorded at Pozhiyoor (CSP10), Poovar North (CSP21), Adimalathura (CSP34), Azhimala (CSP35A), Kovalam (CSP42,45-46), Valliyathura (CSP64A), the stretch from Valliyathura to Shangumugham South (CSP67-68), Shangumugham North (CSP70), Vettucaud (CSP74), Valiyaveli (CSP78), and Thumba (CSP81).

An error was identified at CSP15 in June 2024. The data for May and June 2024 is identical at CSP35. In June 2024, there was less than 10m distance covered at CSP72, so these profiles were omitted from the analysis. Accretion was observed from Poovar north to Karumkulam (CSP20-22), Kovalam (CSP43), Punthura (CSP53), Shangumugham south (CSP69), Vettucaud to Kochuveli (CSP74-75), Valiyaveli (CSP78), and Thumba (CSP80-81). Erosion was detected at Pozhiyoor (CSP10), the area from Poovar south to Poovar (CSP15-19), Mullur (CSP36-37), Kovalam (CSP40A), Kovalam (CSP42), Panathura north (CSP52), Shangumugham north (CSP71), and the stretch from Kochuveli to Valiyaveli (CSP76-77).

CSP71 was found to be incorrect in July 2024, leading to its exclusion from the analysis. Accretion was recorded at Pozhiyoor (CSP10), stretching from Poovar south to Karumkulam (CSP17-22), Punthura (CSP53), Cheriyathura (CSP62), Valiyathura (CSP64A), south of Shangumugham (CSP69), Vettucaud (CSP74), and along the route from Valiyaveli to Thumba (CSP79-81). Erosion occurred at Adimalathura (CSP34), Mullur (CSP36-37), Kovalam (CSP40A, 42-45), Punthura (CSP54, 55), Beemapally (CSP60), north of Shangumugham (CSP70), Vettucaud (CSP73), and between Kochuveli and Valiyaveli (CSP75-78).

Accretion was observed in Pozhiyoor (CSP10), the southern region of Poovar (CSP15,17), Poovar (CSP18), Adimalathura (CSP31), Kovalam (CSP40A,44), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), and the stretch from Vettucaud to Thumba (CSP72-81). Erosion was detected from Poovar to Karumkulam (CSP19-22), in Adimalathura (CSP32-34), Mullur (CSP36-37), Kovalam (CSP42-43,45), at Valiyathura (CSP64A), and from Shangumugham south to north (CSP69,70) in August 2024.

Erosion has been noted in southern Poovar (CSP15,17), Adimalathura (CSP31,33), Kovalam (CSP40A,44), Beemapally (CSP60), Vettucaud (CSP72), Kochuveli (CSP76-77), and Thumba (CSP80), whereas accretion has been reported at southern Poovar (CSP16), from Poovar to Karumkulam (CSP18-22), Adimalathura (CSP34), Mullur (CSP36,37), Kovalam (CSP42-43,45-46), Punthura (CSP53-55), Cheriyathura (CSP62), the area extending from Shangumugham south to north (CSP69-71), Vettucaud to Kochuveli (CSP73-75), Valiyaveli (CSP78-79), and Thumba (CSP81) during September 2024.



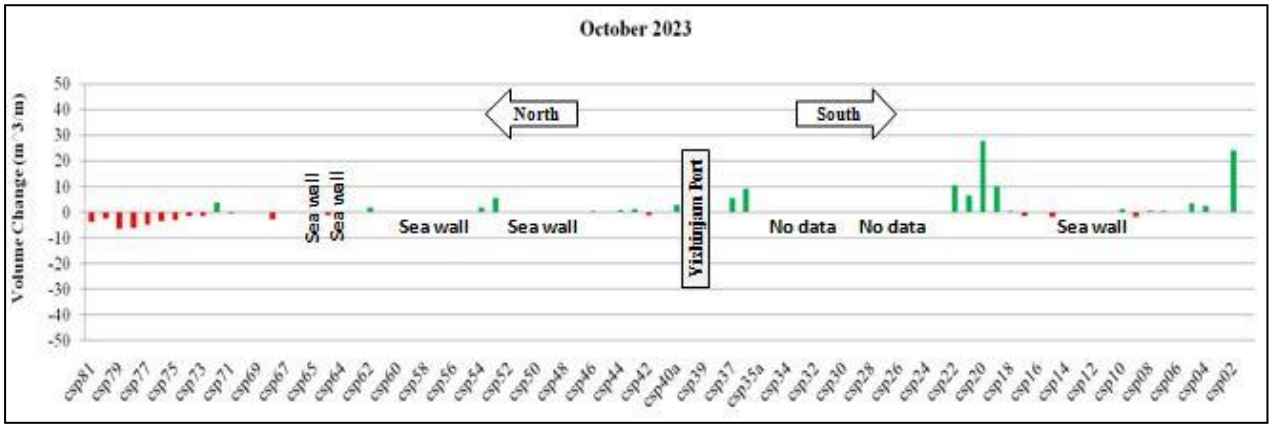
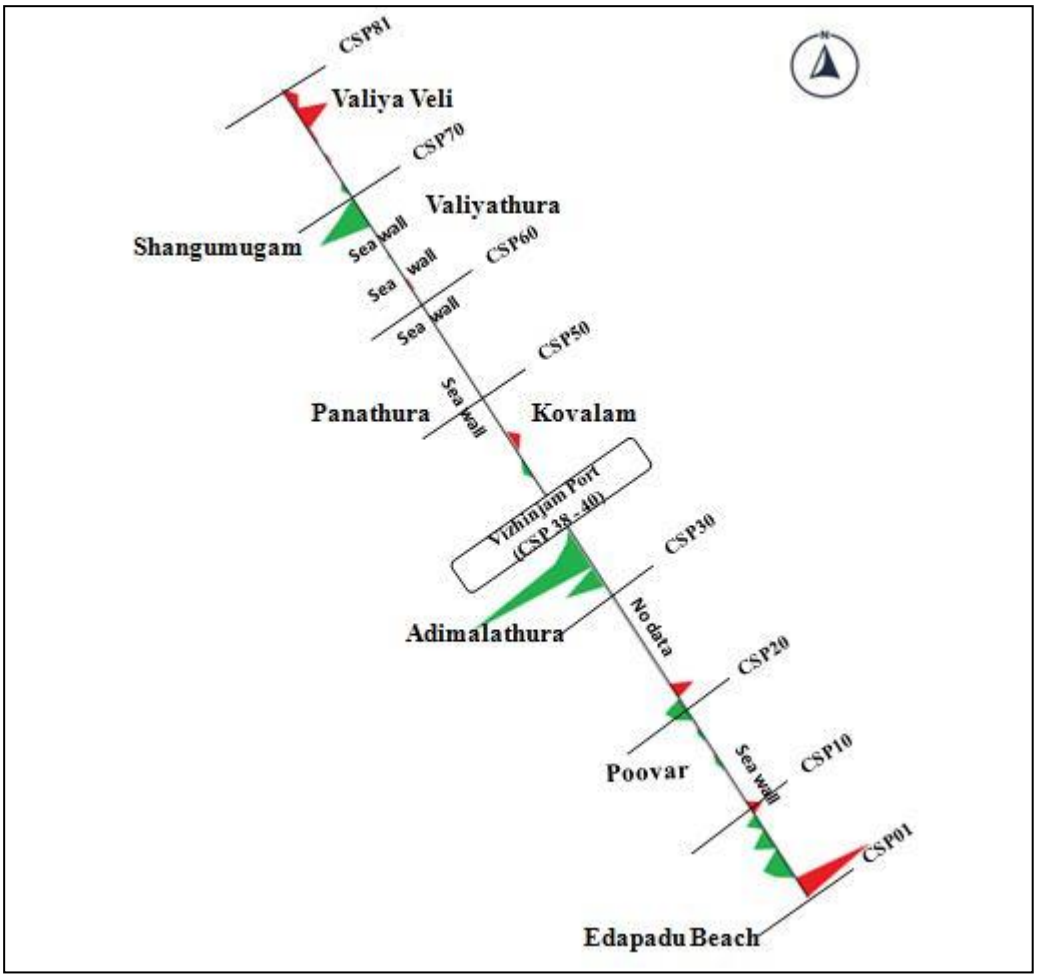


Figure A.1 Monthly Beach Volume Changes in October 2023 in m3/m (onshore)



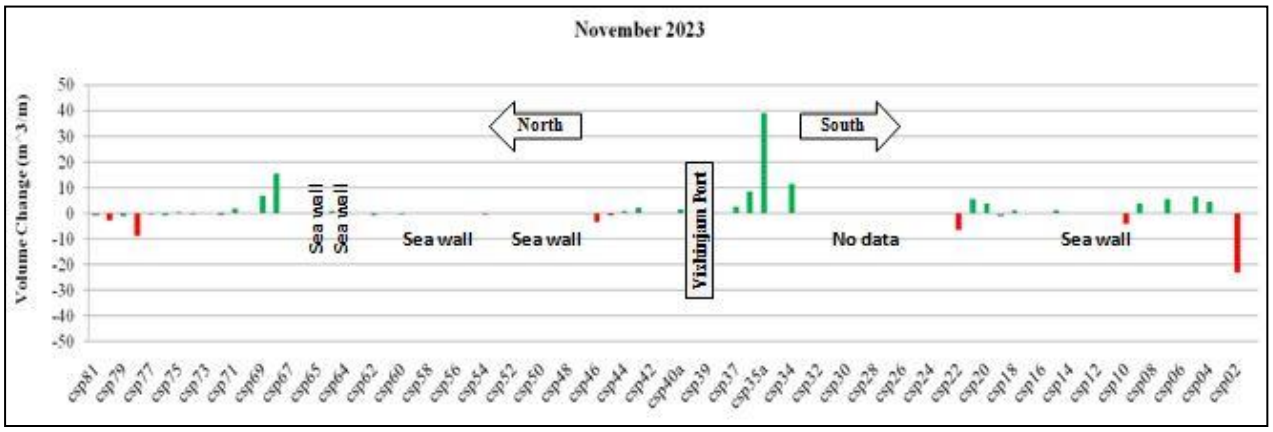
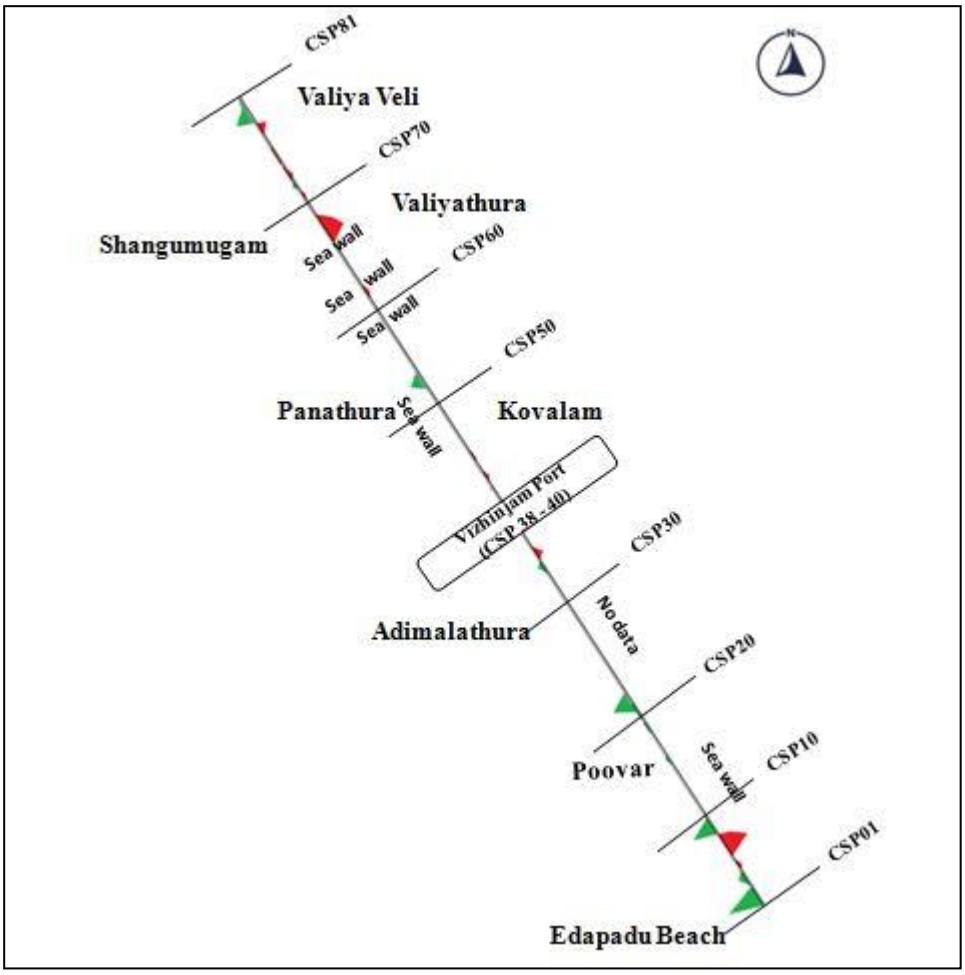


Figure A.2 Monthly Beach Volume Changes in November 2023 in m3/m (onshore)



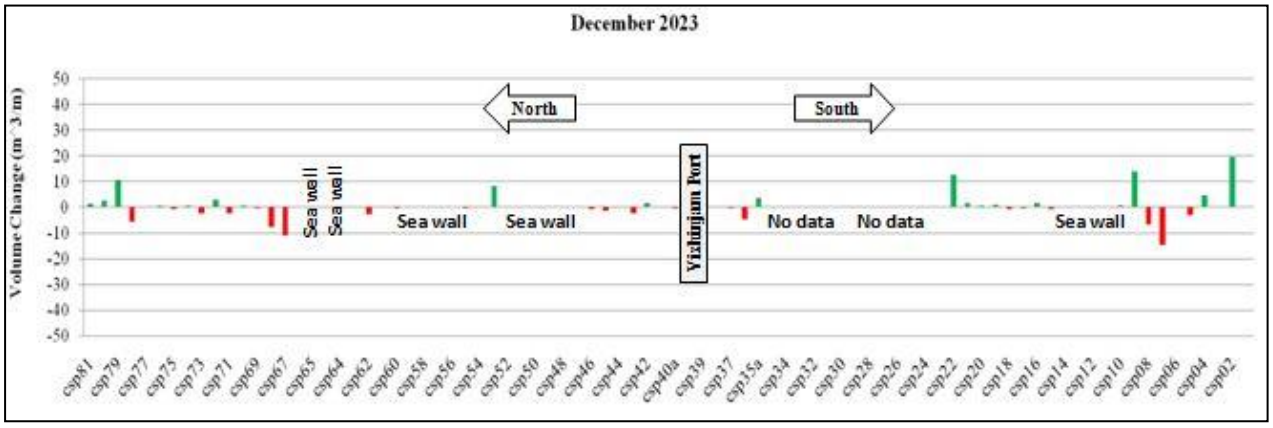
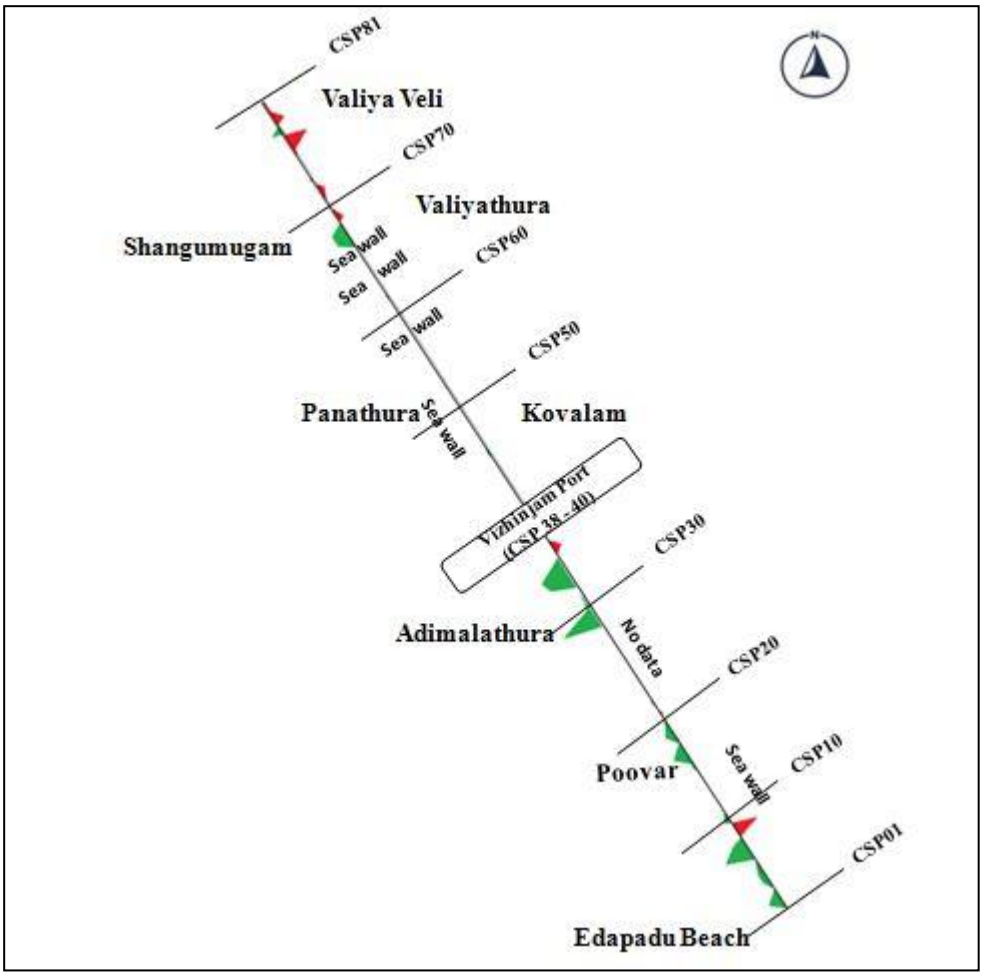


Figure A.3 Monthly Beach Volume Changes in December 2023 in m3/m (onshore)



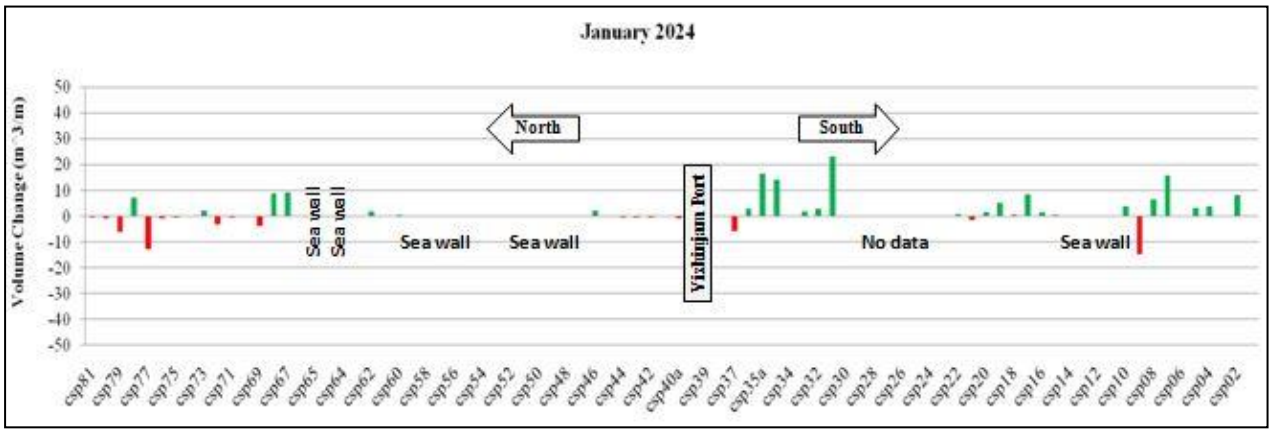
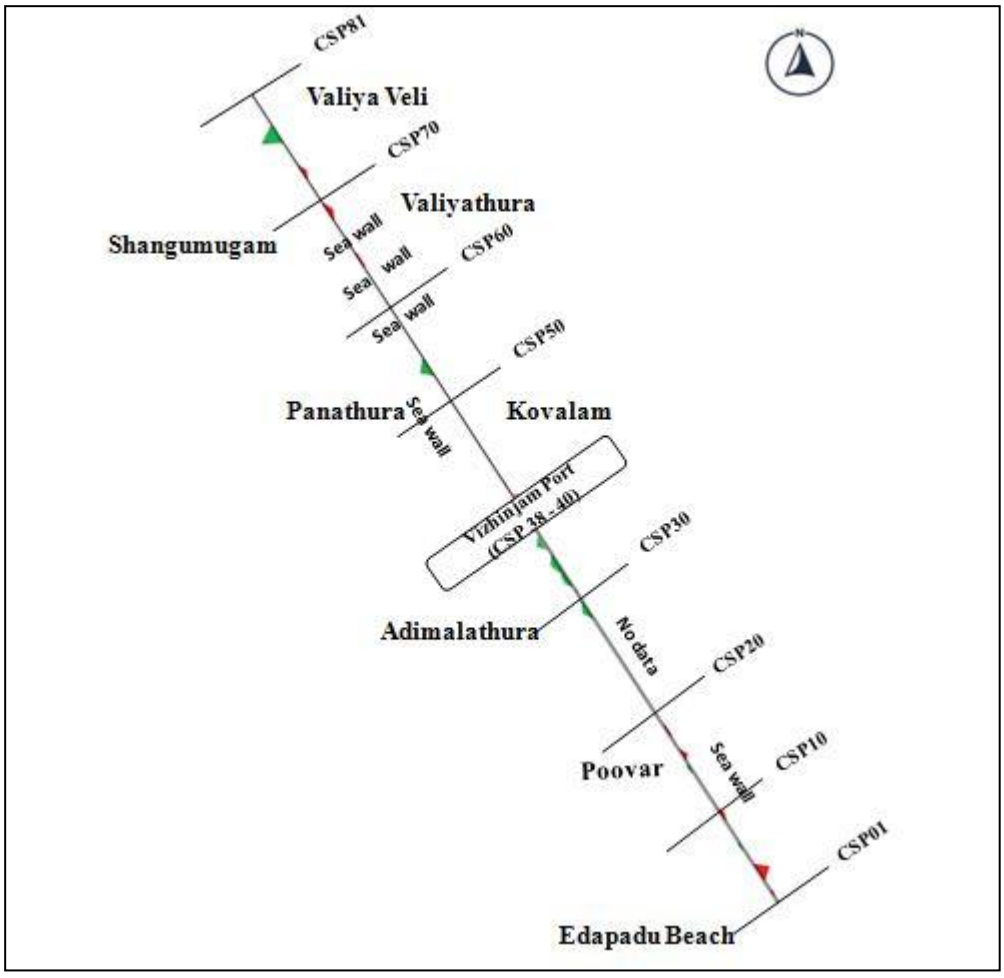


Figure A.4 Monthly Beach Volume Changes in January 2024 in m3/m (onshore)



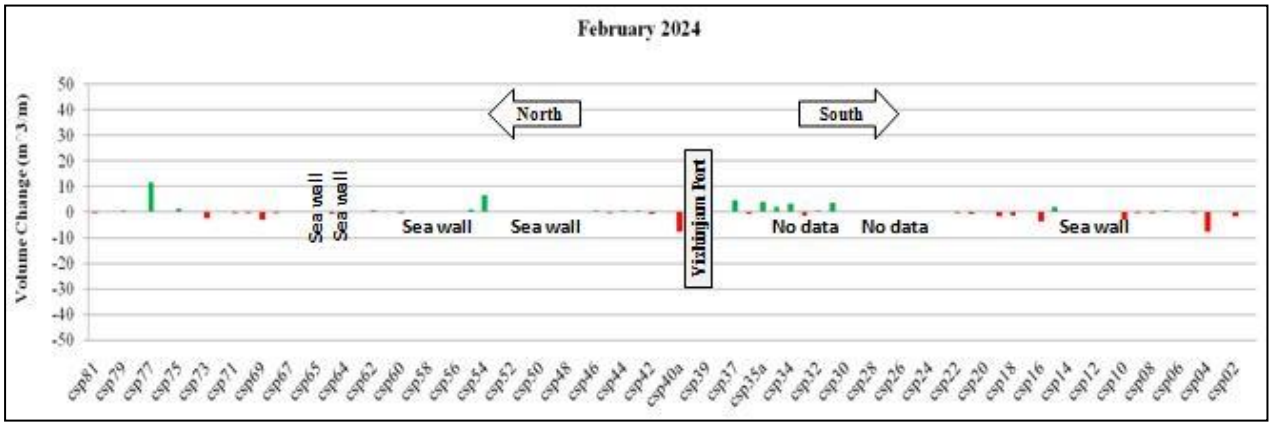
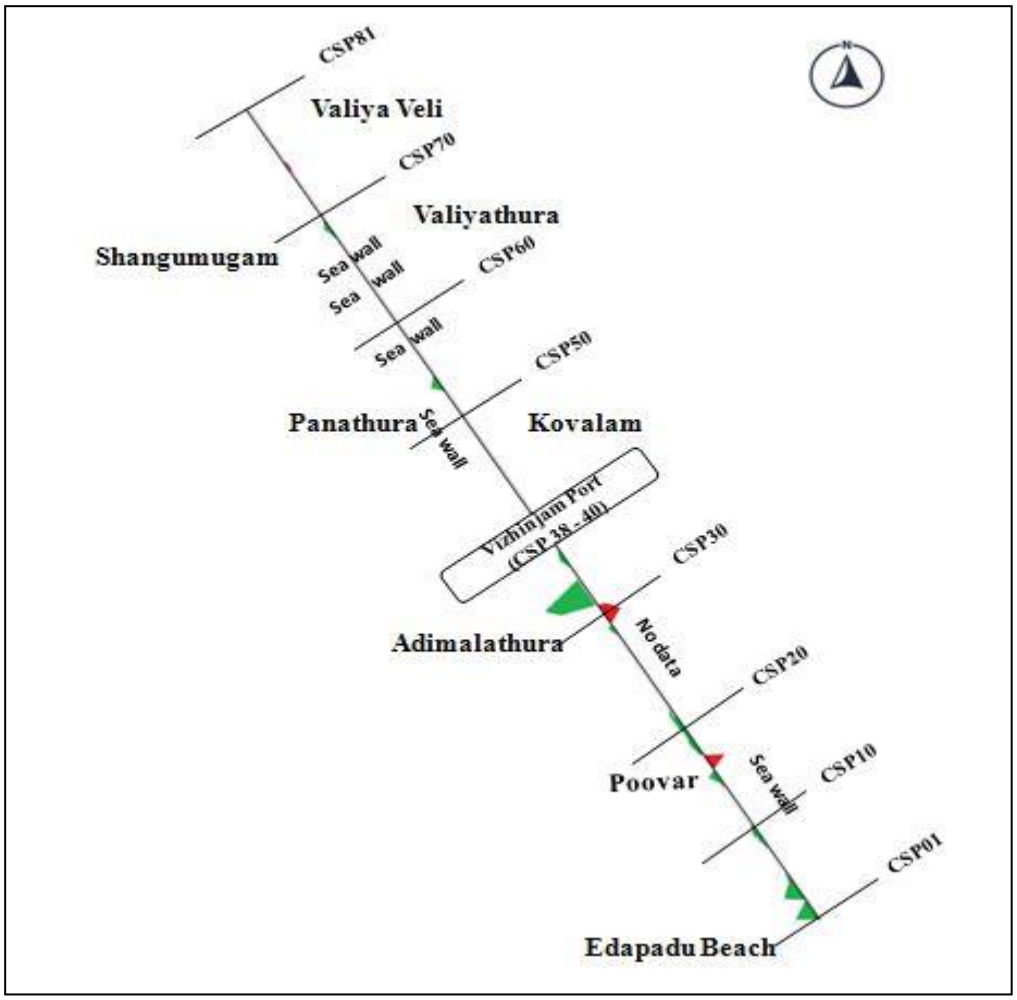


Figure A.5 Monthly Beach Volume Changes February 2024 in m^3/m (onshore)



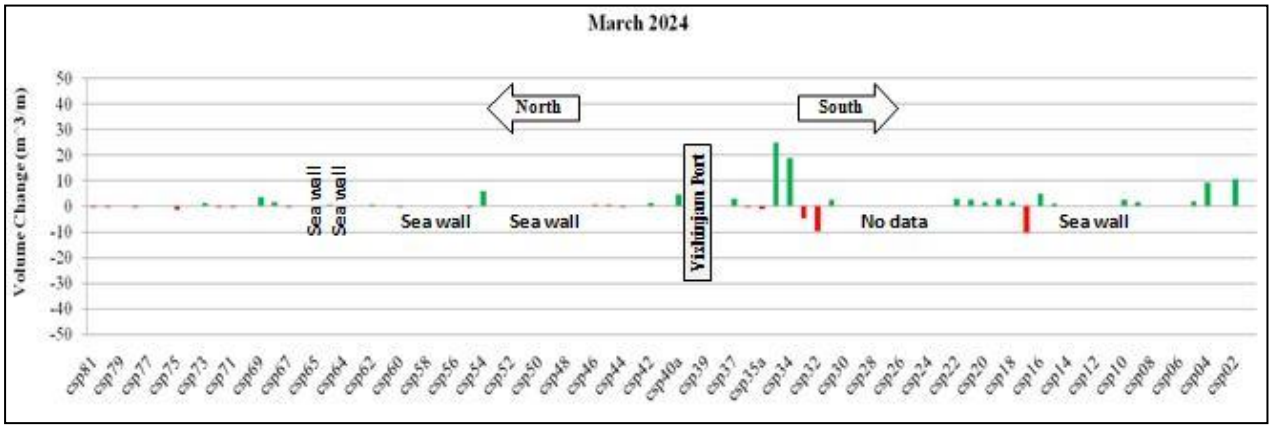
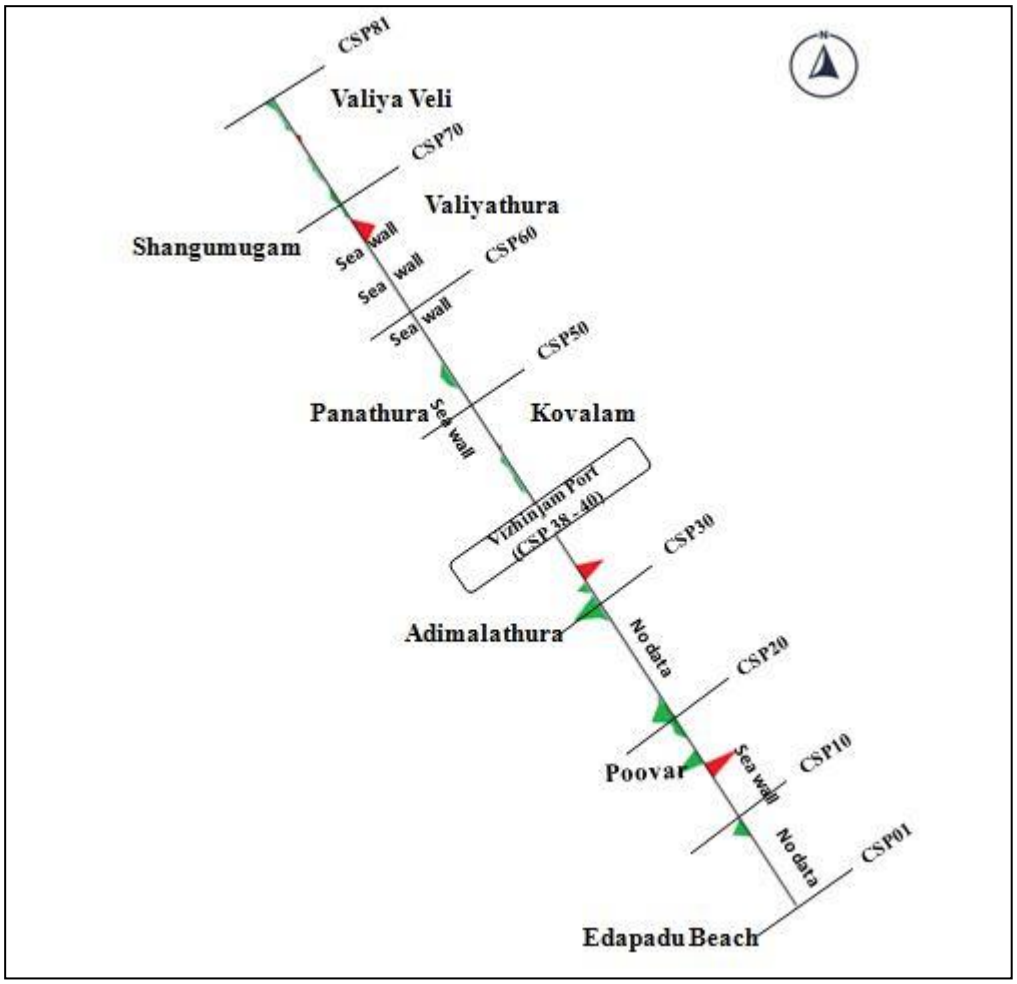


Figure A.6 Monthly Beach Volume Changes in March 2024 in m^3/m (onshore)



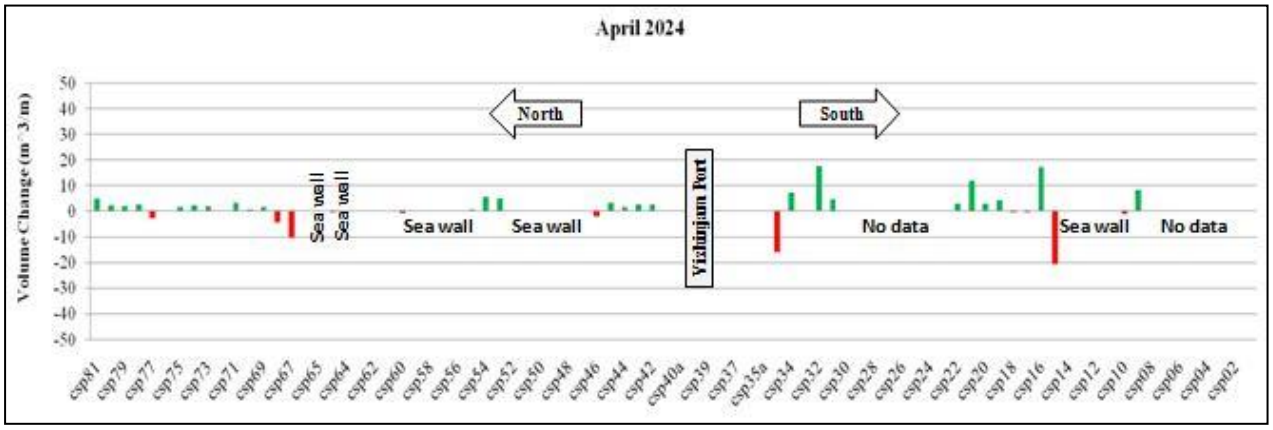
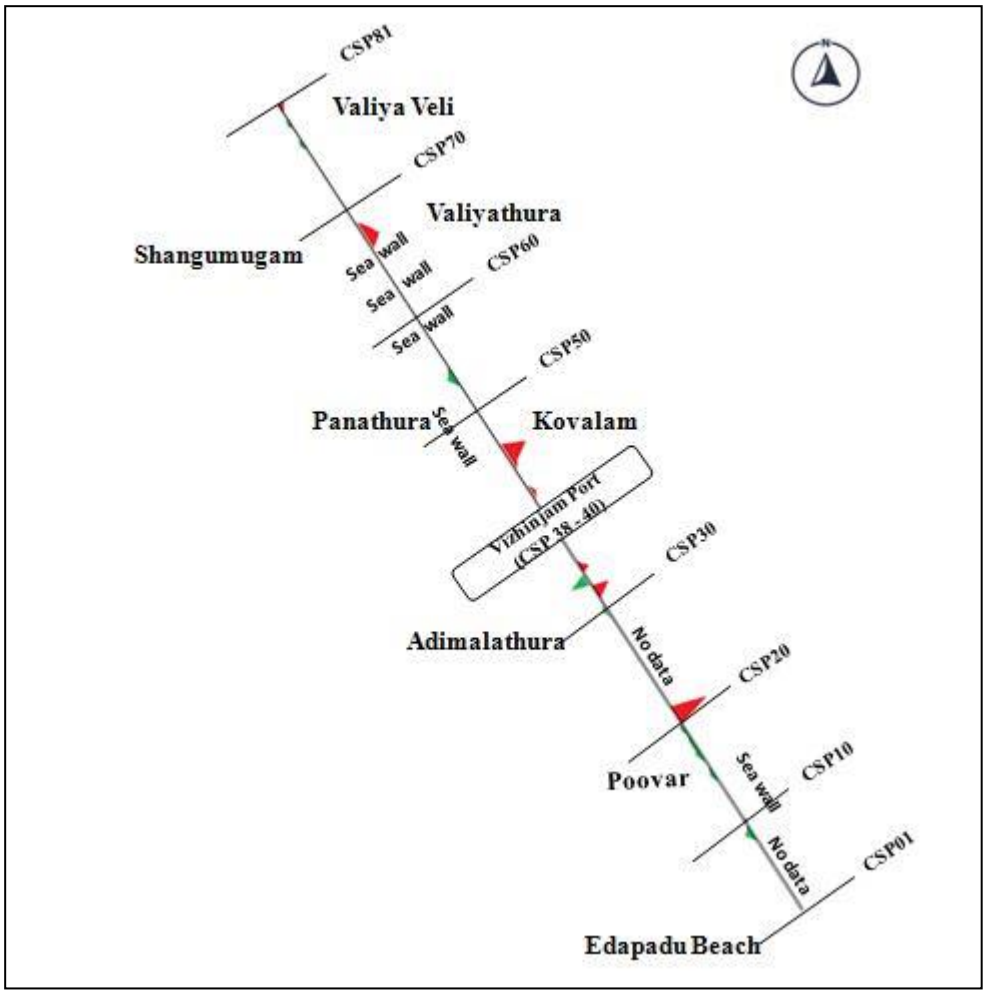


Figure A.7 Monthly Beach Volume Changes in April 2024 in m^3/m (onshore)



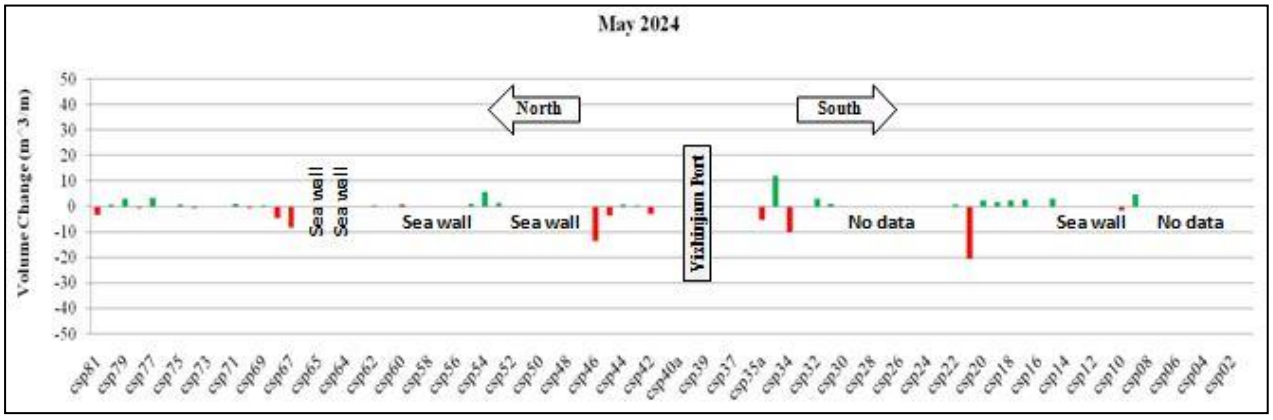
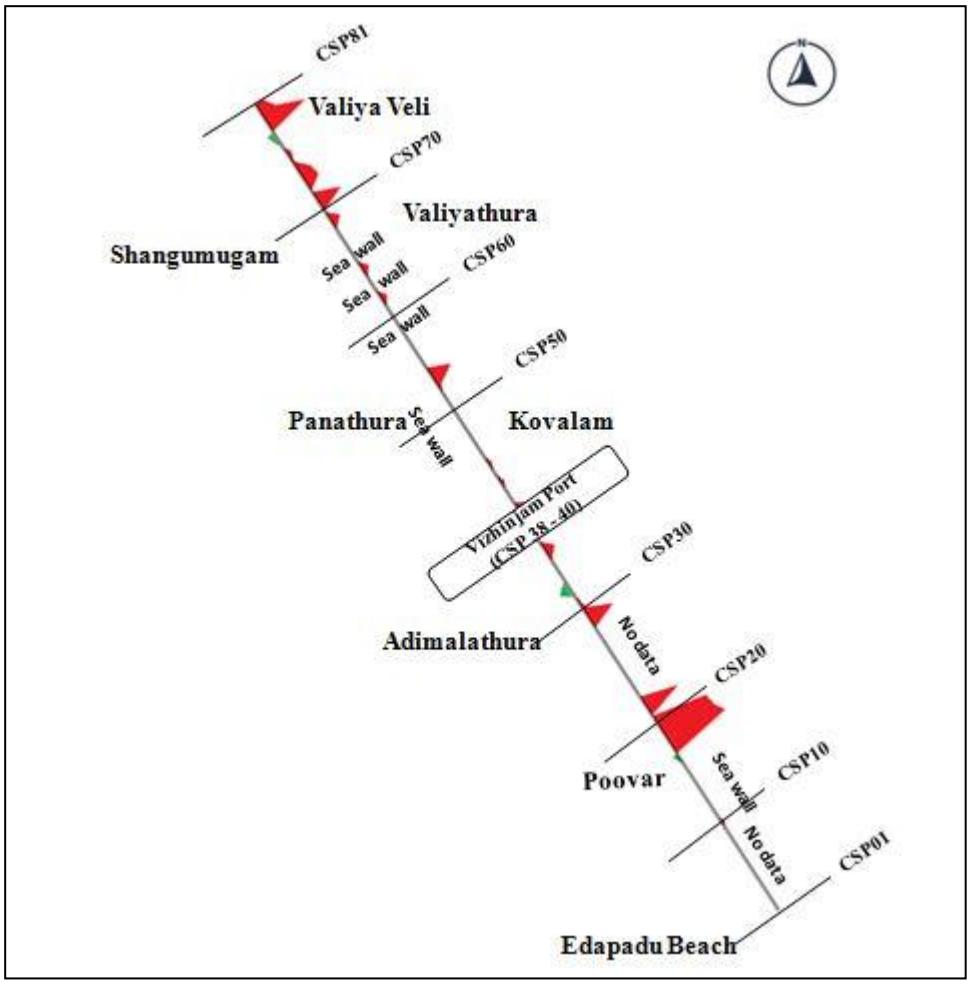


Figure A.8 Monthly Beach Volume Changes in May 2024 in m^3/m (onshore)



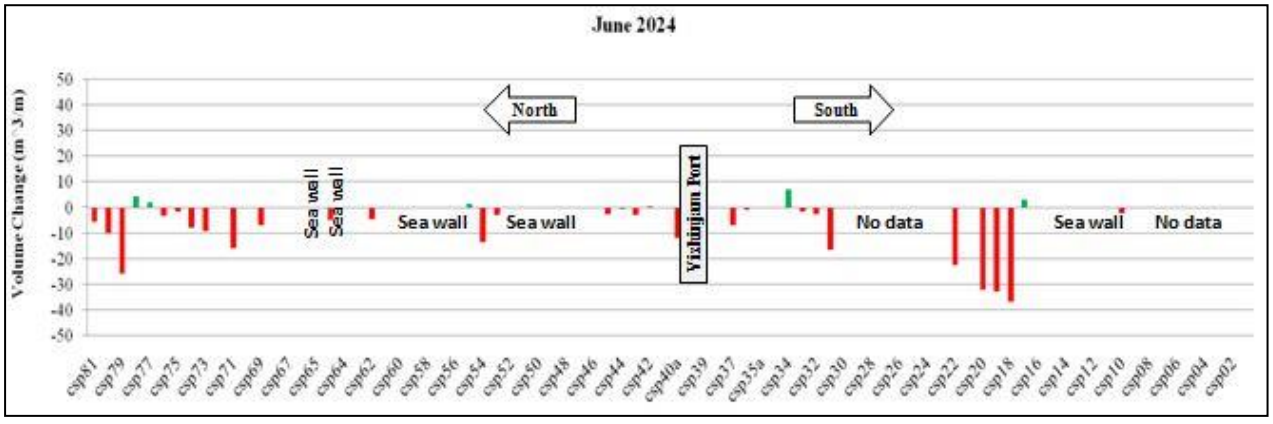
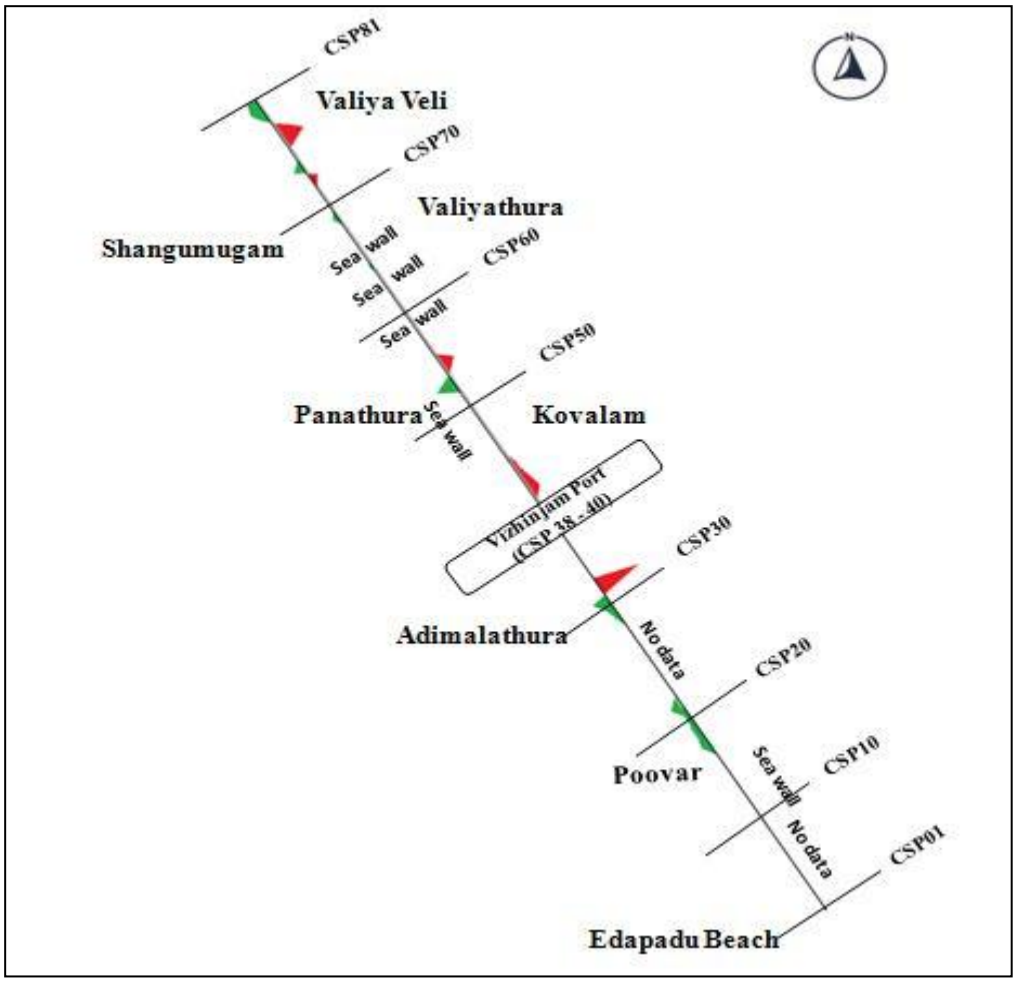


Figure A.9 Monthly Beach Volume Changes in June 2024 in m^3/m (onshore)



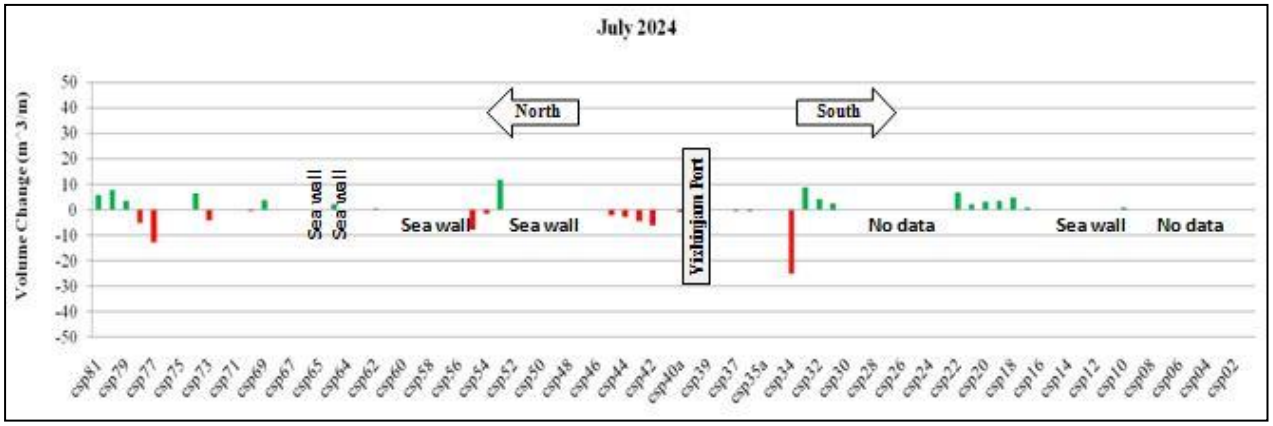
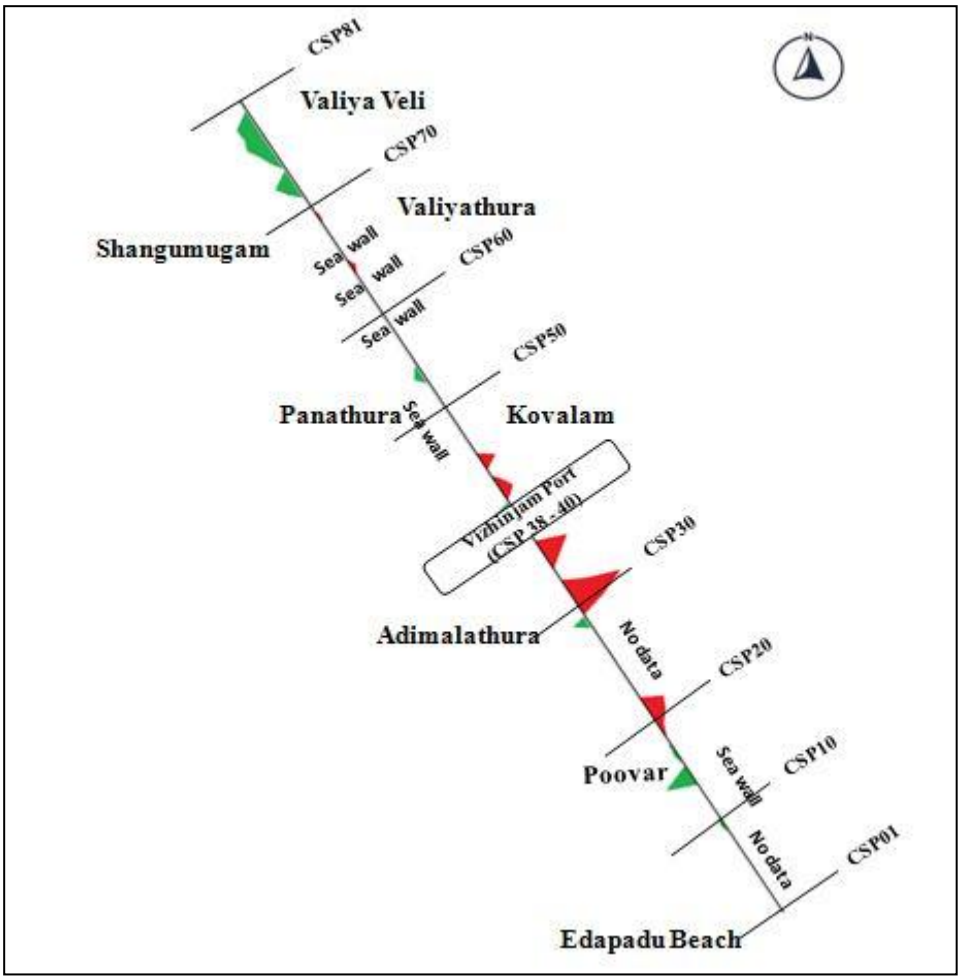


Figure A.10 Monthly Beach Volume Changes in July 2024 in m^3/m (onshore)



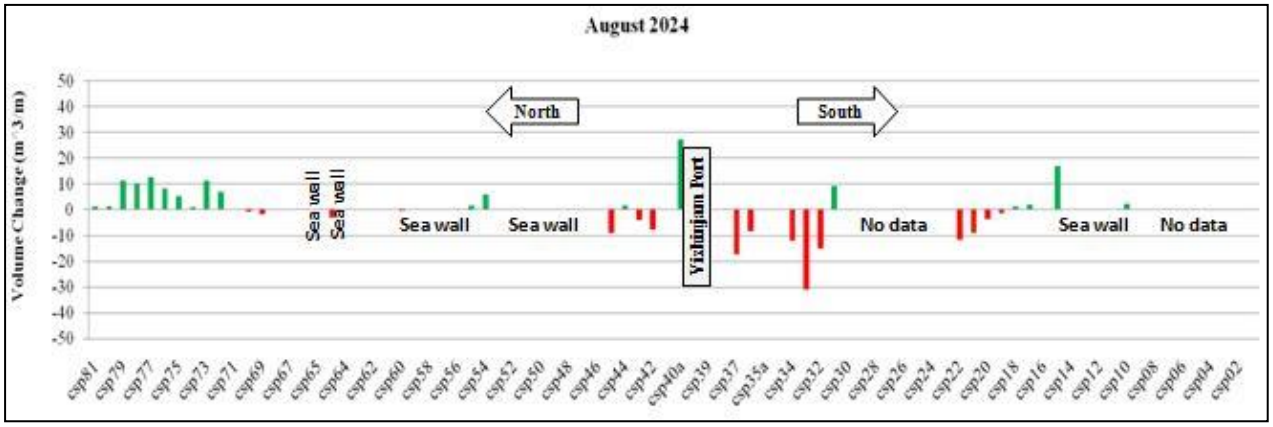
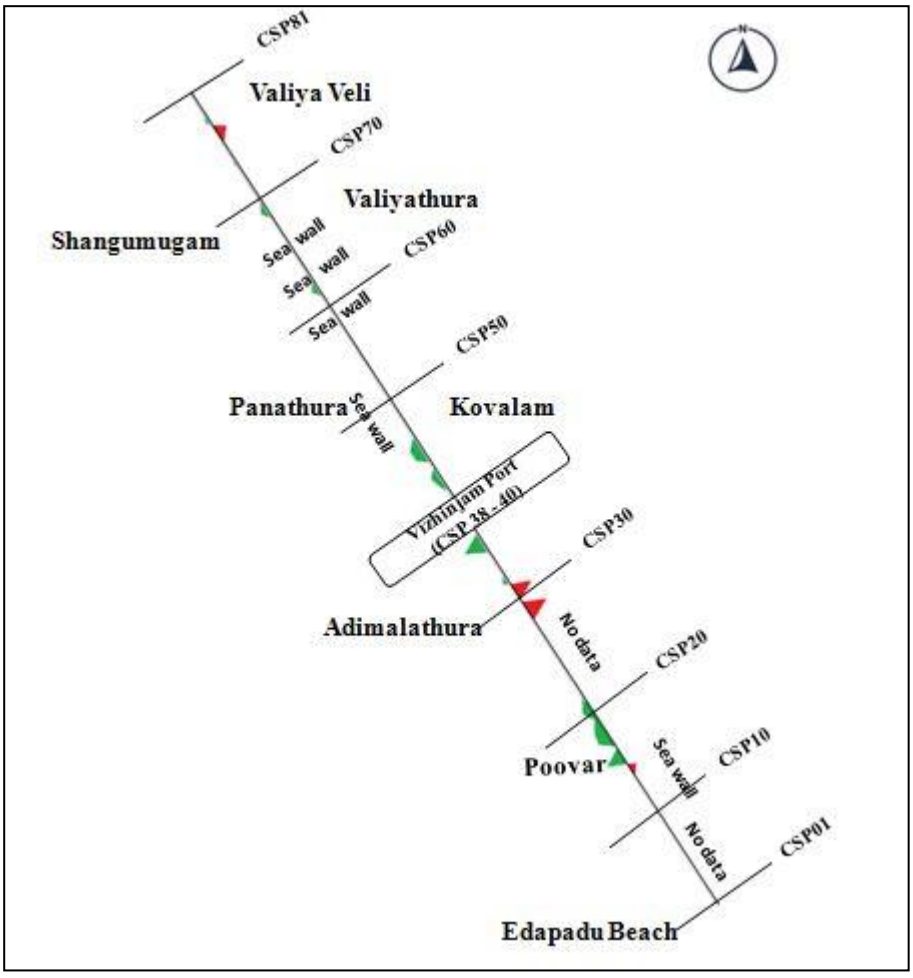


Figure A.11 Monthly Beach Volume Changes in August 2024 in m^3/m (onshore)



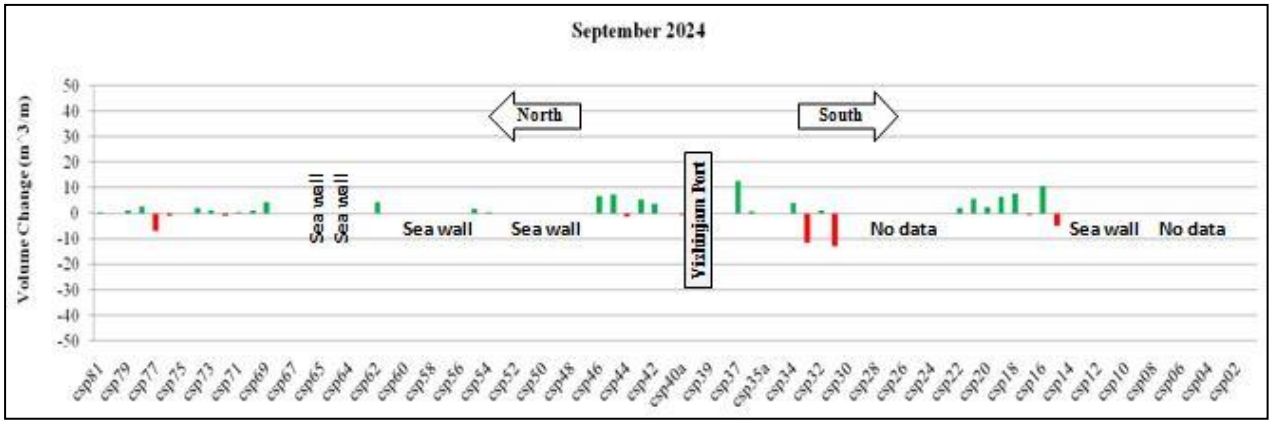


Figure A.12 Monthly Beach Volume Changes in September 2024 in m^3/m (onshore)

Table A.1 Monthly Beach Volume Changes from October 2023 to September 2024 in m^3/m (onshore)

CSP NOs.	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024	April 2024	May 2024	June 2024	July 2024	Aug 2024	Sept 2024
CSP01	**Sea wall**											
CSP02	24.13	-23.21	19.56	7.96	-1.63	10.48	-	-	-	-	-	-
CSP03	**Sea wall**											
CSP04	2.50	4.52	4.63	3.82	-7.75	9.05	-	-	-	-	-	-
CSP05	3.61	6.52	-3.03	3.04	-0.29	1.82	-	-	-	-	-	-
CSP06	**Sea wall**											
CSP07	0.50	5.57	-14.77	15.60	0.67	-	-	-	-	-	-	-
CSP08	0.30	0.18	-6.71	6.43	-0.05	-	-	-	-	-	-	-
CSP09	-1.79	3.79	13.70	-14.73	-0.39	1.45	8.34	4.65	-	-	-	-
CSP10	1.07	-4.00	0.58	3.64	-3.08	2.68	-1.12	-1.54	-2.08	0.85	2.35	-
CSP11												
CSP12												
CSP13												
CSP14	**Sea wall**											
CSP15	-1.74	1.31	-0.85	0.51	1.77	0.94	-20.71	2.86	*	*	16.90	-4.90
CSP16	-	-	1.71	1.52	-3.64	4.72	17.25	-	-	-	-	10.78
CSP17	-1.63	0.15	-0.59	8.37	0.18	-10.34	-0.01	2.72	3.25	0.65	2.06	-0.52
CSP18	0.61	1.19	-0.67	0.55	-1.46	1.42	-0.35	2.35	-36.71	4.75	1.40	7.64
CSP19	10.27	-0.86	0.94	5.19	-1.56	2.80	4.45	1.55	-32.84	3.32	-1.22	6.41
CSP20	27.71	4.01	0.61	1.54	0.20	1.70	3.08	2.35	-32.28	3.05	-3.70	2.25
CSP21	6.32	5.56	1.67	-1.65	-0.79	2.63	12.02	-20.71	0.00	2.27	-9.09	5.84
CSP22	10.41	-6.45	12.37	0.86	-0.41	2.85	3.14	0.50	-22.42	6.92	-11.80	2.01
CSP23	-	-	-	-	-	-	-	-	-	-	-	-
CSP24	-	-	-	-	-	-	-	-	-	-	-	-
CSP25	-	-	-	-	-	-	-	-	-	-	-	-
CSP26	-	-	-	-	-	-	-	-	-	-	-	-
CSP27	-	-	-	-	-	-	-	-	-	-	-	-
CSP28	-	-	-	-	-	-	-	-	-	-	-	-
CSP29	-	-	-	-	-	-	-	-	-	-	-	-
CSP30	-	-	-	-	-	-	-	-	-	-	-	-
CSP31	-	-	-	23.22	3.54	2.52	4.49	1.13	-16.53	2.32	9.21	-12.99
CSP32	-	-	-	2.68	0.66	-9.83	17.64	3.09	-2.44	4.10	-15.08	1.19
CSP33	-	-	-	1.95	-1.53	-4.79	-	-	-1.69	8.81	-30.97	-11.48
CSP34	-	11.46	-	-	3.15	18.77	7.14	-9.94	6.96	-25.12	-12.17	4.08
CSP35	-	-	-	14.20	2.02	24.88	-16.01	11.89	*	*	-	-
CSP35A	-	39.00	3.55	16.44	4.06	-1.21	0.00	-5.22	-	-	-	-
CSP36	9.22	8.65	-4.73	2.80	-0.66	-0.03	-	-	-0.97	-0.39	-8.45	0.75
CSP37	5.48	2.53	-0.07	-5.74	4.74	2.80	-	-	-6.98	-0.53	-17.23	12.68
CSP38	**Port Area**											
CSP39												
CSP40												
CSP40A	2.92	1.37	-0.17	-0.81	-7.85	4.65	-	-	-11.71	-0.83	27.38	-0.59
CSP41	**Sea wall**											
CSP42	-1.08	0.12	1.68	-0.48	-0.81	1.18	2.75	-3.07	0.29	-6.10	-7.61	3.77
CSP43	1.23	2.35	-2.59	-0.49	0.67	0.17	2.51	0.21	-2.81	-4.59	-4.05	5.52
CSP44	0.68	0.86	0.09	-0.60	0.72	-0.44	1.70	0.51	-0.47	-2.88	1.72	-1.14

CSP45	0.14	-0.86	-1.53	-0.18	-0.18	0.55	3.35	-3.52	-2.54	-2.15	-9.02	7.19
CSP46	0.59	-3.35	-0.64	2.13	0.68	0.46	-1.88	-13.57	-	-	-	6.79
CSP47	**Sea wall**											
CSP48												
CSP49												
CSP50												
CSP51												
CSP52												
CSP53	5.53	0.31	8.21	*	*	-	4.81	1.29	-2.91	11.61	0.43	0.20
CSP54	1.65	-0.33	-	-	6.69	5.71	5.68	5.52	-13.47	-1.57	6.04	0.24
CSP55	*	*	-0.48	0.03	1.00	-0.31	0.57	1.15	1.53	-7.88	1.52	1.55
CSP56	**Sea wall**											
CSP57												
CSP58												
CSP59												
CSP60	0.26	-0.29	0.04	0.30	-0.04	-0.11	-0.59	0.63	-0.13	-0.01	0.10	-0.02
CSP61	**Sea wall**											
CSP62	1.88	-0.72	-2.79	1.65	0.56	0.48	0.23	0.24	-4.46	0.51	0.43	4.46
CSP63	**Sea wall**											
CSP64												
CSP64A	-1.13	0.91	0.14	0.24	-0.75	0.60	-0.32	-0.24	-4.82	2.18	-3.08	-
CSP65	**Sea wall**											
CSP66												
CSP67	-	-	-11.05	9.15	0.33	-0.07	-10.41	-8.25	-	-	-	-
CSP68	-2.90	15.46	-7.72	8.85	-0.23	1.53	-4.40	-4.67	-	-	-	-
CSP69	-0.18	6.92	-0.37	-3.77	-3.03	3.46	1.75	0.23	-6.78	3.89	-1.85	4.47
CSP70	-0.06	0.00	0.41	-0.34	-0.03	0.20	0.80	-0.67	-0.16	-0.43	-0.65	0.97
CSP71	-0.60	1.95	-2.28	-0.58	-0.39	-0.21	3.23	0.89	-15.77	*	*	0.40
CSP72	3.86	-0.15	2.73	-3.35	0.39	-0.25	*	*	*	*	6.93	-0.85
CSP73	-1.48	0.22	-2.42	2.02	-2.53	1.16	2.09	0.00	-9.30	-4.27	11.29	0.95
CSP74	-1.68	-0.54	0.61	-0.24	0.24	0.34	2.38	-0.76	-7.75	6.56	0.79	1.88
CSP75	-3.18	0.45	-0.91	-0.38	1.21	-1.31	1.71	0.55	-1.55	-0.22	5.38	0.11
CSP76	-3.51	-0.69	0.47	-0.71	0.20	0.17	-	-	-3.22	-0.17	8.27	-0.98
CSP77	-4.99	-0.44	0.05	-12.83	11.64	0.10	-2.60	3.48	2.18	-12.77	12.43	-6.79
CSP78	-6.11	-8.76	-5.77	7.19	0.19	-0.23	2.71	-0.63	4.38	-5.31	10.25	2.66
CSP79	-6.57	-1.03	10.43	-6.13	0.68	0.22	1.83	2.93	-25.66	3.45	11.13	1.13
CSP80	-2.50	-2.90	2.69	-0.71	0.15	-0.14	2.15	0.53	-9.88	7.78	1.31	-0.03
CSP81	-3.91	-0.49	1.11	-0.63	-0.19	-0.06	5.13	-3.19	-5.50	5.86	1.18	0.41

*Data not considered for analysis

-No data

A.1.2 Monthly Beach Volume variations for October 2023 to September 2024 for the offshore part

There were no offshore surveys conducted in September 2023 at any of the locations, in December 2023 at CSP34, in February 2024 at CSP53-81, in March 2024 at CS01-25, in April 2025 at CSP40A-81. Hence, these locations were excluded from the analysis of each month. Results are represented graphically in **Figures A.13 to A.18** and in **Table A.2.**

Since there was no offshore data in September 2023, the analysis of October 2023 could not carried out. In October 2023, CSP24 identified data that was incorrect. Therefore, this

profile has been excluded from the analysis for November 2023. In November 2023, Edappadu Beach (CSP01), Neerody (CSP09), Poovar south to Karumkulam (17-23), Karumkulam (CSP25-26), Adimalathura (CSP31 and 34), Azhimala (CSP35A), Mullur (CSP37), the port reclamation area to Kovalam (CSP40A–41), Kovalam (CSP43–44), Kovalam to Panathura (CSP46–48), Punthura (CSP53), Beemapally (CSP60), Valiyathura (CSP65–67), Shangumugham (CSP69–70), Vetucaud to Kochuveli (CSP72–77), and Valiyaveli (CSP79) experienced erosion. Meanwhile, accretion was observed in November 2023 at Edappadu beach to Neerody (CSP02-08), Pozhiyoor to Poovar south (CSP10-16), Pulluvila (CSP27-30), Adimalathura (CSP32-33), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP42 and 45), Panathura (CSP49-52), Punthura to Beemapally (CSP54-59), Cheriyathura to Valiyathura (CSP61-64a), Shangumugham south (CSP68), Shangumugham north (CSP71), Valiyaveli (CSP78), and Thumba (CSP80-81).

In December 2023, erosion took place at Edappadu Beach (CSP02-03), Vallavilay (CSP05-06), Pozhiyoor to Poovar south (CSP12-17), Karumkulam to Pulluvila (26-28), at Adimalathura (CSP31 and 33), Azhimala (CSP35A), in the Port reclamation area (CSP40A), Kovalam (CSP42,44-46), from Panathura south to north (CSP49-50), between Panathura north and Punthura (CSP52-53), at Punthura (CSP55), Beemapally (CSP58), Valiyathura (CSP63-64,67), and from Shangumugham south to north (CSP69-71). During the same month, accretion was observed at the following sites: Edappadu beach (CSP01), Vallavilay (CSP04), Neerody to Pozhiyoor (CSP07-11), Poovar to Karumkulam (CSP18-25), Pulluvila (CSP29-30), Adimalathura (CSP32), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP41 and 43), from Kovalam north to Panathura south (CSP47-48), Panathura north (CSP51), Punthura (CSP54), Punthura (CSP56-57), from Beemapally to Cheriyathura (CSP59-62), Valiyathura (CSP64a-66), Shangumugham south (CSP68), and from Vettucaud to Thumba (CSP72-81).

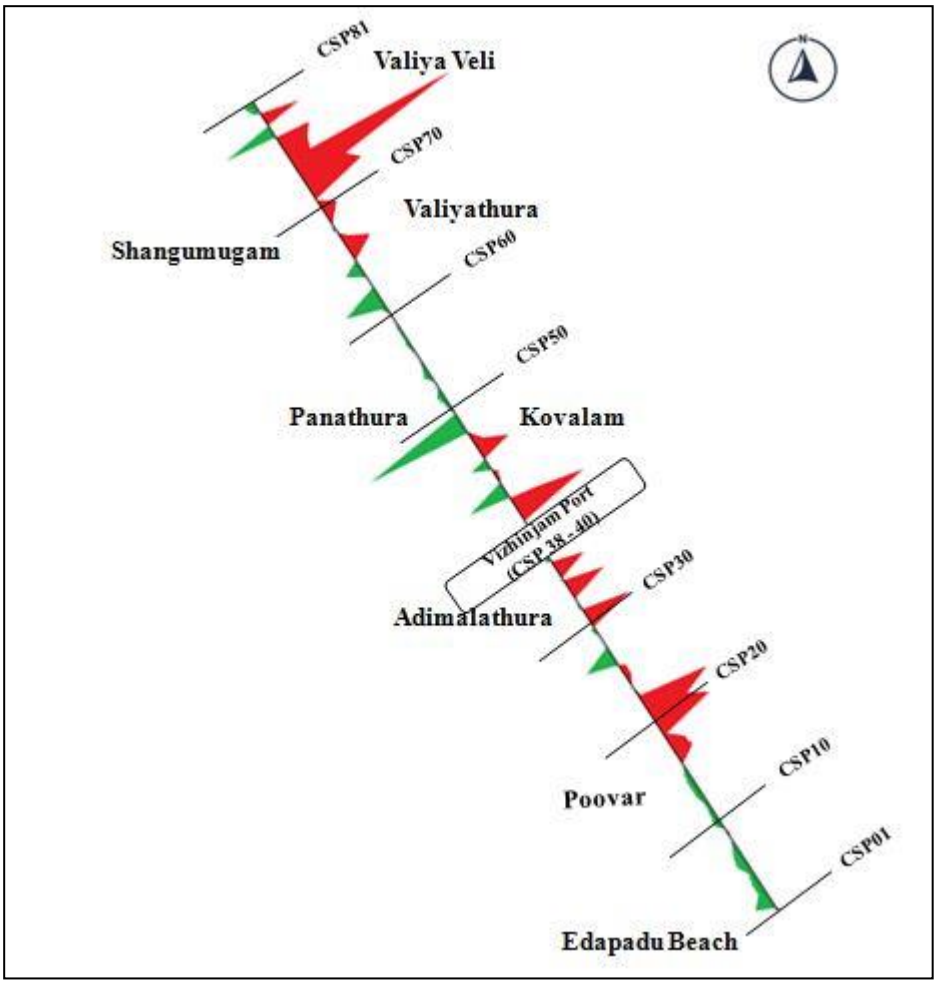
A profile was found to be erroneous at CSP40A in January 2024, resulting in its exclusion from the analysis. Erosion was observed from Edappadu beach (CSP01), Neerody to Pozhiyoor (CSP07-12), Paruthiyoor to Poovar south (CSP14-16), Poovar to Karumkulam (CSP18-25), Pulluvila (CSP27), between Pulluvila and Adimalathura (CSP29-31), Adimalathura to Mullur (CSP33-37), from Punthura to Valiyathura (CSP56-64), in Shangumugham south (CSP68), at Kochuveli (CSP75-76), and at Valiyaveli (CSP78). Accretion was recorded at Edappadu beach to Vallavilay (CSP02-06), Paruthiyoor (CSP13), Poovar south (CSP17), Karumkulam (CSP26), Pulluvila (CSP28), Adimalathura

(CSP32), along the stretch from Kovalam to Panathura north (CSP41-52), at Punthura (CSP53, 55), at Valliyathura (CSP64A-67), at Kochuveli (CSP77), and from Valiyaveli to Thumba (CSP79-81) in January 2024.

The same data was observed in January and February of 2024 at CSP23, and errors were found in the profiles at CSP40A and CSP35A. In February 2024, erosion was observed at Edappadu Beach (CSP01), from Edappadu Beach to Poovar South (CSP03-15), Poovar South (CSP17), between Poovar and Poovar North (CSP19-21), from Karumkulam to Pulluvila (CSP24-30), Adimalathura (CSP32-34), and in Kovalam (CSP43). Conversely, accretion was noted at Edappadu Beach (CSP02), Poovar South (CSP16), Poovar (CSP18), Karumkulam (CSP22), Adimalathura (CSP31), from Azhimala to Mullur (CSP35-37), and in Kovalam (CSP41-42), as well as between Kovalam and Panathura north (CSP44-52).

Beach erosion was seen in Pulluvila (CSP28-29), Adimalathura (CSP32-33), Kovalam (CSP41-43,46), and Panathura South (CSP49) in March 2024. At Pulluvila (CSP26-27), Pulluvila to Adimalathura (CSP30-31), Adimalathura to Mullur (CSP34-37), Kovalam (CSP44-45), Kovalam north to Panathura south (CSP47-48), and Panathura north (CSP50-52), accretion was also discovered in March 2024.

In April 2024, erosion occurred at Azhimala (CSP35A) and Karumkulam to Adimalathura (CSP26-31). An accretion was found at Adimalathura to Azhimala (CSP32-35), Mullur (CSP36-37).



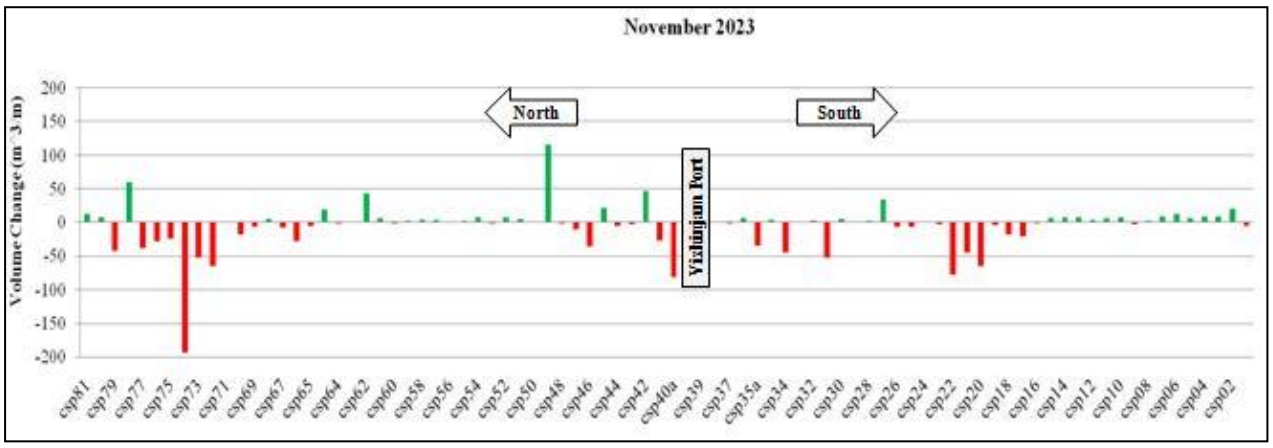
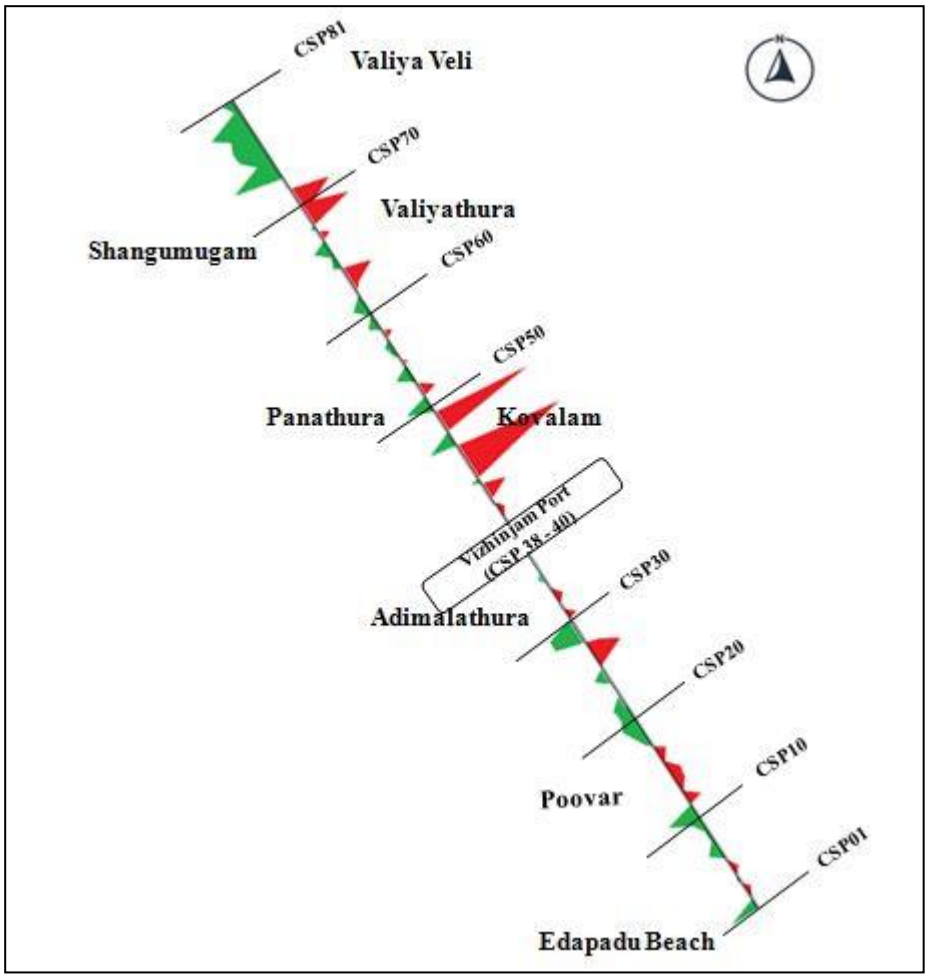


Figure A.13 Monthly Beach Volume Changes in November 2023 in m^3/m (offshore)



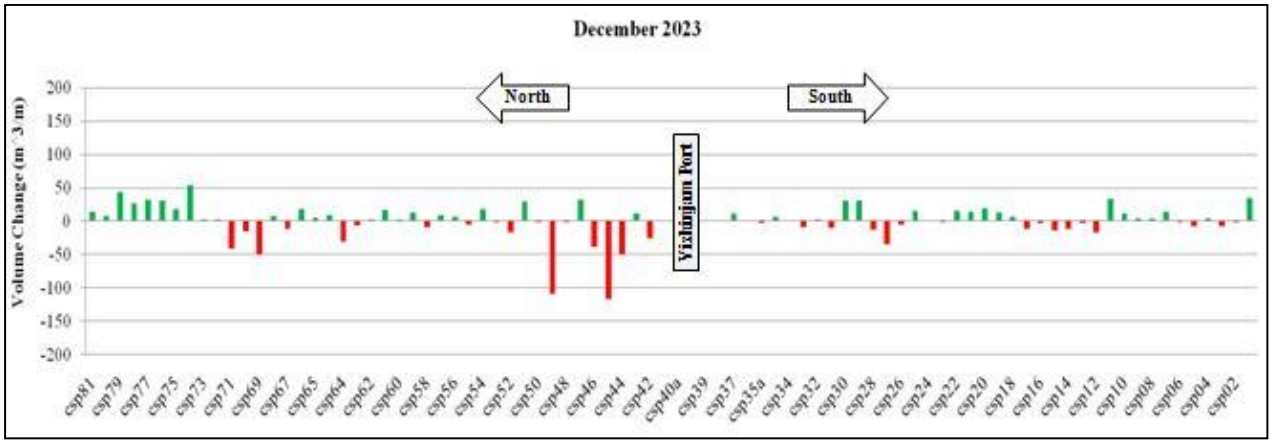
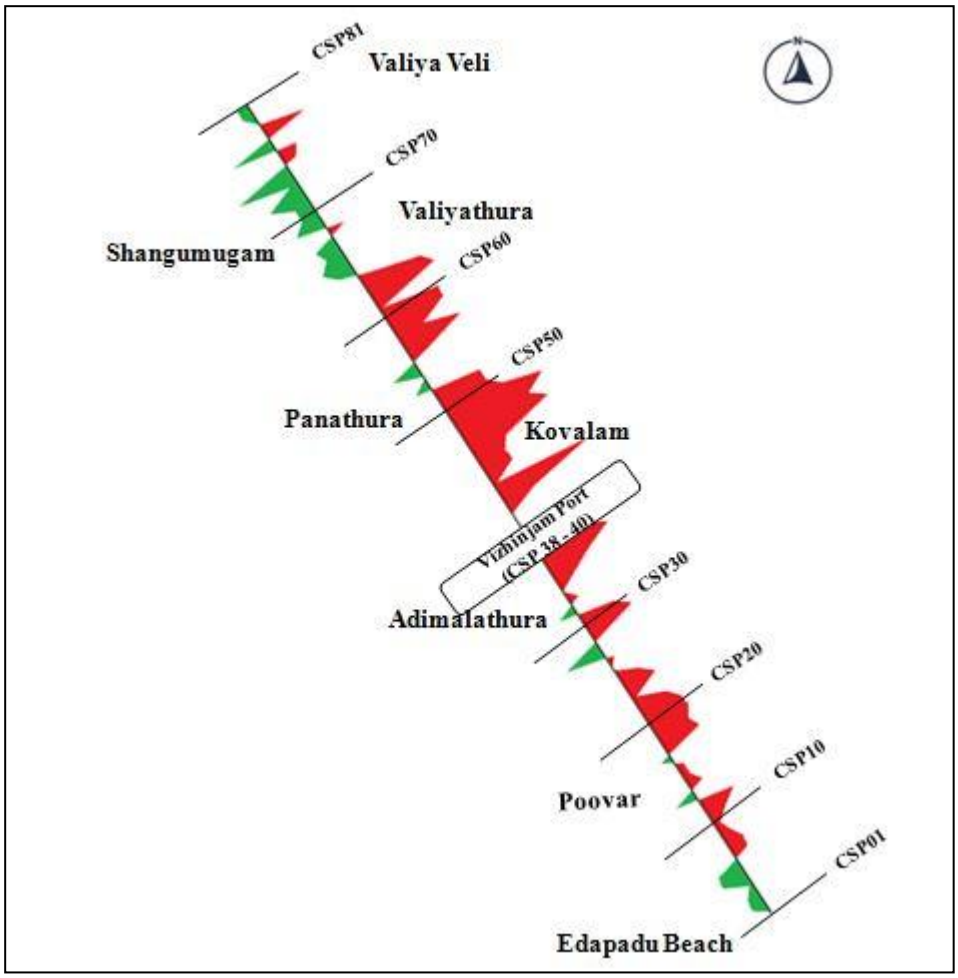


Figure A.14 Monthly Beach Volume Changes in December 2023 in m^3/m (offshore)



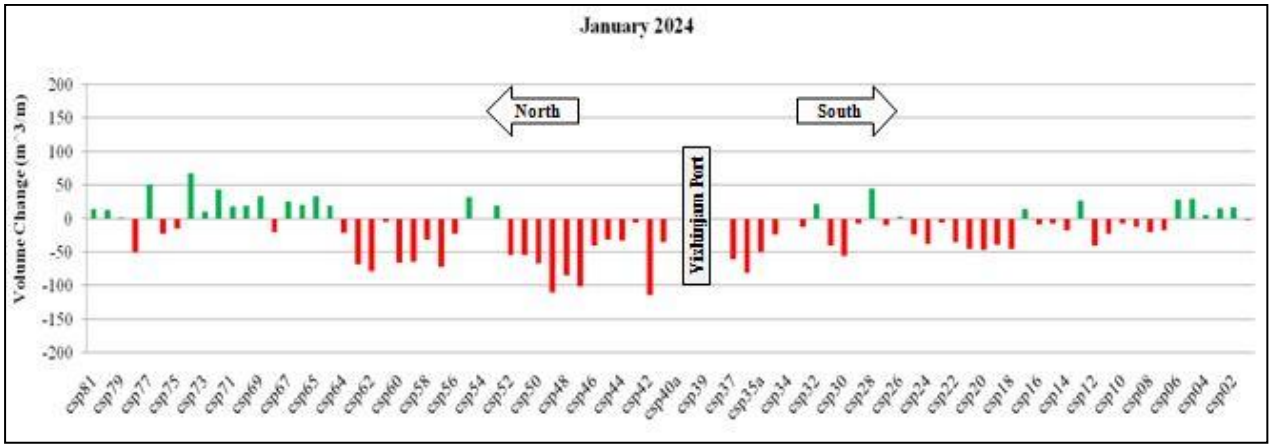
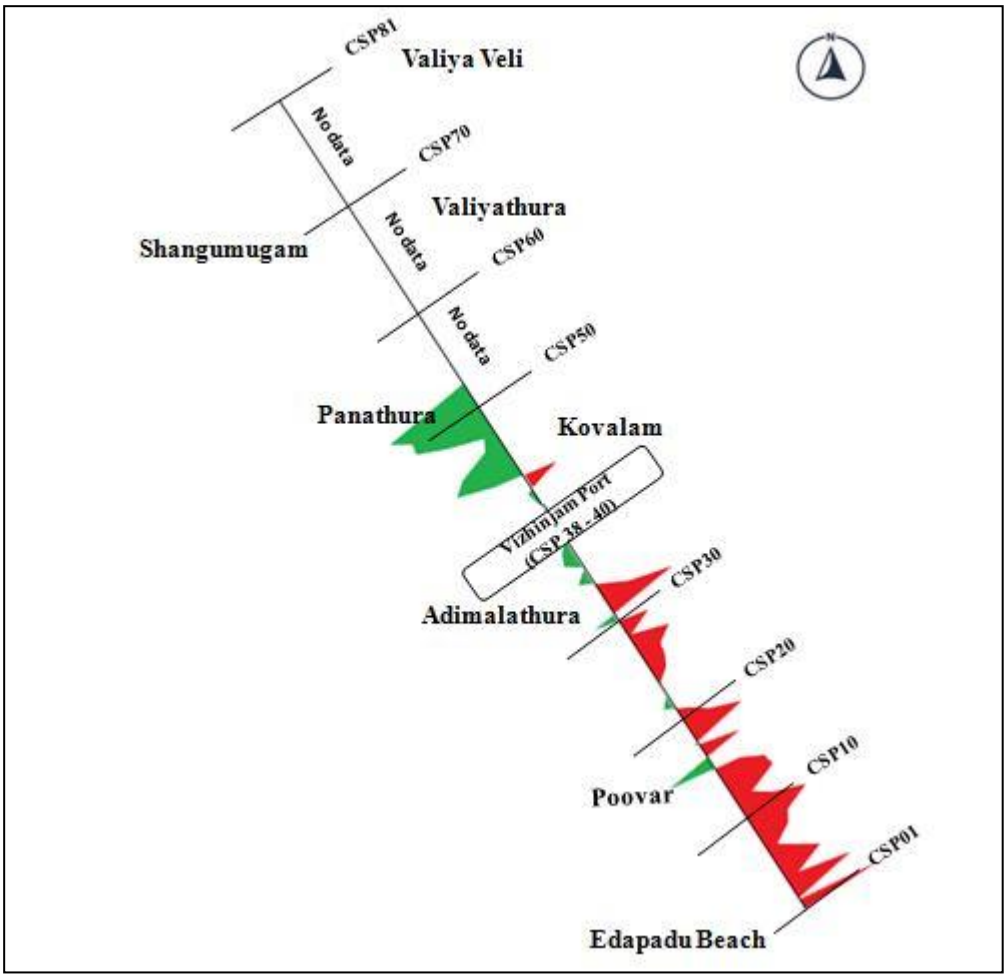


Figure A.15 Monthly Beach Volume Changes in January 2024 in m^3/m (offshore)



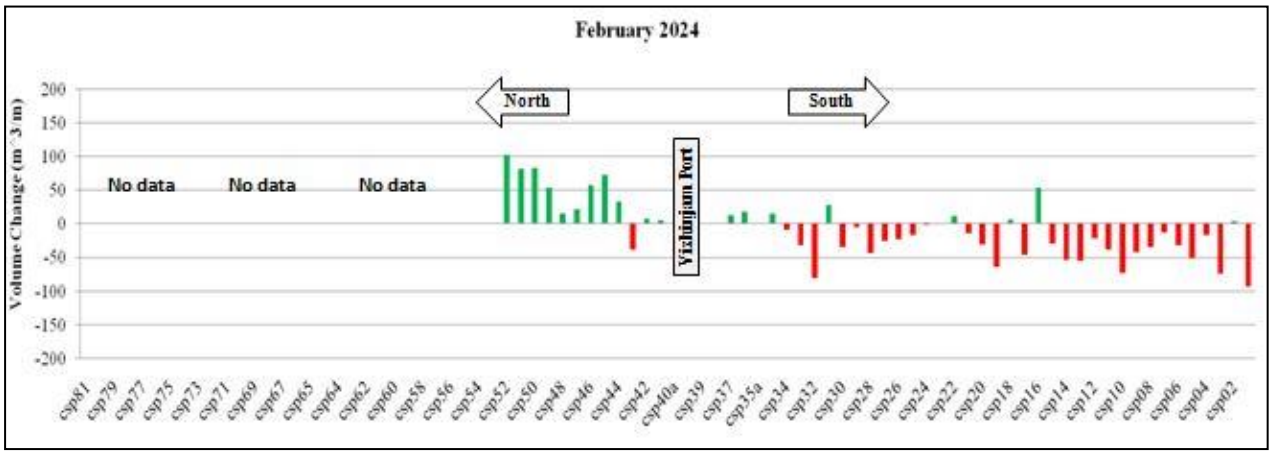
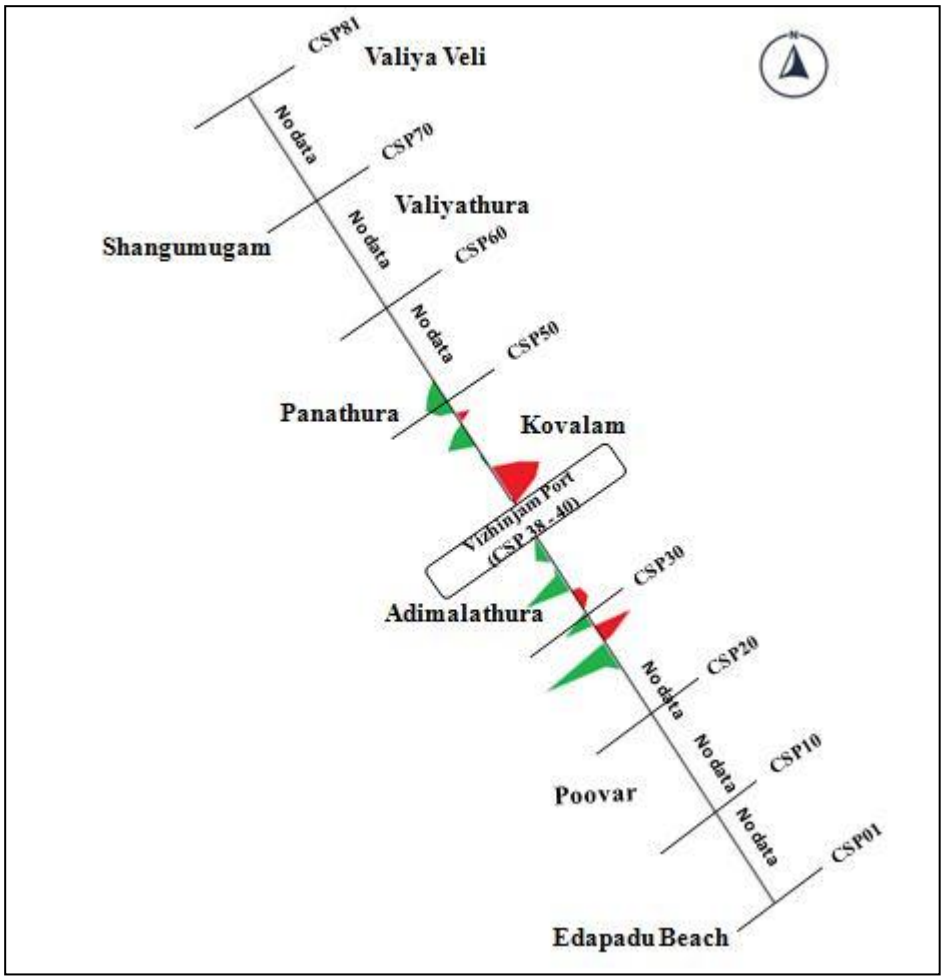


Figure A.16 Monthly Beach Volume Changes in February 2024 in m^3/m (offshore)



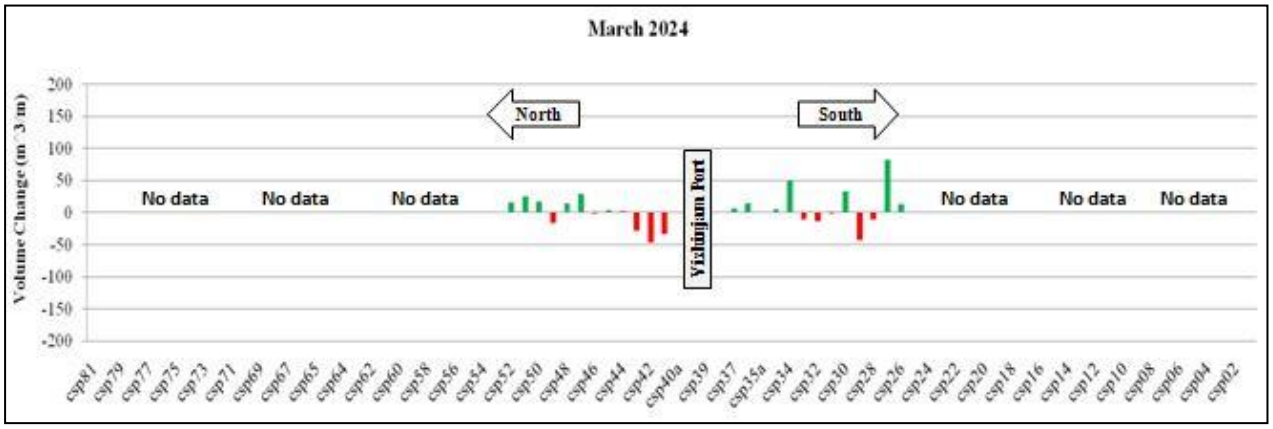
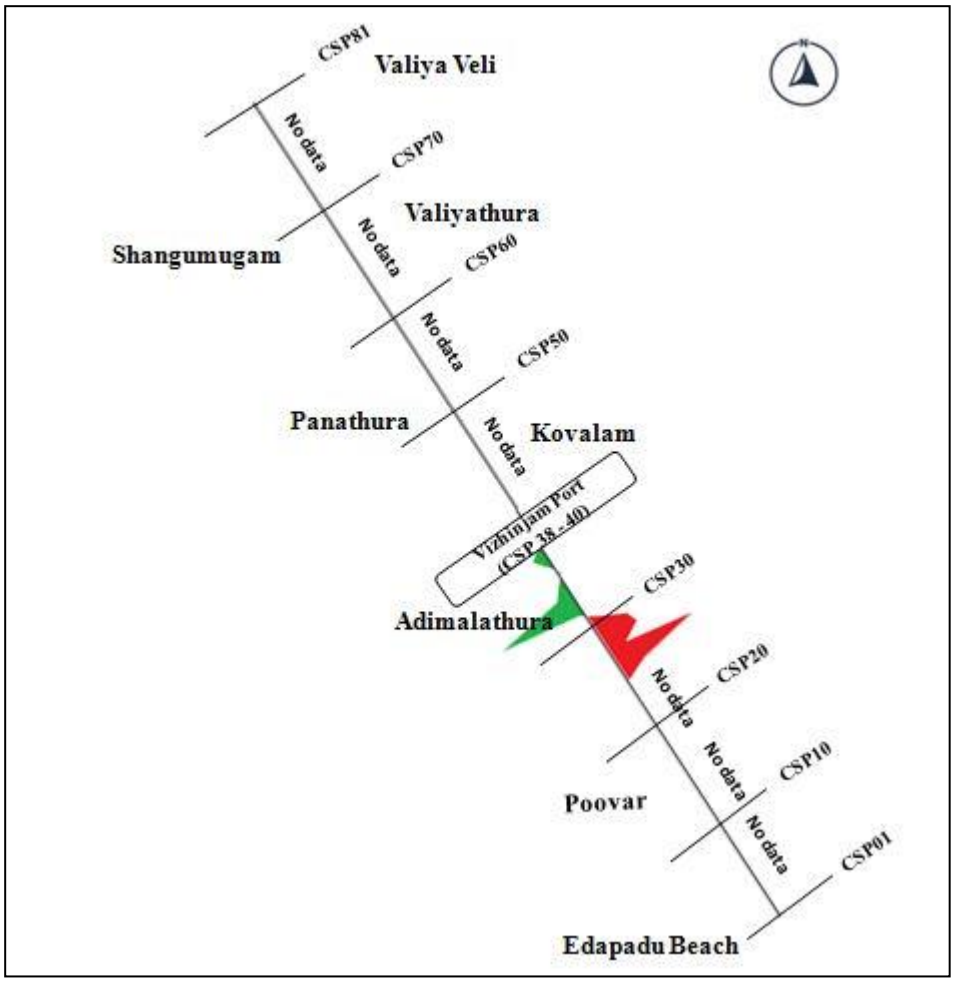


Figure A.17 Monthly Beach Volume Changes in March 2024 in m^3/m (offshore)



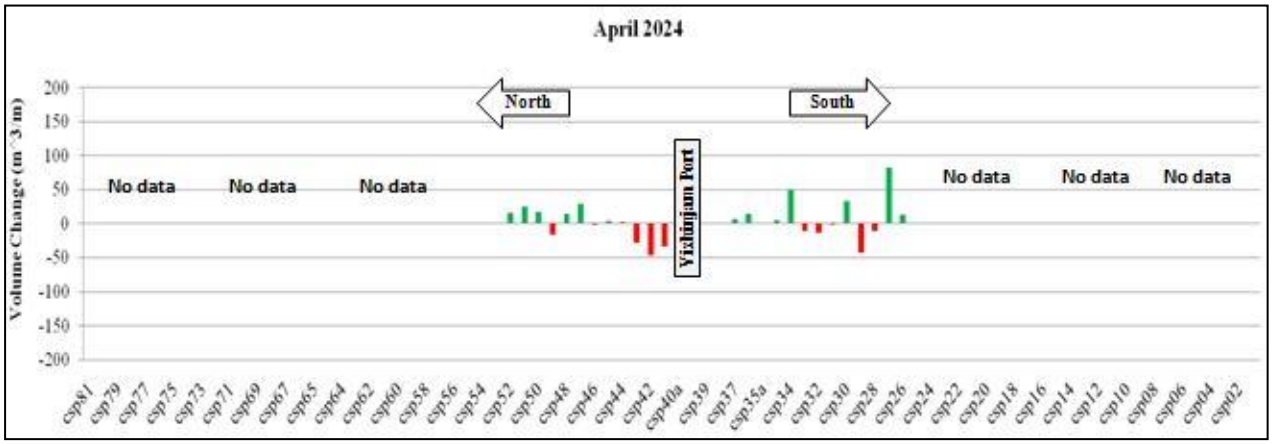


Figure A.18 Monthly Beach Volume Changes in April 2024 in m^3/m (offshore)

Table A.2 Monthly Beach Volume Changes from October 2023 to September 2024 in m^3/m (offshore)

CSP NOs.	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mar 2024	April 2024	May 2024	June 2024	July 2024	Aug 2024	Sep 2024
CSP01	-	-5.68	34.39	-2.19	-92.89	-	-	-	-	-	-	-
CSP02	-	21	-0.87	17.15	3.27	-	-	-	-	-	-	-
CSP03	-	9.29	-7.51	15.33	-74.37	-	-	-	-	-	-	-
CSP04	-	8.97	3.9	5.4	-16.11	-	-	-	-	-	-	-
CSP05	-	6.05	-8	30.04	-51.32	-	-	-	-	-	-	-
CSP06	-	12.26	-0.84	28.75	-31.66	-	-	-	-	-	-	-
CSP07	-	9.25	14.1	-17.62	-13.29	-	-	-	-	-	-	-
CSP08	-	2.91	3.49	-19.94	-34.8	-	-	-	-	-	-	-
CSP09	-	-2.63	3.58	-12.54	-41.9	-	-	-	-	-	-	-
CSP10	-	7.9	11.08	-7.14	-73.03	-	-	-	-	-	-	-
CSP11	-	6.31	33.59	-22.15	-38.64	-	-	-	-	-	-	-
CSP12	-	4.21	-16.53	-40.36	-21.14	-	-	-	-	-	-	-
CSP13	-	7.78	-2.51	26.74	-55.03	-	-	-	-	-	-	-
CSP14	-	7.3	-11.53	-16.91	-53.19	-	-	-	-	-	-	-
CSP15	-	6.74	-13.53	-7.75	-29.98	-	-	-	-	-	-	-
CSP16	-	0.6	-2.85	-8.1	53.93	-	-	-	-	-	-	-
CSP17	-	-19.76	-11.92	13.93	-46.3	-	-	-	-	-	-	-
CSP18	-	-17.77	6.09	-45.35	6.18	-	-	-	-	-	-	-
CSP19	-	-3.96	12.55	-39.02	-64.48	-	-	-	-	-	-	-
CSP20	-	-64.9	19.31	-46.86	-30.82	-	-	-	-	-	-	-
CSP21	-	-44.57	13.63	-45.2	-13.83	-	-	-	-	-	-	-
CSP22	-	-77.51	15.33	-35.12	11.36	-	-	-	-	-	-	-
CSP23	-	-2.86	0.41	-5.55	*	-	-	-	-	-	-	-
CSP24	-	*	1.22	-37.24	-0.25	-	-	-	-	-	-	-
CSP25	-	-6.37	15.22	-23.16	-16.39	-	-	-	-	-	-	-
CSP26	-	-5.93	-4.88	2.63	-22.70	12.46	-28.14	-	-	-	-	-
CSP27	-	34.58	-34.58	-9.21	-25.14	81.62	-96.57	-	-	-	-	-
CSP28	-	2.40	-13.44	45.16	-43.92	-11.29	-21.01	-	-	-	-	-
CSP29	-	0.92	31.03	-6.86	-4.60	-43.50	-42.58	-	-	-	-	-
CSP30	-	5.64	31.23	-56.05	-34.19	32.81	-37.82	-	-	-	-	-
CSP31	-	-52.55	-10.70	-39.66	28.06	0.01	-13.09	-	-	-	-	-
CSP32	-	3.07	2.20	22.34	-80.44	-13.11	6.51	-	-	-	-	-
CSP33	-	0.97	-9.45	-11.66	-32.32	-10.77	95.13	-	-	-	-	-
CSP34	-	-44.03	-	-	-8.71	50.41	17.99	-	-	-	-	-
CSP35	-	4.44	6.31	-24.07	15.58	4.99	8.53	-	-	-	-	-
CSP35A	-	-34.65	-2.22	-49.26	*	*	-3.76	-	-	-	-	-
CSP36	-	6.69	1.07	-81.16	17.36	13.73	7.07	-	-	-	-	-
CSP37	-	-0.76	11.12	-60.95	12.13	6.88	16.77	-	-	-	-	-
CSP38 CSP39 CSP40	Port Area											
CSP40A	-	-82.12	-7.69	*	*	*	-	-	-	-	-	-
CSP41	-	-27.14	0.87	-35.03	4.58	-34.21	-	-	-	-	-	-
CSP42	-	46.82	-25.62	-113.86	7.61	-47.43	-	-	-	-	-	-
CSP43	-	-2.24	12.14	-5.63	-38.48	-28.48	-	-	-	-	-	-
CSP44	-	-5.16	-50.1	-32.46	32.94	2.12	-	-	-	-	-	-
CSP45	-	21.04	-117.05	-31.18	72.82	3.7	-	-	-	-	-	-
CSP46	-	-35.74	-38.65	-39.91	57.83	-1.61	-	-	-	-	-	-
CSP47	-	-10.76	31.58	-101.62	21.48	29.14	-	-	-	-	-	-
CSP48	-	-1.85	0.18	-85.13	14.79	13.71	-	-	-	-	-	-
CSP49	-	116.36	-109	-110.48	53.62	-16.1	-	-	-	-	-	-
CSP50	-	1.86	-0.54	-67.32	82.98	16.78	-	-	-	-	-	-
CSP51	-	4.48	29.31	-53.77	82.12	24.96	-	-	-	-	-	-
CSP52	-	8	-16.62	-54.64	101.66	14.97	-	-	-	-	-	-
CSP53	-	-1.83	-0.9	19.57	-	-	-	-	-	-	-	-

CSP54	-	8.22	18.21	-1.18	-	-	-	-	-	-	-	-
CSP55	-	3.06	-5.58	32.37	-	-	-	-	-	-	-	-
CSP56	-	1.33	5.77	-22.94	-	*	-	-	-	-	-	-
CSP57	-	3.86	8.87	-71.36	-	-	-	-	-	-	-	-
CSP58	-	3.47	-9.52	-31.85	-	-	-	-	-	-	-	-
CSP59	-	2.8	12.87	-64.54	-	-	-	-	-	-	-	-
CSP60	-	-0.16	3.16	-66.11	-	-	-	-	-	-	-	-
CSP61	-	6.51	16.65	-4.39	-	-	-	-	-	-	-	-
CSP62	-	43.55	2.17	-77.81	-	-	-	-	-	-	-	-
CSP63	-	1.48	-7.01	-67.67	-	-	-	-	-	-	-	-
CSP64	-	0.37	-31.47	-21.2	-	-	-	-	-	-	-	-
CSP64A	-	19.42	9.46	19.82	-	-	-	-	-	-	-	-
CSP65	-	-5.51	4.52	33.16	-	-	-	-	-	-	-	-
CSP66	-	-28.1	18.06	20.44	-	-	-	-	-	-	-	-
CSP67	-	-7.22	-11.14	26.21	-	-	-	-	-	-	-	-
CSP68	-	4.54	7.42	-20.03	-	-	-	-	-	-	-	-
CSP69	-	-6.47	-50.25	34.01	-	-	-	-	-	-	-	-
CSP70	-	-17.47	-15	19.06	-	-	-	-	-	-	-	-
CSP71	-	0.79	-41.48	18.85	-	-	-	-	-	-	-	-
CSP72	-	-64.4	2.62	44.2	-	-	-	-	-	-	-	-
CSP73	-	-52.53	2.11	11.21	-	-	-	-	-	-	-	-
CSP74	-	-193.08	54.4	68.04	-	-	-	-	-	-	-	-
CSP75	-	-23.91	17.91	-14.37	-	-	-	-	-	-	-	-
CSP76	-	-28.42	30.71	-22.66	-	-	-	-	-	-	-	-
CSP77	-	-38.13	32.34	51.84	-	-	-	-	-	-	-	-
CSP78	-	59.38	27.1	-50.37	-	-	-	-	-	-	-	-
CSP79	-	-42.24	43.51	1.51	-	-	-	-	-	-	-	-
CSP80	-	7.51	7.47	13.67	-	-	-	-	-	-	-	-
CSP81	-	12.93	14.27	13.88	-	-	-	-	-	-	-	-

*Data not considered for analysis

-No data

A.1.3 Seasonal and Overall Beach Volume variations from October 2023 to September 2024

Seasonal variation has been analysed as post-monsoon (October 2023 to November 2023), fair weather period (December 2023 to March 2024), pre-monsoon period (April 2024 to May 2024) and Monsoon (June 2024 to September 2024) for the period October 2023 to September 2024. 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.19 to A.25** and **Table A.3 and Table A.4.**

No offshore surveys were conducted in September 2023 and from May to September 2024 for any of the 81 locations. As a result, the analysis for the monsoon season (June-September 2024) and pre-monsoon (April-May 2024) for the offshore could not be

performed. No onshore surveys were carried out from CSP23-30 during any month from September 2023 to September 2024.

Beach Volume Change in Post monsoon Period 2023 (October 2023-November 2023)-onshore

There was a lack of onshore survey at CSP16, 31-33, 35,67 in October 2023 and at CSP23-30 in October and November 2023, resulting in the inability to conduct analysis in these areas.

In Post monsoon 2023, accretion occurred in the following locations on the onshore: Vallavilay (04-05), Neerody (CSP07-09), Poovar south (CSP15), Poovar north (CSP20-21), Adimalathura (CSP34), the stretch from Adimalathura to Mullur (CSP35A-37), Kovalam (CSP40A), Kovalam (CSP42-44), Punthura (CSP53), Valiyathura (CSP64A), the area from Shangumugham south to Shangumugham north (CSP68-71), Vettucaud (CSP73), and Kochuveli (CSP75). Edappadu beach (CSP02), Pozhiyoor (CSP10), Poovar (CSP19), Karumkulam (CSP22), Kovalam (CSP45-46), Punthura (CSP54), Beemapally (CSP60), Cheriyathura (CSP62), Vettucaud (CSP72,74), and the section from Kochuveli to Thumba (CSP76-81) are the locations where erosion has been reported in Post monsoon 2023. The findings are displayed in Figure A.19.

Beach Volume Change in Post monsoon Period 2023 (October 2023-November 2023)-offshore

In October 2023, CSP24 identified data that was incorrect. Therefore, this profile has been excluded from the analysis. In post-monsoon 2023 on the offshore, Edappadu Beach (CSP01), Neerody (CSP09), Poovar south to Karumkulam (17-23), Karumkulam (CSP25-26), Adimalathura (CSP31 and 34), Azhimala (CSP35A), Mullur (CSP37), the port reclamation area to Kovalam (CSP40A-41), Kovalam (CSP43-44), Kovalam to Panathura (CSP46-48), Punthura (CSP53), Beemapally (CSP60), Valiyathura (CSP65-67), Shangumugham (CSP69-70), Vetucaud to Kochuveli (CSP72-77), and Valiyaveli (CSP79) experienced erosion. Meanwhile, accretion was observed at Edappadu beach to Neerody (CSP02-08), Pozhiyoor to Poovar south (CSP10-16), Pulluvila (CSP27-30), Adimalathura (CSP32-33), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP42 and 45), Panathura (CSP49-52), Punthura to Beemapally (CSP54-59), Cheriyathura to Valiyathura (CSP61-

64a), Shangumugham south (CSP68), Shangumugham north (CSP71), Valiyaveli (CSP78), and Thumba (CSP80-81). Results are shown in Figure A.20

Beach Volume Change in Fair Weather Period 2024 (December 2023-March 2024)-onshore

No onshore survey was conducted at CSP7-8 in March 2024, at CSP34 and 54 in December 2023, and at CSP 23-30 in December and March. Therefore, analysis could not be performed at these locations.

In fair weather, the beach displays accretion along Edappadu Beach (CSP02), Vallavilay (CSP04-05), Pozhiyoor (CSP10), Poovar to Karumkulam (CSP19-22), Adimalathura (CSP31-33), Azhimala to Mullur (CSP35-37), Kovalam (CSP43 and 46), Punthura (CSP55), Beemapally (CSP60), Cheriyathura (CSP62), Valiyathura (CSP64A), Valiyathura to Shangumugham (CSP67-68), Vettucaud (CSP73-74), Valiyaveli (CSP78), Thurmba (CSP 80). The following areas have demonstrated erosion during the fair weather season: Neerody (CSP09), Poovar South to Poovar (CSP15-18), Port reclamation area (CSP40A), Kovalam (CSP42 and 44-45), Punthura (CSP53), Shangumugham to Vettucaud (CSP69-72), Kochuveli (CSP75-77), Valiyaveli (CSP79), and Thumba (CSP81). Figure A.21 displays the results for the onshore part.

Beach Volume Change in Fair Weather Period 2024 (December 2023-March 2024)-offshore

The offshore survey was not conducted at CSP34 in December 2023 and at 1-25, while an error was detected at 56 and 64A in March 2024. Hence, profiles are not included in the analysis.

During the fair weather season of 2024, beach erosion was observed at the following locations: Karumkulam (CSP26), Pulluvila to Adimalathura (CSP28-33), Azhimala (CSP35), Mullur (CSP36-37), Port reclamation area to Kovalam (CSP40A-43), Kovalam to Panathura (CSP47-49), Punthura (CSP57), Valiyathura to Shangumugham (CSP64a,65-71), and Kochuveli to Thumba (CSP75-81). Conversely, beach accretion occurred at Pulluvila (CSP27), Azhimala (CSP35A), Kovalam (CSP44-46), Panathura to Punthura (CSP50-55), Beemapally to Valiyathura (CSP58-63), and Vettucaud (CSP72-74). Results are shown in Figure A.22.

Beach Volume Change in Pre Monsoon 2024 (April 2024-May 2024)-onshore

In April 2024, there were no surveys at CSP02, CSP04, CSP05, CSP07, CSP08, CSP40A and CSP76. Therefore, these locations are not included in the analysis.

In Pre-monsoon 2024, accretion was noted at Neerody (CSP09), Poovar South (CSP15), Poovar North (CSP17-20), Karumkulam (CSP22), Adimalathura (CSP31-32), Azhimala (CSP35), Kovalam (CSP43-44), Punthura (CSP53-55), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham South (CSP69), Shangumugham North (CSP71), Kochuveli (CSP75,77), and from Valiyaveli to Thumba (CSP79-80). Erosion was recorded at Pozhiyoor (CSP10), Poovar North (CSP21), Adimalathura (CSP34), Azhimala (CSP35A), Kovalam (CSP42,45-46), Valliyathura (CSP64A), the stretch from Valliyathura to Shangumugham South (CSP67-68), Shangumugham North (CSP70), Vettucaud (CSP74), Valiyaveli (CSP78), and Thumba (CSP81). Results are shown in Figure A.23.

Beach Volume Change in Pre Monsoon 2024 (April 2024-May 2024)-offshore

No survey was conducted offshore during May 2024.

Beach Volume Change in Monsoon 2024 (June 2024-September 2024)-onshore

No surveys were conducted at CSP01-11 and CSP64A in September 2024, nor at CSP13, 14, 16, 46, 67, and 68 in June 2024 on the onshore. Additionally, no survey was performed at CSP35A during June and September 2024. An error was detected at CSP15 in June 2024. CSP35 displayed identical data for May and June. Surveys conducted at CSP12 and CSP72 in June 2024 covered distances of less than 10 meters, resulting in these profiles being excluded from the analysis.

Locations from south Poovar to north Poovar (CSP17-20), the port reclamation area (CSP40A), Punthura (CSP53-54), Beemapally (CSP60), Cheriyathura (CSP62), Shangumugham south (CSP69), Shangumugham north (CSP71), Vettucaud to Kochuveli (CSP73-76), and Valiyaveli to Thumba (CSP78-81) were observed to have accretion, whereas areas from north Poovar to Kaumkulam (CSP21-22), Adimalathura (CSP31-34), Mullur (CSP36-37), Kovalam (CSP42-45), Punthura (CSP55), Shangumugham north (CSP70), and Kochuveli (CSP77) experienced erosion during the monsoon season of 2024 on the onshore. The results are illustrated in Figure A.24.

Beach Volume Change in Monsoon 2023 (June 2024-September 2024)-offshore

No offshore survey was carried out from June 2024 to September 2024.

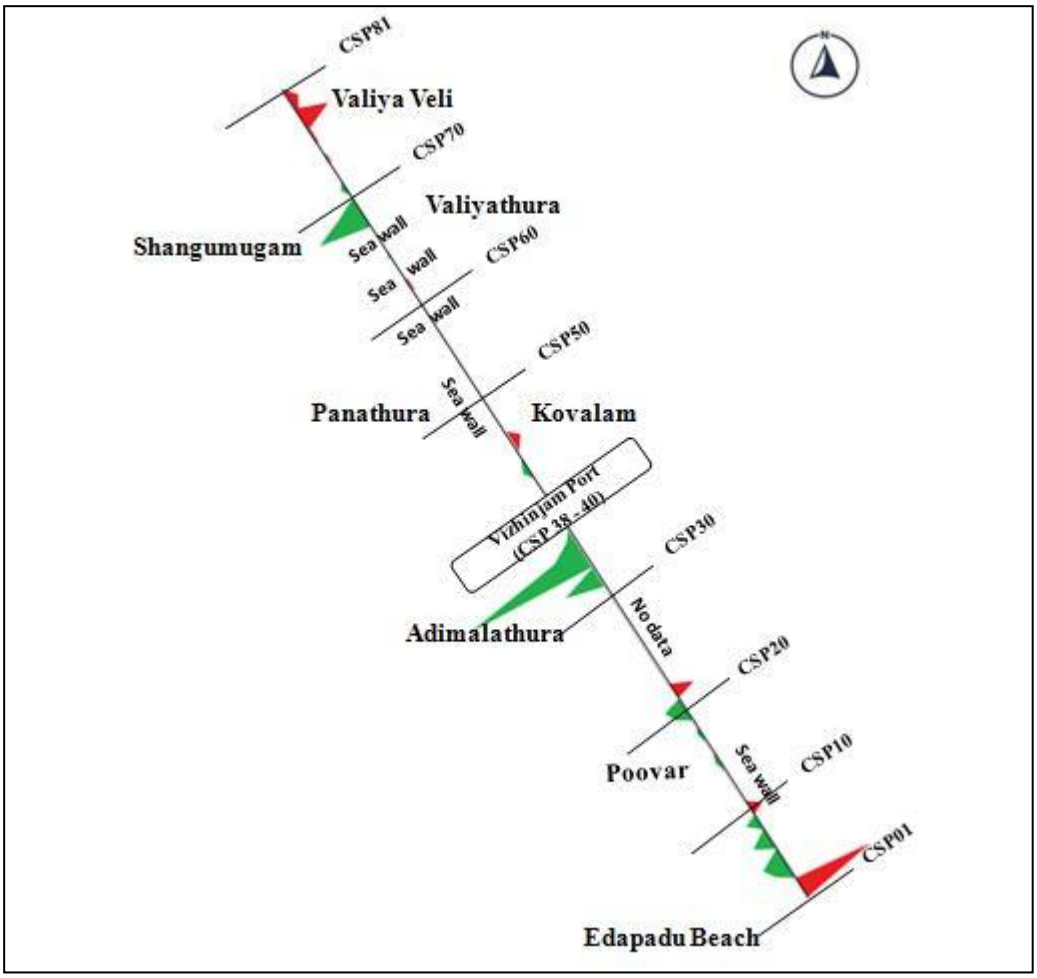
Overall beach volume variation from October 2023 to September 2024 (onshore)

No surveys took place at CSP01-11, 35A, and CSP64A in September 2024. Additionally, there were no onshore surveys at CSP16 and CSP31-33, 35,67 in October 2023. In October 2023, CSP55 detected inaccuracies in the data on the onshore.

From October 2023 to September 2024, erosion has been observed onshore 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). Meanwhile, accretion has been detected onshore 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). The results are illustrated in Figure A.25.

Overall beach volume variation from October 2023 to September 2024 (offshore)

No offshore survey was conducted in September 2024 in any of the locations.



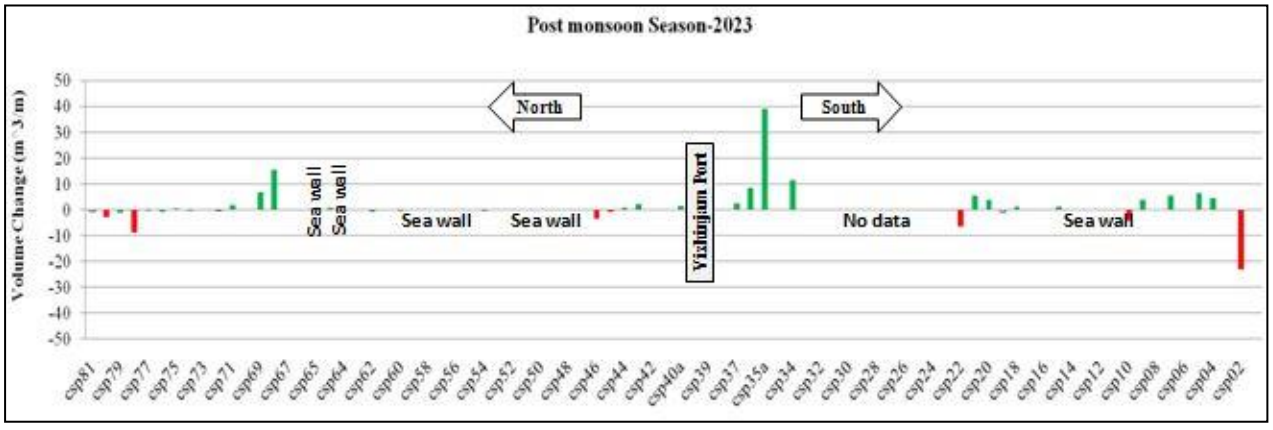
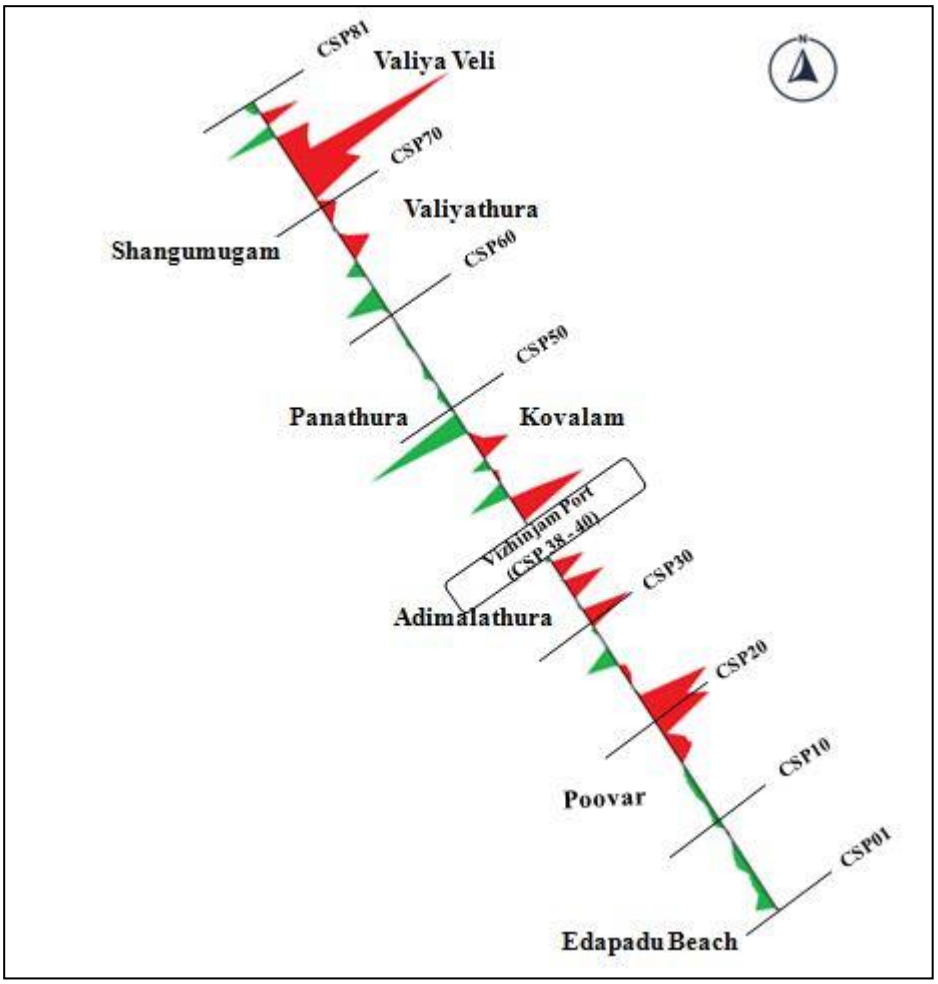


Figure A.19 Seasonal Beach Volume Changes during Post monsoon Period in m³/m (onshore)



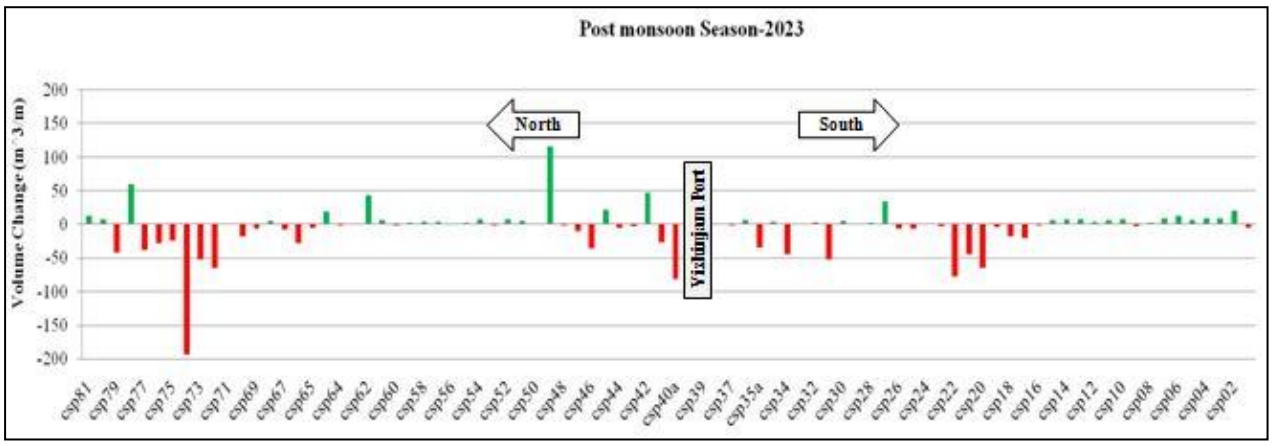
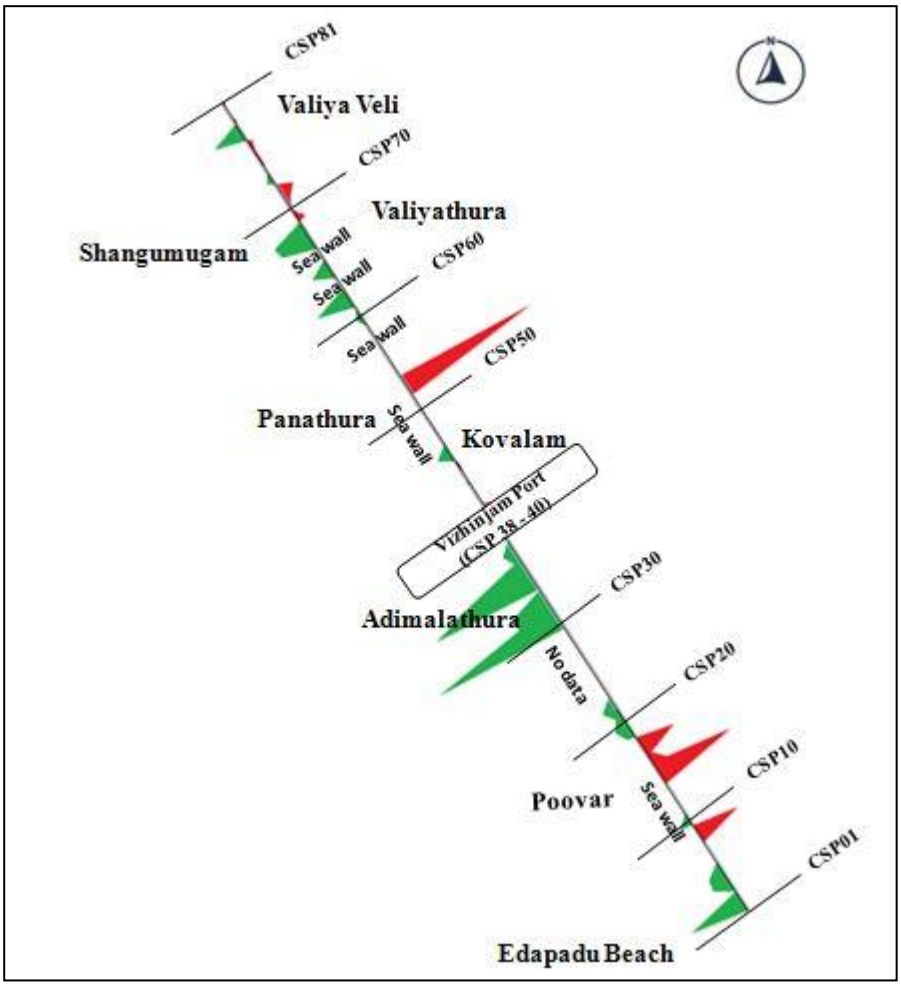


Figure A.20 Seasonal Beach Volume Changes during Post monsoon Period in m³/m (offshore)



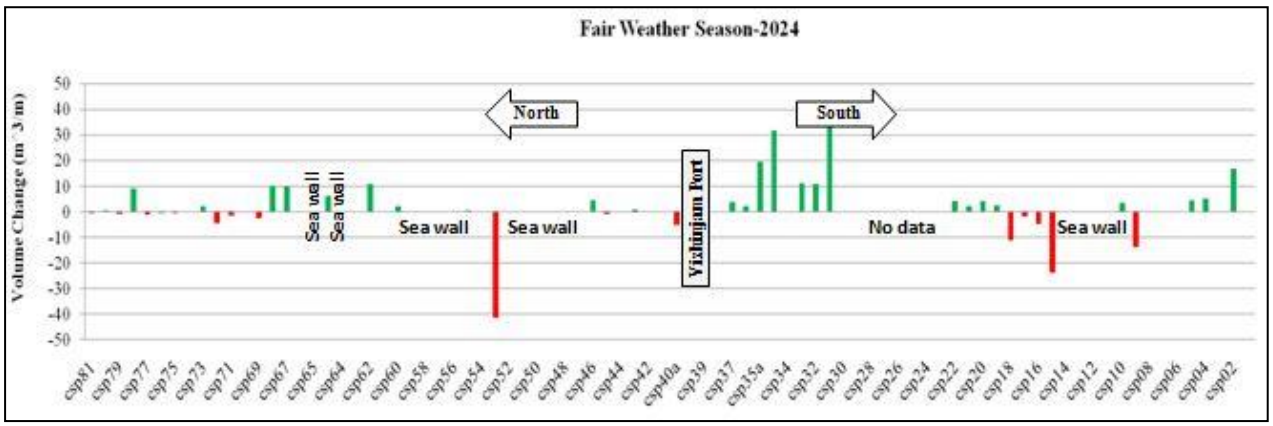
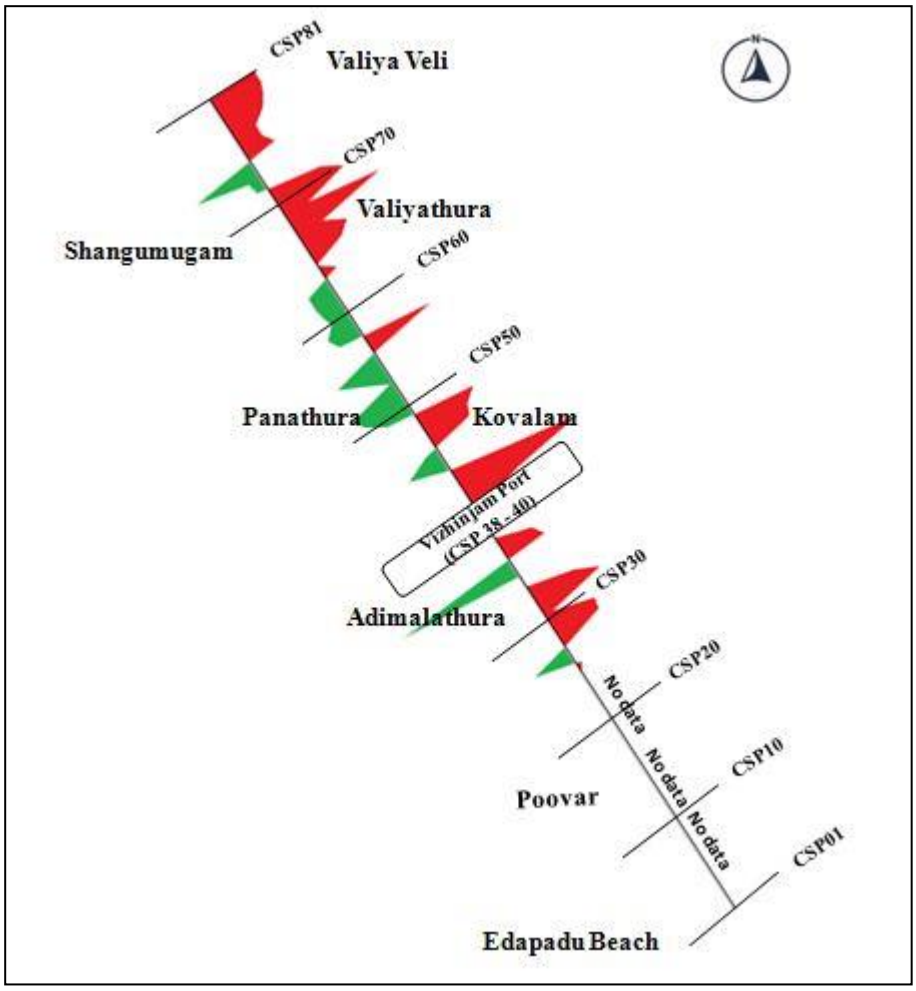


Figure A.21 Seasonal Beach Volume Changes during Fair Weather Period in m³/m (onshore)



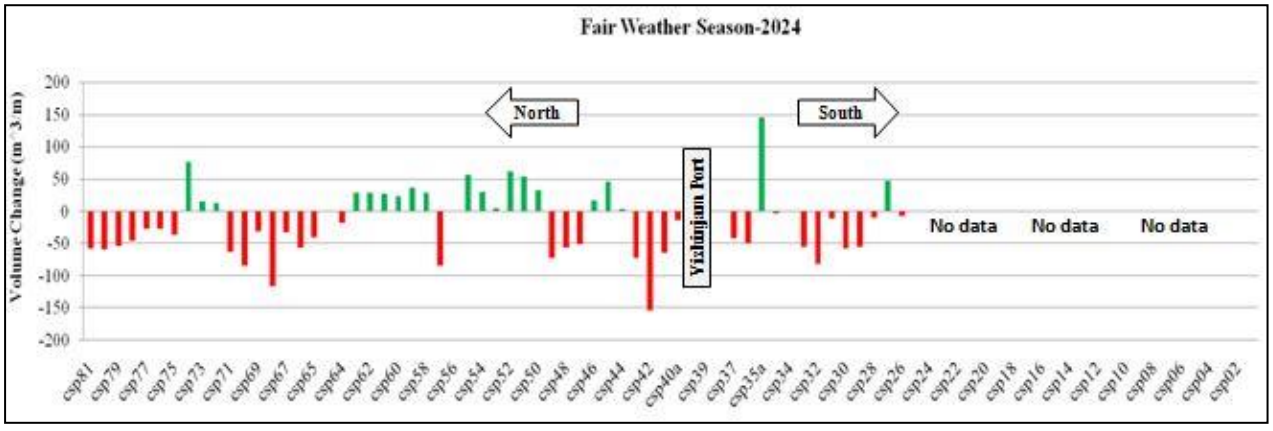
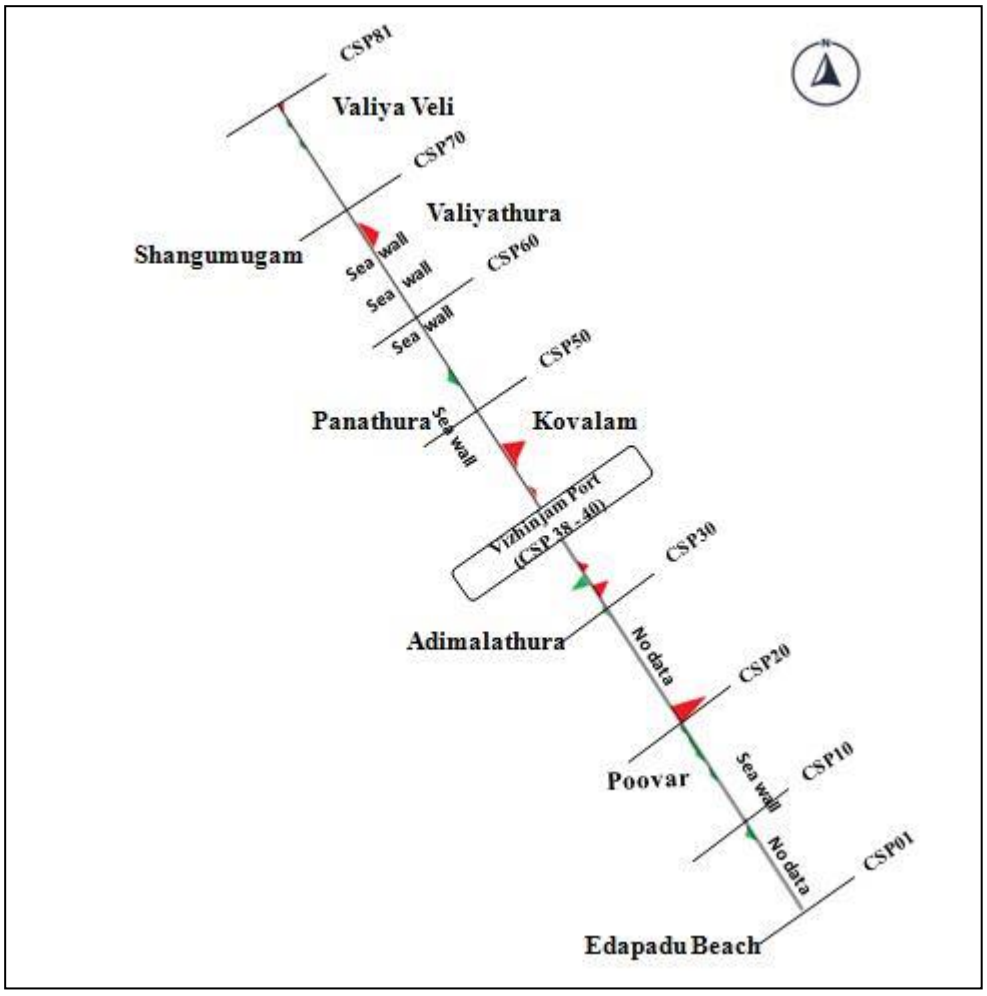


Figure A.22 Seasonal Beach Volume Changes during Fair Weather Period in m^3/m (offshore)



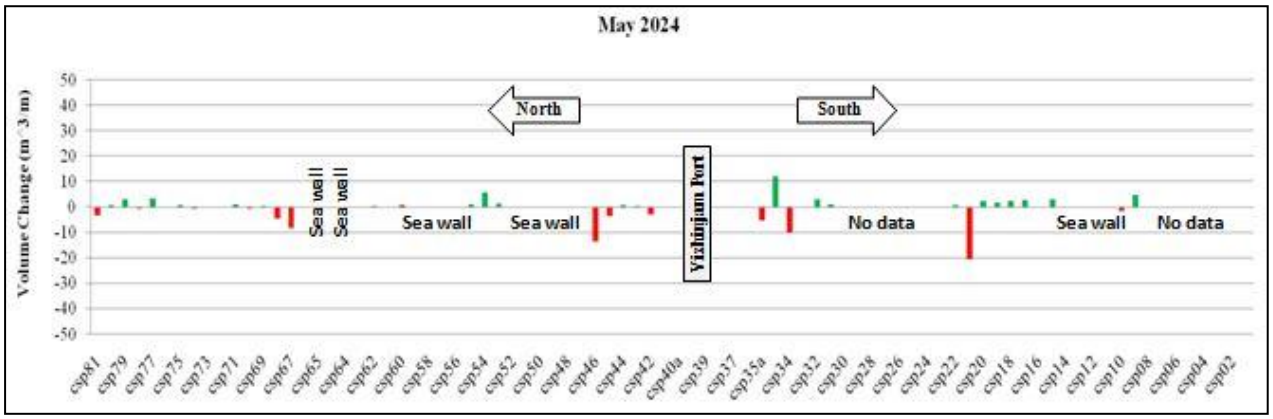
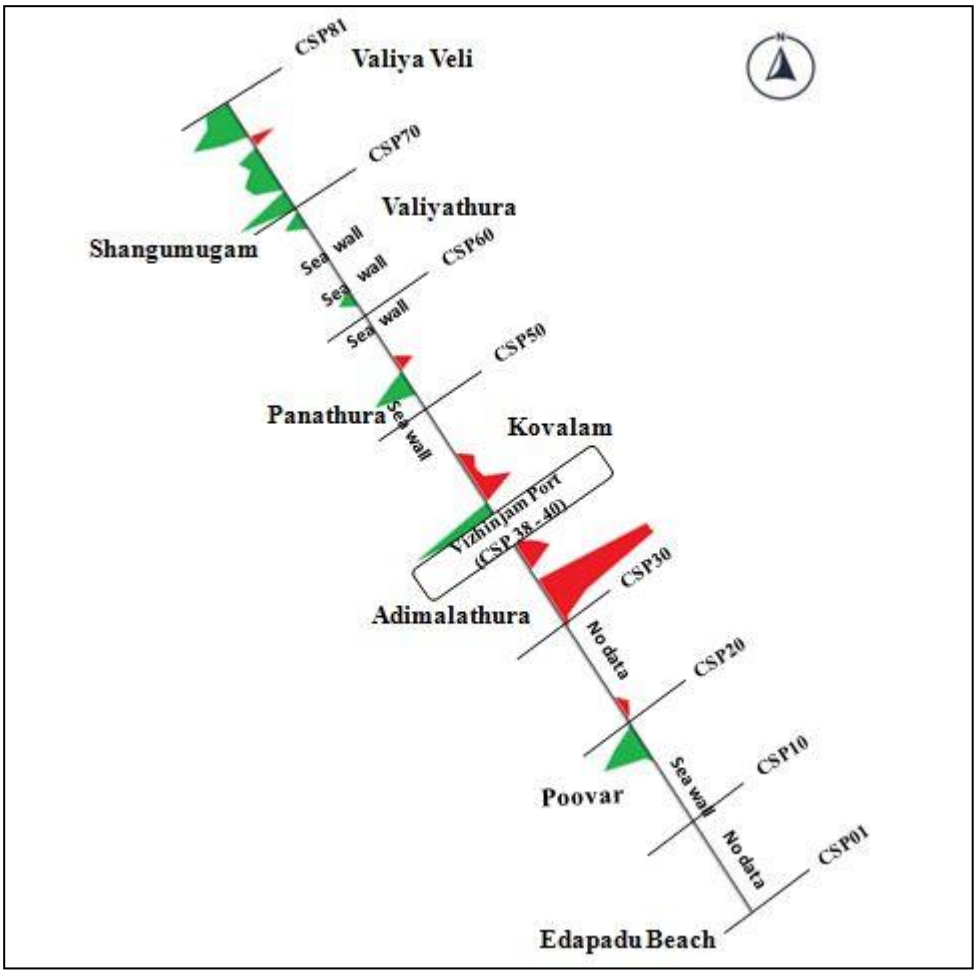


Figure A.23 Seasonal Beach Volume Changes during the Pre-monsoon Period in m³/m (onshore)



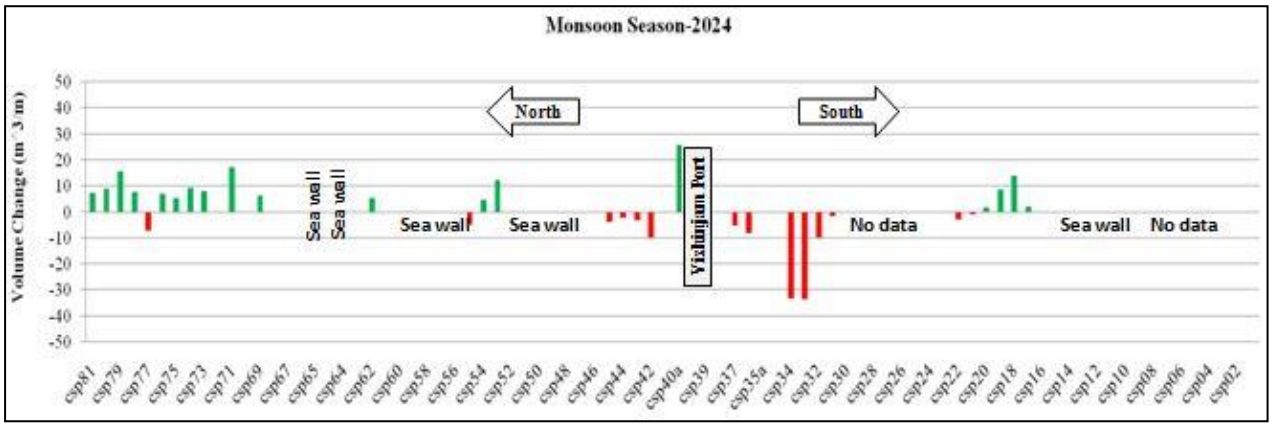
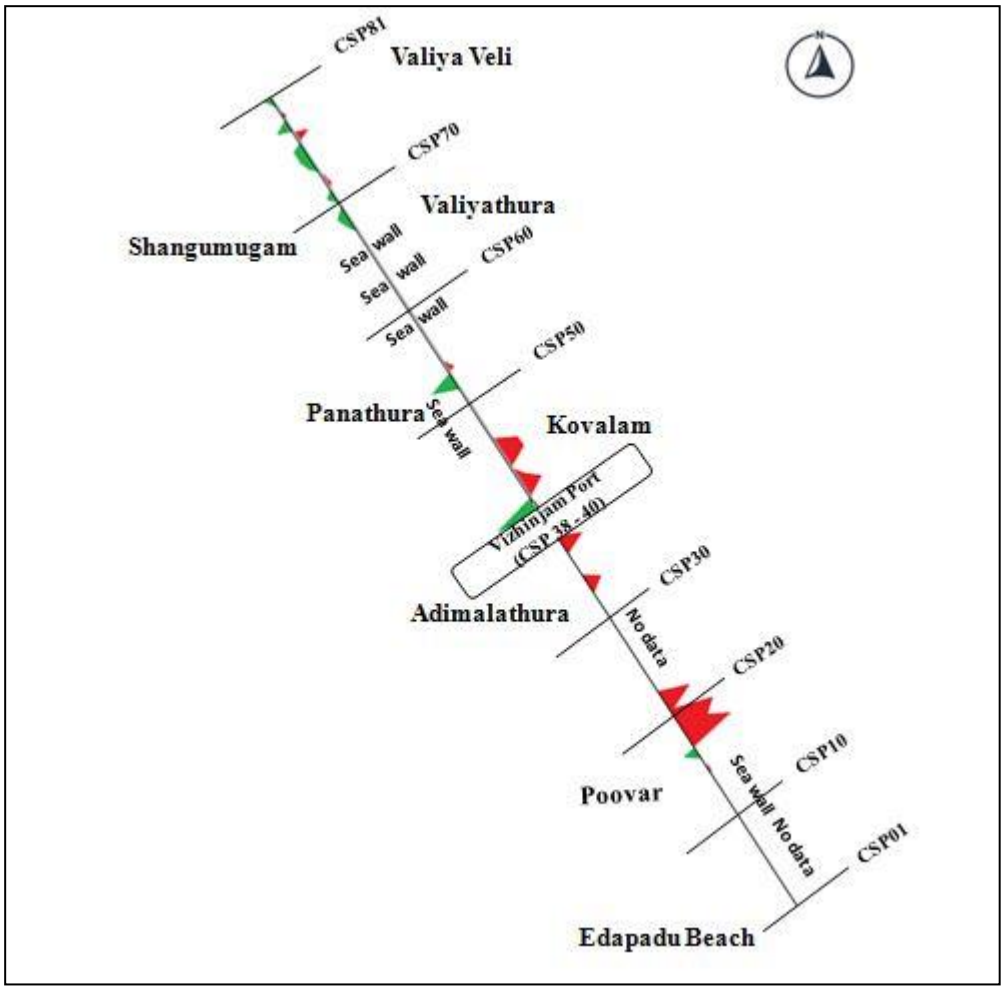


Figure A.24 Seasonal Beach Volume Changes in Monsoon Period in m^3/m (onshore)



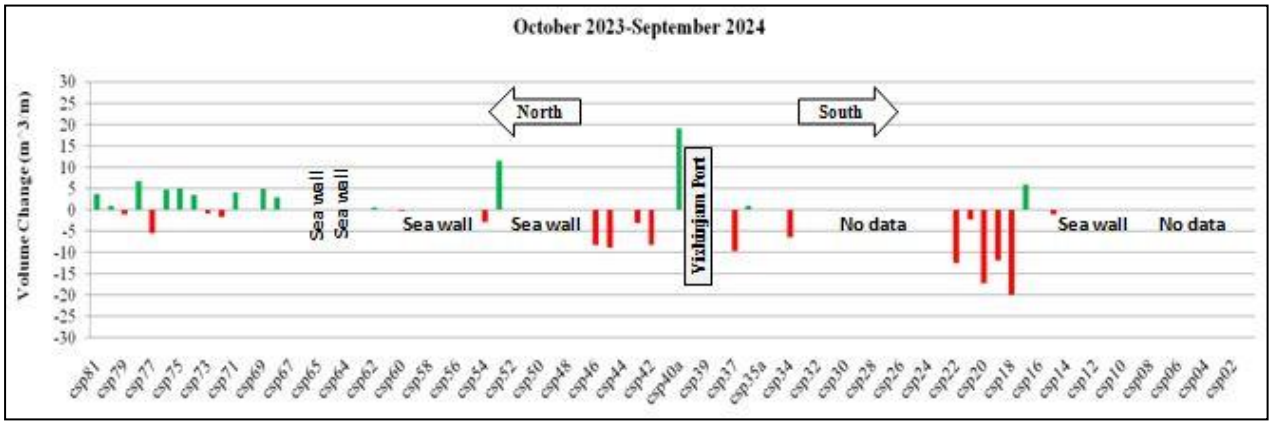


Figure A.25 Overall Beach Volume Changes for the period of October 2023 to September 2024 in m3/m (onshore)

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

CSP NOs.	AREA	October 2023 to November 2023 (Post monsoon Period 2023)	December 2023 to March 2024 (Fair weather Period 2024)	April 2024 to May 2024 (Pre-monsoon Period 2024)	June 2024 to September 2024 (Monsson Period 2024)	October 2023 to September 2024 (overall)
CSP01	SOUTH OF PORT	**Sea wall**				
CSP02		-23.21	16.81	-	-	-
CSP03		**Sea wall**				
CSP04		4.52	5.12	-	-	-
CSP05		6.52	4.56	-	-	-
CSP06		**Sea wall**				
CSP07		5.57	-	-	-	-
CSP08		0.18	-	-	-	-
CSP09		3.79	-13.68	4.65	-	-
CSP10		-4.00	3.54	-1.54	-	-
CSP11		**Sea wall**				
CSP12						
CSP13						
CSP14						
CSP15		1.31	-23.85	2.86	-	-1.12
CSP16		-	-4.70	-	-	-
CSP17		0.15	-1.80	2.72	2.19	5.91
CSP18		1.19	-11.26	2.35	13.79	-19.88
CSP19		-0.86	2.34	1.55	8.51	-11.84
CSP20		4.01	3.99	2.35	1.61	-17.18
CSP21		5.56	2.02	-20.71	-0.98	-2.25
CSP22		-6.45	4.24	0.50	-2.87	-12.44
CSP23		-	-	-	-	-
CSP24		-	-	-	-	-
CSP25		-	-	-	-	-
CSP26		-	-	-	-	-
CSP27		-	-	-	-	-
CSP28		-	-	-	-	-
CSP29		-	-	-	-	-
CSP30		-	-	-	-	-
CSP31		-	39.81	1.13	-1.47	-
CSP32		-	10.70	3.09	-9.78	-
CSP33		-	11.13	-	-33.65	-
CSP34		11.46	-	-9.94	-33.21	-6.45
CSP35		-	31.81	11.89	-	-
CSP35A		39.00	19.30	-5.22	-	-
CSP36		8.65	2.11	-	-8.09	0.83
CSP37		2.53	3.75	-	-5.08	-9.61
CSP38	**PORT AREA**					
CSP39						
CSP40						
CSP40A	NORTH OF PORT	1.37	-5.32	-	25.95	19.17
CSP41		**Sea wall**				
CSP42		0.12	-0.12	-3.07	-9.94	-8.29
CSP43		2.35	0.68	0.21	-3.11	-3.10
CSP44		0.86	-0.13	0.51	-2.30	0.09
CSP45		-0.86	-0.98	-3.52	-3.97	-8.88
CSP46		-3.35	4.41	-13.57	-	-8.34
CSP47		**Sea wall**				
CSP48						
CSP49						
CSP50						
CSP51						
CSP52						
CSP53		0.31	-41.46	1.29	12.24	11.40
CSP54		-0.33	-	5.52	4.71	-2.84
CSP55		*	0.41	1.15	-4.81	*
CSP56		**Sea wall**				
CSP57						

CSP58						
CSP59						
CSP60		-0.29	2.02	0.63	0.07	-0.12
CSP61		**Sea wall**				
CSP62		-0.72	10.81	0.24	5.41	0.60
CSP63		**Sea wall**				
CSP64						
CSP64A		0.91	6.17	-0.24	-	-
CSP65		**Sea wall**				
CSP66						
CSP67		-	9.66	-8.25	-	-
CSP68		15.46	10.16	-4.67	-	3.00
CSP69		6.92	-2.38	0.23	6.52	4.90
CSP70		0.00	-0.26	-0.67	-0.11	0.09
CSP71		1.95	-1.45	0.89	17.21	4.06
CSP72		-0.15	-4.46	*	-	-1.63
CSP73		0.22	2.27	0.00	7.98	-0.78
CSP74		-0.54	0.12	-0.76	9.22	3.50
CSP75		0.45	-0.69	0.55	5.27	5.03
CSP76		-0.69	-0.43	-	7.12	4.65
CSP77		-0.44	-1.34	3.48	-7.13	-5.55
CSP78		-8.76	9.26	-0.63	7.60	6.67
CSP79		-1.03	-0.71	2.93	15.71	-1.01
CSP80		-2.90	0.47	0.53	9.07	0.95
CSP81		-0.49	-0.58	-3.19	7.46	3.65

*Data not considered for analysis

-No data

Table A.4 Overall beach volume variation from October 2023 to September 2024 (offshore)

CSP NOs.	AREA	October 2023 to November 2023 (Post monsoon Period 2023)	December 2023 to March 2024 (Fair weather Period 2024)	April 2024 to May 2024 (Pre-monsoon Period 2024)	June 2024 to September 2024 (Monsson Period 2024)	October 2023 to September 2024 (overall)
CSP01		-5.68	-	-	-	-
CSP02		21	-	-	-	-
CSP03		9.29	-	-	-	-
CSP04		8.97	-	-	-	-
CSP05		6.05	-	-	-	-
CSP06		12.26	-	-	-	-
CSP07		9.25	-	-	-	-
CSP08		2.91	-	-	-	-
CSP09		-2.63	-	-	-	-
CSP10		7.9	-	-	-	-
CSP11		6.31	-	-	-	-
CSP12		4.21	-	-	-	-
CSP13		7.78	-	-	-	-
CSP14		7.3	-	-	-	-
CSP15		6.74	-	-	-	-
CSP16		0.6	-	-	-	-
CSP17		-19.76	-	-	-	-
CSP18		-17.77	-	-	-	-
CSP19		-3.96	-	-	-	-
CSP20		-64.9	-	-	-	-
CSP21		-44.57	-	-	-	-
CSP22		-77.51	-	-	-	-
CSP23		-2.86	-	-	-	-
CSP24		*	-	-	-	-
CSP25		-6.37	-	-	-	-
CSP26		-5.93	-7.61	-	-	-
CSP27		34.58	47.28	-	-	-
CSP28		2.40	-10.04	-	-	-
CSP29		0.92	-54.96	-	-	-

CSP30		5.64	-57.43	-	-	-
CSP31		-52.55	-11.59	-	-	-
CSP32		3.07	-81.90	-	-	-
CSP33		0.97	-54.75	-	-	-
CSP34		-44.03	-	-	-	-
CSP35		4.44	-3.38	-	-	-
CSP35A		-34.65	146.16	-	-	-
CSP36		6.69	-50.07	-	-	-
CSP37		-0.76	-41.93	-	-	-
CSP38	**Port Area**					
CSP39						
CSP40						
CSP40A	NORTH OF PORT	-82.12	-14.66	-	-	-
CSP41		-27.14	-64.66	-	-	-
CSP42		46.82	-153.68	-	-	-
CSP43		-2.24	-72.59	-	-	-
CSP44		-5.16	2.59	-	-	-
CSP45		21.04	45.34	-	-	-
CSP46		-35.74	16.31	-	-	-
CSP47		-10.76	-51.00	-	-	-
CSP48		-1.85	-56.62	-	-	-
CSP49		116.36	-72.97	-	-	-
CSP50		1.86	32.44	-	-	-
CSP51		4.48	53.31	-	-	-
CSP52		8	61.99	-	-	-
CSP53		-1.83	4.67	-	-	-
CSP54		8.22	29.68	-	-	-
CSP55		3.06	56.48	-	-	-
CSP56		1.33	*	-	-	-
CSP57		3.86	-84.18	-	-	-
CSP58		3.47	28.47	-	-	-
CSP59		2.8	36.08	-	-	-
CSP60		-0.16	22.79	-	-	-
CSP61		6.51	27.10	-	-	-
CSP62		43.55	28.72	-	-	-
CSP63		1.48	28.24	-	-	-
CSP64		0.37	-18.11	-	-	-
CSP64A		19.42	*	-	-	-
CSP65		-5.51	-40.52	-	-	-
CSP66		-28.1	-56.26	-	-	-
CSP67		-7.22	-32.39	-	-	-
CSP68		4.54	-116.06	-	-	-
CSP69		-6.47	-31.36	-	-	-
CSP70		-17.47	-85.03	-	-	-
CSP71		0.79	-63.53	-	-	-
CSP72		-64.4	12.45	-	-	-
CSP73		-52.53	15.23	-	-	-
CSP74		-193.08	76.07	-	-	-
CSP75		-23.91	-36.55	-	-	-
CSP76		-28.42	-27.52	-	-	-
CSP77		-38.13	-27.99	-	-	-
CSP78		59.38	-45.65	-	-	-
CSP79		-42.24	-54.20	-	-	-
CSP80		7.51	-59.24	-	-	-
CSP81		12.93	-58.21	-	-	-

*Data not considered for analysis

-No data

A.1.4 Seasonal Beach Volume comparison between the period October 2022 and October 2023, February 2023 and February 2024, May 2023 and May 2024 and September 2023 and September 2024

Beach Volume comparison between October 2022 and October 2023

In October 2022, there was a failure to conduct the onshore survey at CSP15-37,40A,53,64A and at CSP23-30, CSP67 in October 2023, which led to the incapacity to perform analysis in these locations. Beaches at Edappadu Beach (CSP02), Vallavilay (04-05), Neerody (CSP07-08), Pozhiyoor (CSP10), Kovalam (CSP42-43 and 45-46), Cheriyathura (CSP62), Shangumugham (CSP71), Vettucaud (CSP74), Kochuveli to Thumba (CSP76-80) showed accretion during the period of October 2022 to October 2023 on the onshore. Beach erosion occurred from October 2022 to October 2023 in the following locations on the onshore: Thumba (CSP81), Vettucaud (CSP72-73), Changumugham (CSP68-70), Neerody (CSP09), Kochuveli (CSP75), and Shanghaimugham (CSP44). Results are displayed in Figure A.26.

No offshore survey was carried out in October 2022. Hence, it was not possible to compare the beach volume in October 2022 and October 2023.

Beach Volume comparison between February 2023 and February 2024

In February 2023, no onshore survey was conducted at CSP64A and 35, and also at CSP23-30,53 in February 2024, leading to the inability to analyze these locations.

Beaches in the following locations showed accretion between February 2023 and February 2024 on the onshore: Edappadu Beach (CSP02), Vallavilay (04-05), Neerody to Pozhiyoor (CSP07-10), Poovar south (CSP15), Poovar to Karumkulam (CSP18-22), Port reclamation area (CSP40A), Kovalam (CSP43), Cheriyathura (CSP62), and Vettucaud (CSP73). The following beaches showed signs of erosion between February 2023 and February 2024: Poovar South (CSP16-17), Adimalathura (CSP31-34), Azhimala to Mullur (CSP35A-37), Kovalam (CSP42 AND 44-46), Punthura (CSP54-55), Beemapally (CSP60), Valiyathura to Vettucaud (CSP67-72) and Vettucaud to Thumba (CSP74-81) on the onshore. Results are shown in Figure A.27.

The same data was observed in January and February of 2024 at CSP23, and errors were found in the profiles at CSP40A and CSP35A. No offshore survey was carried out at 53-81 in February 2024, and CSP35 and CSP02 were carried out in February 2023. Hence,

these profiles are not included in the analysis. The offshore at Poovar south (CSP16), Karumkulam (CSP23-24), Pulluvila (CSP28-29), Adimalathura (CSP32 and 34), Mullur (CP37), Kovalam (CSP41-46), and Panathura (CSP49 and 51-52) exhibited beach accretion from February 2023 to February 2024. Conversely, erosion was observed at Edappadu (CSP01), Edappadu to Poovar south (CSP03-15), Poovar south to Karumkulam (CSP17-22), Karumkulam to Pulluvila (CSP25-27), Pulluvila to Adimalathura (CSP30-31), Adimalathura (CSP33), Mullur (CSP36), and Kovalam to Panathura (CSP47-48), as well as at Panathura (CSP50) on the offshore. The findings are shown in the image labelled as Figure A.28.

Beach Volume comparison between May 2023 and May 2024

Onshore surveys at CSP23-30,16 were not carried out in May 2024. During this timeframe, the beach experienced accretion from Neerody to Pozhiyoor (CSP09-10), Poovar to Poovar North (CSP19-20), Karumkulam (CSP22), Mullur (CSP37), the port reclamation area (CSP40A), and Punthura (CSP53-55), while erosion took place at Poovar South (CSP15,17), Poovar (CSP18), Poovar North (CSP21), the area from Adimalathura to Mullur (CSP33-36), Kovalam (CSP42-46), Beemapally (CSP60), Cheriyathura (CSP62), and from Valiyathura to Thumba (CSP67-81). Results are shown in Figure A.29.

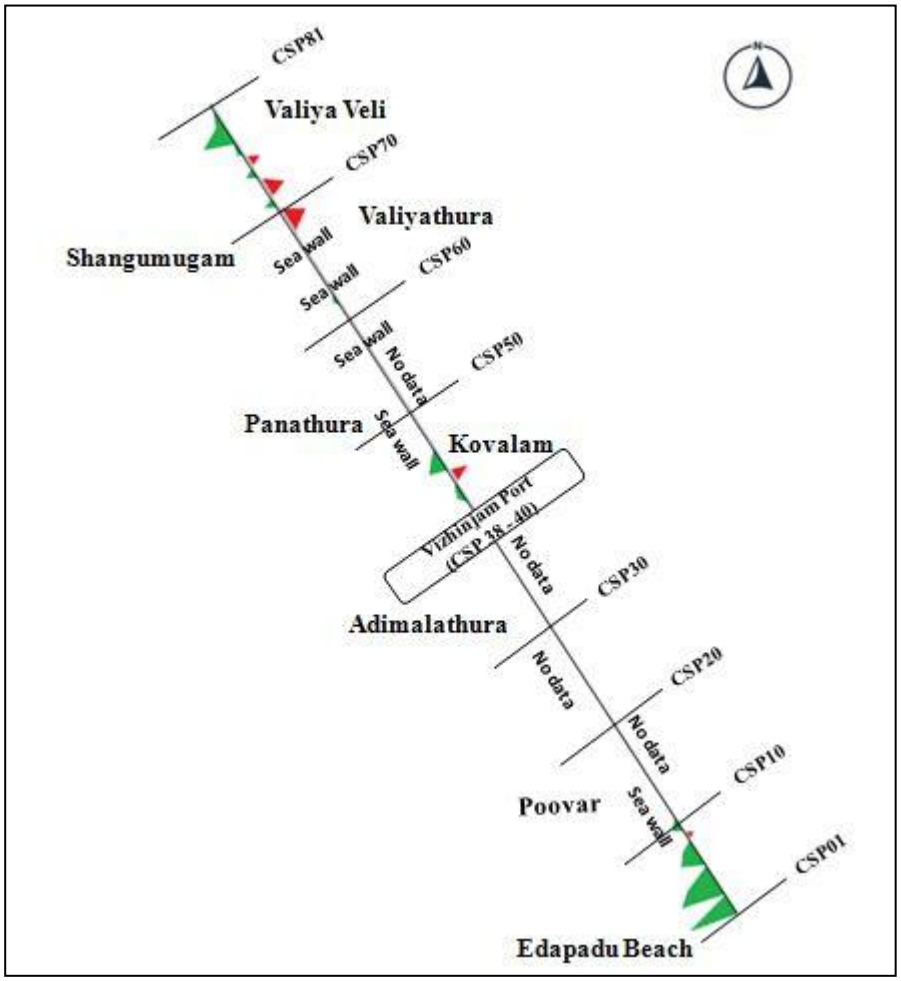
There was no offshore survey carried out in May 2024; hence, it was not possible to compare the beach volume in May 2023 and May 2024.

Beach Volume comparison between September 2023 and September 2024

No onshore surveys were conducted at CSP01-11, CSP35A, and CSP64A in September 2024. In September 2023, no onshore survey was conducted at CSP31-35A.

From September 2023 to September 2024, erosion was observed on the onshore at Poovar south (CSP15), Poovar (CSP18-19), Karumkulam (CSP22), Mullur (CSP37), Kovalam (CSP42-43, 45-46), Punthura (CSP54-55), Valiyathura (CSP67), Vettucaud (CSP73), Kochuveli (CSP77), and the stretch from Valiyathura to Thumba (CSP79-81). In contrast, accretion occurred at Poovar south (CSP16-17), Poovar north (CSP20-21), Mullur (CSP36), the port reclamation area (CSP40A), Punthura (CSP53), Beemapally (CSP60), Cheriyathura (CSP62), the southern section of Shangumugham to Vettucaud (CSP68-72), the stretch from Vettucaud to Kochuveli (CSP74-76), and Valiyaveli (CSP78).

The results are illustrated in Figure A.30. No offshore surveys were conducted either in September 2023 or September 2024.



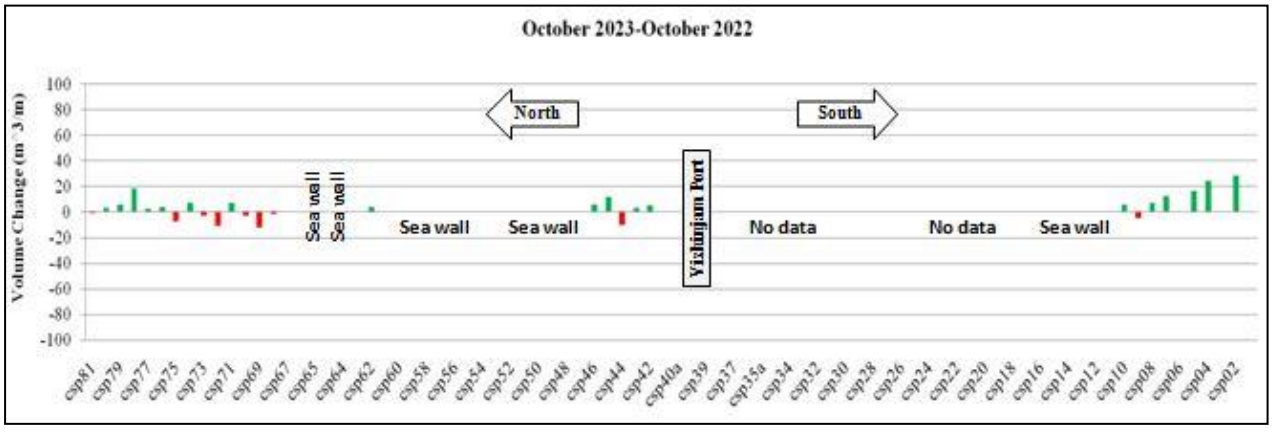
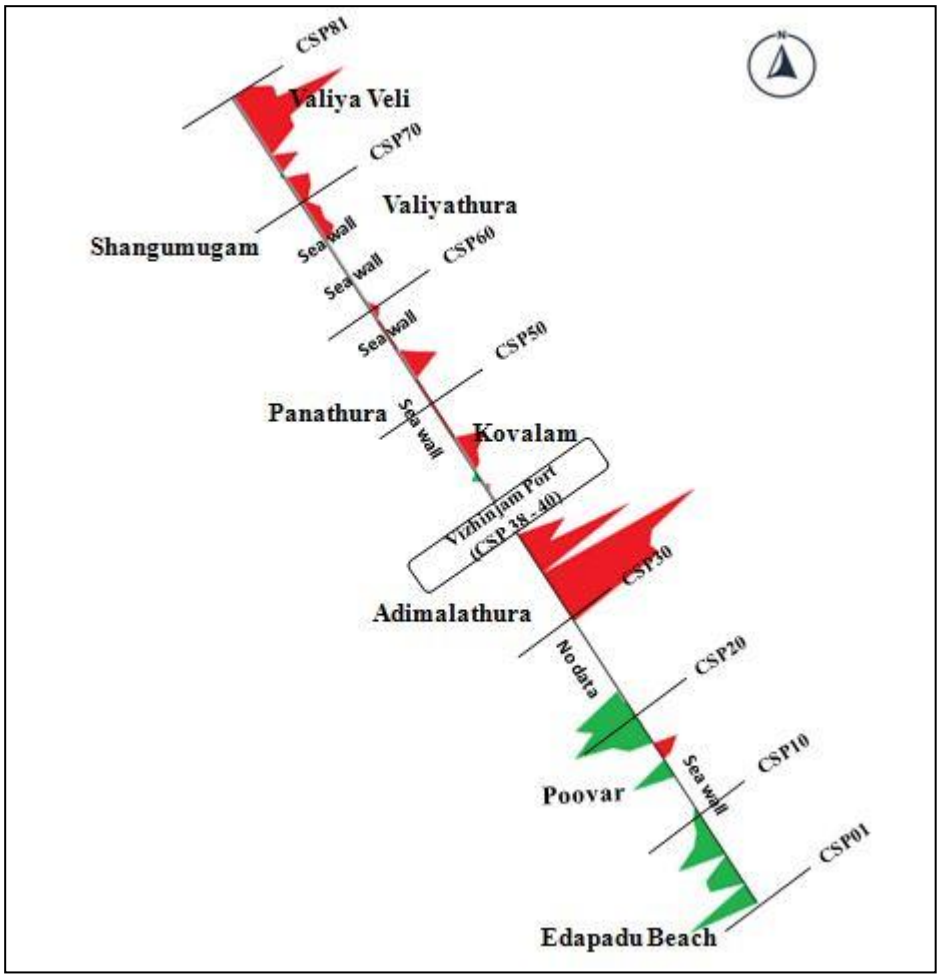


Figure A.26 Beach Volume Change comparison between October 2022 and October 2023 in m^3/m (onshore)



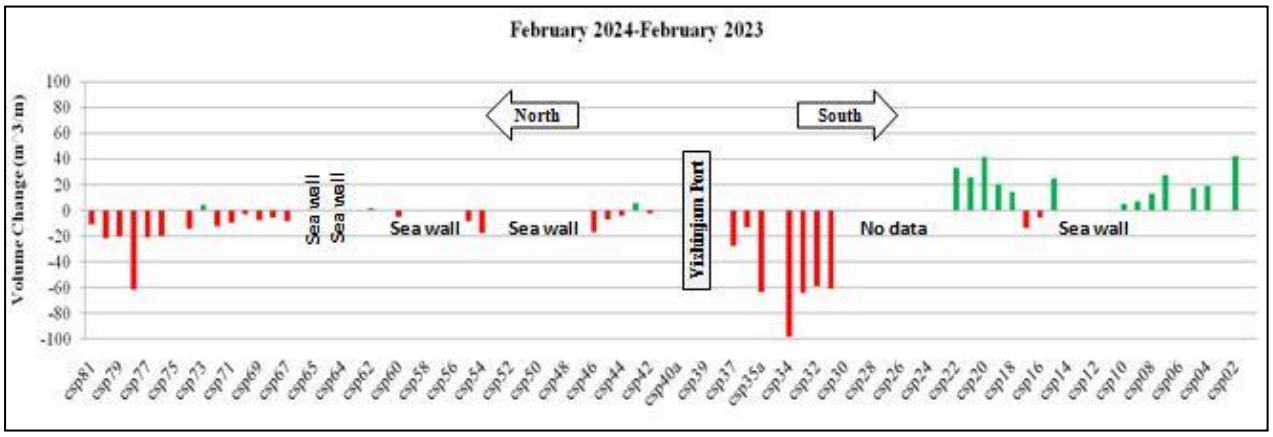
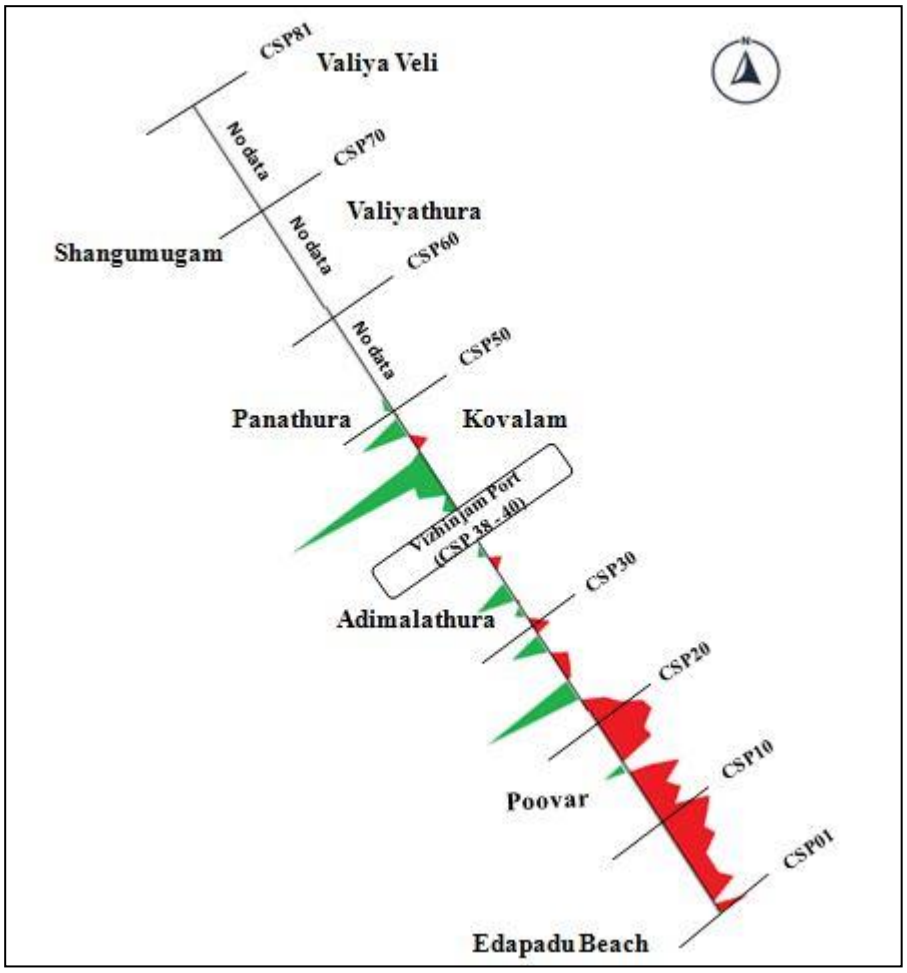


Figure A.27 Beach Volume Change comparison between February 2023 and February 2024 in m^3/m (onshore)



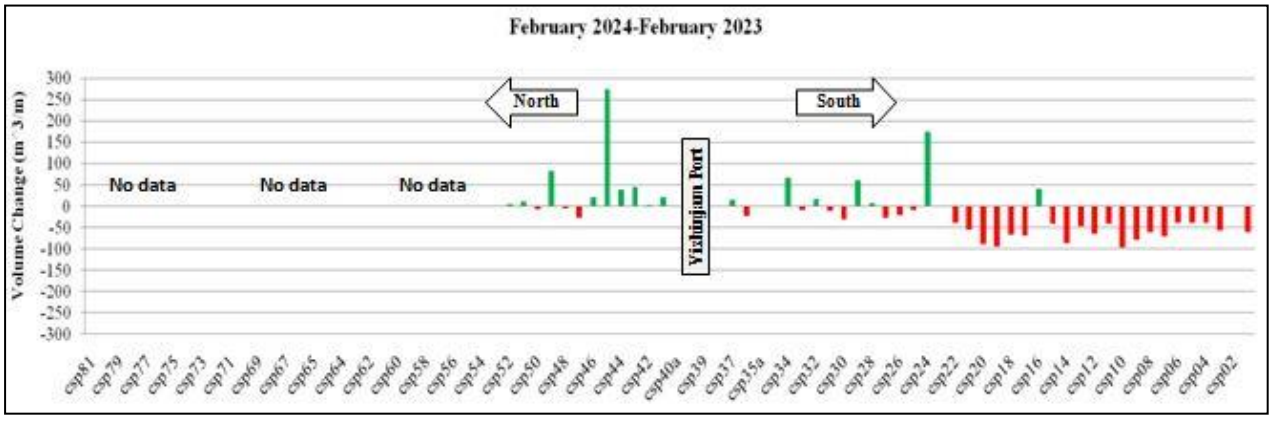
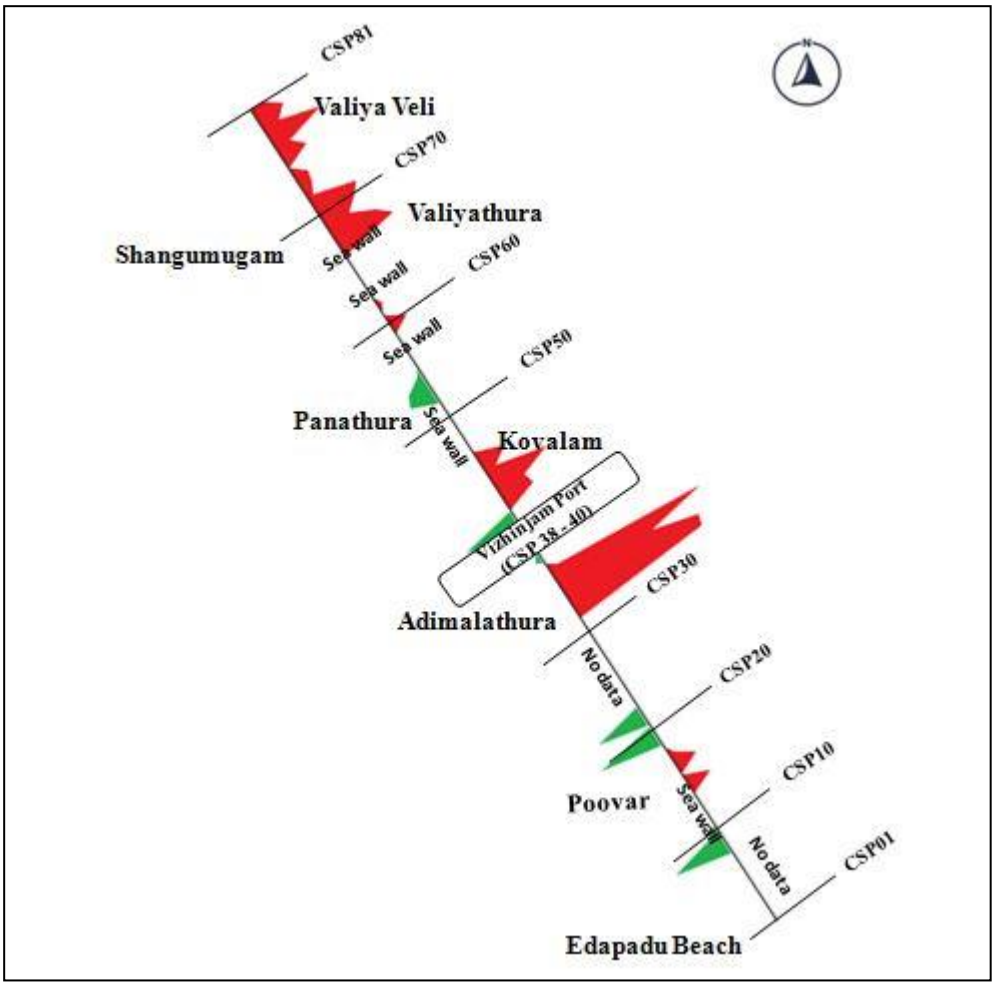


Figure A.28 Beach Volume Change comparison between February 2023 and February 2024 in m^3/m (offshore)



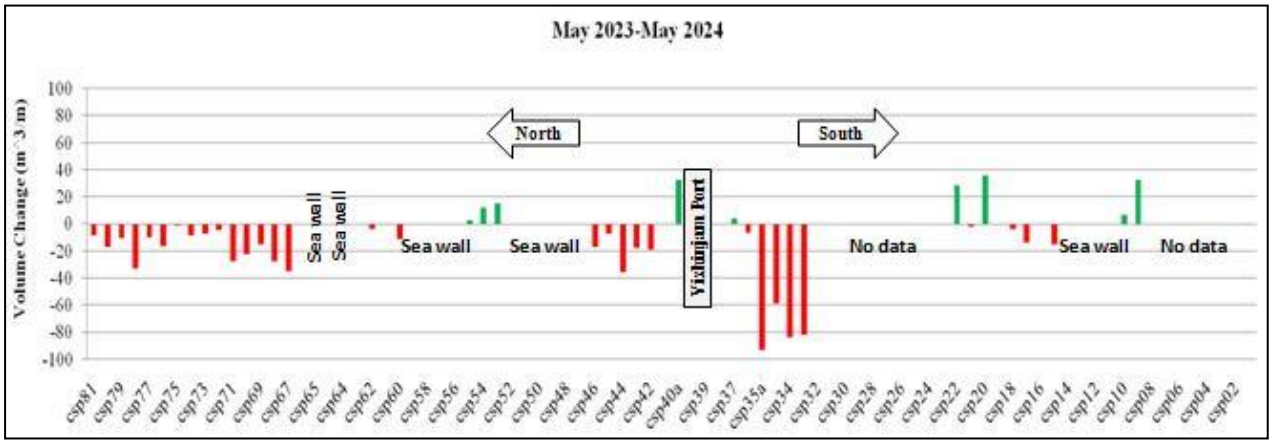
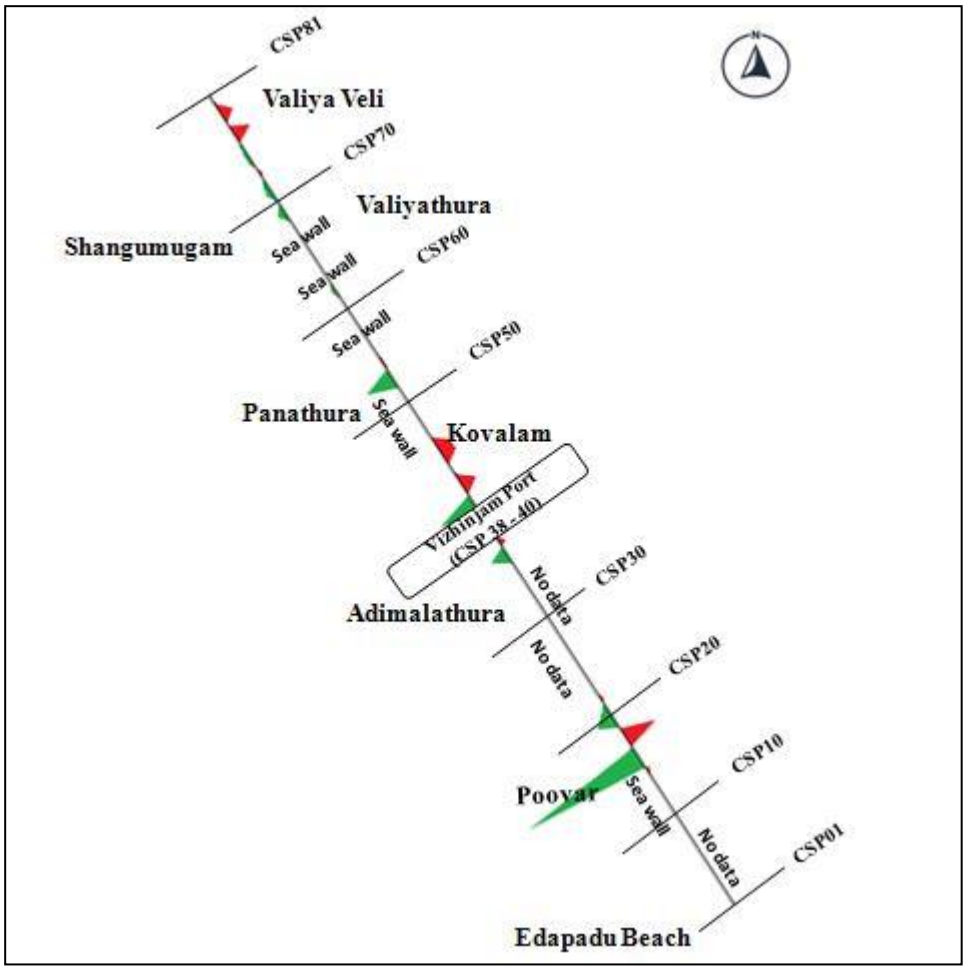


Figure A.29 Beach Volume Change comparison between May 2023 and May 2024 in m^3/m (onshore)



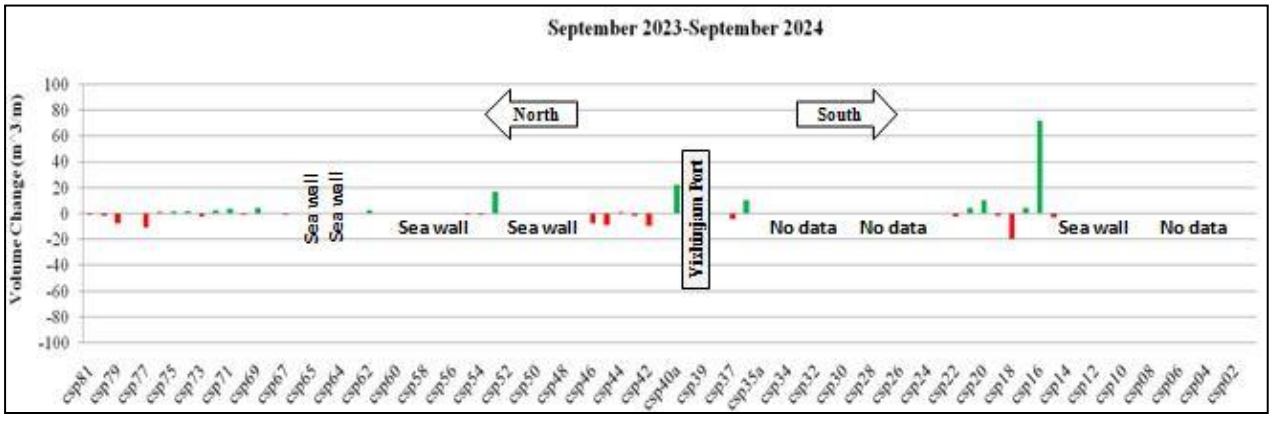


Figure A.30 Beach Volume Change comparison between September 2023 and September 2024 in m^3/m (onshore)

Table A.5 Beach Volume Changes comparing the months of October 2022 and October 2023, February 2023 and February 2024, May 2022 and May 2023, September 2023 and September 2024 in m^3/m

Location	October 2022 and October 2023 (onshore)	October 2022 and October 2023 (offshore)	February 2023 and February 2024 (onshore)	February 2023 and February 2024 (offshore)	May 2023 and May 2024 (onshore)	May 2023 and May 2024 (offshore)	September 2023 and September 2024 (onshore)	September 2023 and September 2024 (offshore)
CSP01	**Sea wall**	-	**Sea wall**	-62.05	**Sea wall**	-	**Sea wall**	-
CSP02	28.3	-	42.01	-	-	-	-	-
CSP03	**Sea wall**	-	**Sea wall**	-56.99	**Sea wall**	-	**Sea wall**	-
CSP04	24.48	-	19	-38.44	-	-	-	-
CSP05	16.68	-	17.54	-39.23	-	-	-	-
CSP06	**Sea wall**	-	**Sea wall**	-39.55	**Sea wall**	-	**Sea wall**	-
CSP07	12.43	-	27.86	-70.22	-	-	-	-
CSP08	7.41	-	12.97	-60.34	-	-	-	-
CSP09	-4.95	-	7.1	-79.85	32.49	-	-	-
CSP10	5.75	-	5.02	-96.13	6.74	-	-	-
CSP11		-		-40.24		-		-
CSP12		-		-64.55		-		-
CSP13		-		-47.95		-		-
CSP14	**Sea wall**	-	**Sea wall**	-87.33	**Sea wall**	-	**Sea wall**	-
CSP15	-	-	24.7	-41.25	-14.83	-	-2.85	-
CSP16	-	-	-5.77	41.52	-	-	71.86	-
CSP17	-	-	-13.93	-68.22	-13.77	-	4.29	-
CSP18	-	-	14.01	-66.76	-3.94	-	-19.27	-
CSP19	-	-	20.45	-94.03	0.23	-	-1.57	-
CSP20	-	-	41.66	-88.52	35.51	-	10.53	-
CSP21	-	-	25.28	-55.56	-1.81	-	4.08	-
CSP22	-	-	33.08	-38.7	28.88	-	-2.03	-
CSP23	-	-	-	*	-	-	-	-
CSP24	-	-	-	173.72	-	-	-	-
CSP25	-	-	-	-9.41	-	-	-	-
CSP26	-	-	-	-20.24	-	-	-	-
CSP27	-	-	-	-27.69	-	-	-	-
CSP28	-	-	-	7.51	-	-	-	-
CSP29	-	-	-	61.26	-	-	-	-
CSP30	-	-	-	-31.2	-	-	-	-
CSP31	-	-	-60.83	-11.04	-	-	-	-
CSP32	-	-	-58.64	16.32	-	-	-	-
CSP33	-	-	-64.08	-9.52	-81.82	-	-	-
CSP34	-	-	-97.95	66.87	-83.81	-	-	-
CSP35	-	-	-	-	-58.78	-	-	-
CSP35A	-	-	-63.26	*	-93.46	-	-	-
CSP36	-	-	-13.35	-22.25	-6.26	-	10.04	-
CSP37	-	-	-27.62	14.2	4.06	-	-4.14	-
CSP38								
CSP39								
CSP40								
CSP40A	-	-	0.27	*	32.69	-	22.10	-
CSP41	**Sea wall**	-	**Sea wall**	21.41	**Sea wall**	-	**Sea wall**	-
CSP42	5.25	-	-2.11	2.85	-19.04	-	-9.37	-
CSP43	3.15	-	5.86	44.06	-17.50	-	-1.87	-
CSP44	-10.44	-	-4.3	39.45	-35.62	-	0.76	-
CSP45	11.44	-	-7.01	273.94	-7.36	-	-8.74	-
CSP46	6.01	-	-17.04	21.41	-16.99	-	-7.75	-
CSP47		-	**Sea wall**	-26.97	**Sea wall**	-	**Sea wall**	-
CSP48		-		-5.9		-		-
CSP49		-		82.69		-		-
CSP50		-		-7.75		-		-
CSP51		-		11.74		-		-
CSP52	**Sea wall**	-		3.94		-		-
CSP53	-	-	-	-	15.20	-	16.93	-

CSP54	-	-	-17.97	-	12.30	-	-1.19	-
CSP55	-	-	-8.38	-	2.52	-	-1.12	-
CSP56	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-
CSP57		-		-		-		-
CSP58		-		-		-		-
CSP59		-		-		-		-
CSP60	-	-	-4.77	-	-11.20	-	0.14	-
CSP61	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-
CSP62	3.82	-	1.81	-	-3.59	-	2.47	-
CSP63	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-
CSP64		-		-		-		-
CSP64A	-	-	-	-	-	-	-	-
CSP65	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-	**Sea wall**	-
CSP66		-		-		-		-
CSP67	-	-	-8.23	-	-35.04	-	-0.62	-
CSP68	-1.87	-	-5.8	-	-27.82	-	0.10	-
CSP69	-12.51	-	-7.6	-	-15.00	-	4.72	-
CSP70	-2.83	-	-3.12	-	-22.17	-	0.03	-
CSP71	7.05	-	-9.61	-	-27.49	-	3.46	-
CSP72	-10.91	-	-12.25	-	-4.32	-	2.23	-
CSP73	-3.05	-	4.01	-	-7.36	-	-2.26	-
CSP74	6.96	-	-14.29	-	-8.68	-	1.82	-
CSP75	-7.31	-	-0.57	-	-1.24	-	1.85	-
CSP76	3.93	-	-19.46	-	-16.14	-	1.14	-
CSP77	2.43	-	-20.77	-	-9.62	-	-10.54	-
CSP78	18.23	-	-61.54	-	-33.03	-	0.57	-
CSP79	5.61	-	-20.67	-	-10.58	-	-7.58	-
CSP80	2.83	-	-21.96	-	-17.30	-	-1.54	-
CSP81	-1.12	-	-11.3	-	-8.76	-	-0.26	-

*Data not considered for analysis

-No data

A.1.5 Beach volume variation during February 2015 and February 2024

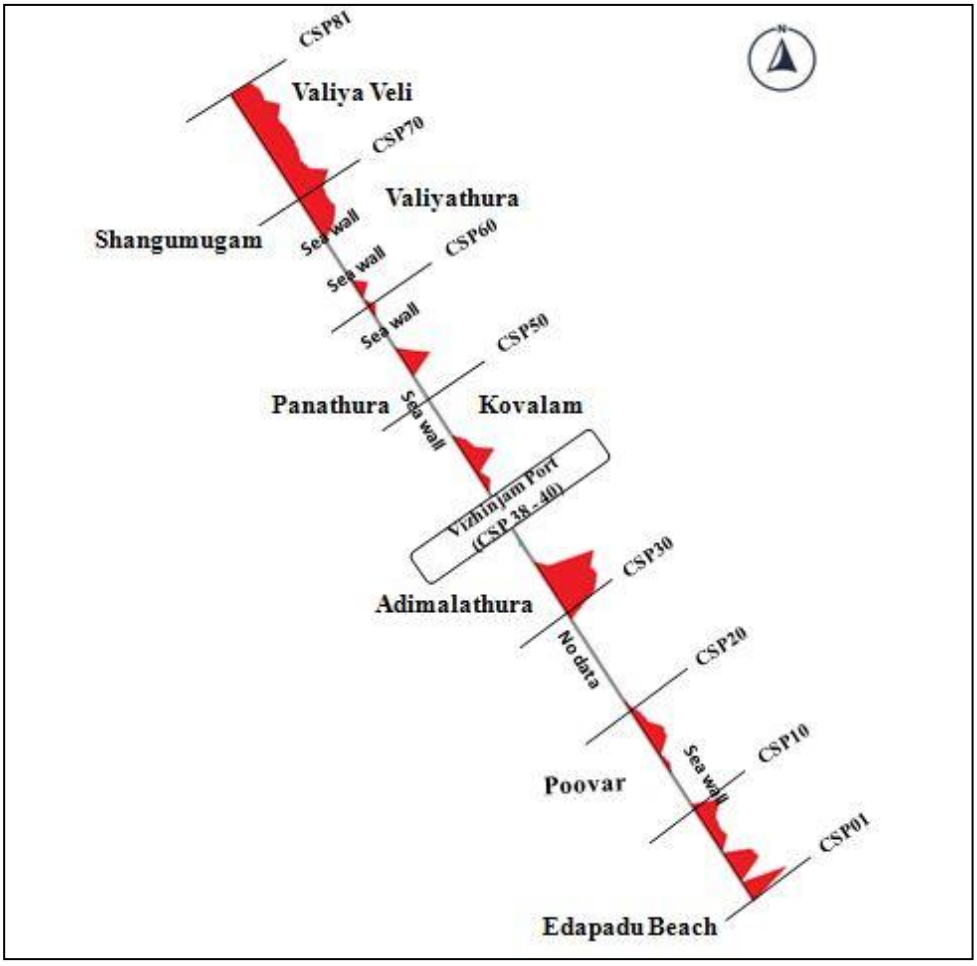
This analysis was carried out to identify and compare the beach volume variation before the commencement of port construction with the current scenario. However, only the profiles with the available coverage (up to 10m depth only in 2015) have been used to compute the volume. The beach volume changes for February 2015 and February 2024 are given in graphs in **Figure A.31, Figure A.32** and **Table A.6**.

In February 2024, no survey occurred at CSP23-30 CSP53.

Accretion was observed onshore at Mullur (CSP36-37). Erosion was detected at Edappadu beach (CSP02), Vallavilay (CSP04-05), the stretch from Neerody to Pozhiyoor (CSP07-10), from Poovar south to Karumkulam (CSP15-22), between Adimalathura and Azhimala (CSP31-35), at Kovalam (CSP42-46), Punthura (CSP54-55), Beemapally (CSP60), Cheriyathura (CSP62), from Valliyathura to Thumba (CSP67-81). There were no offshore surveys conducted in February 2024 at CSP53-81.

Offshore accretion occurred at Karumkulam (CSP23-26), Pulluvila (CSP28-29), Adimalathura (CSP32), and Mullur (CSP36-37). Erosion was noted from Edappadu beach

to Karumkulam (CSP01-22), at Pulluvila (CSP27,30), Adimalathura (CSP31), between Adimalathura and Azhimala (CSP33-35), and along the stretch from Kovalam to Panathura north (CSP41-52).



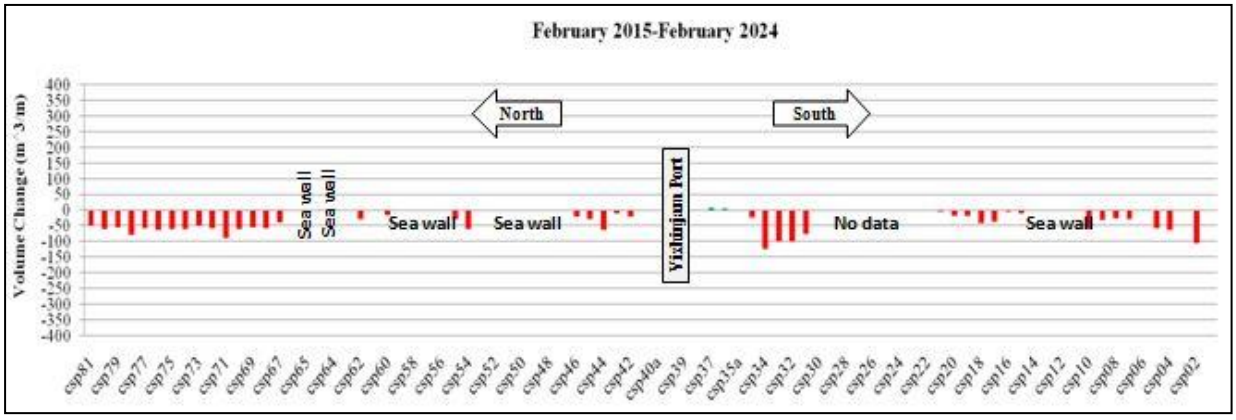
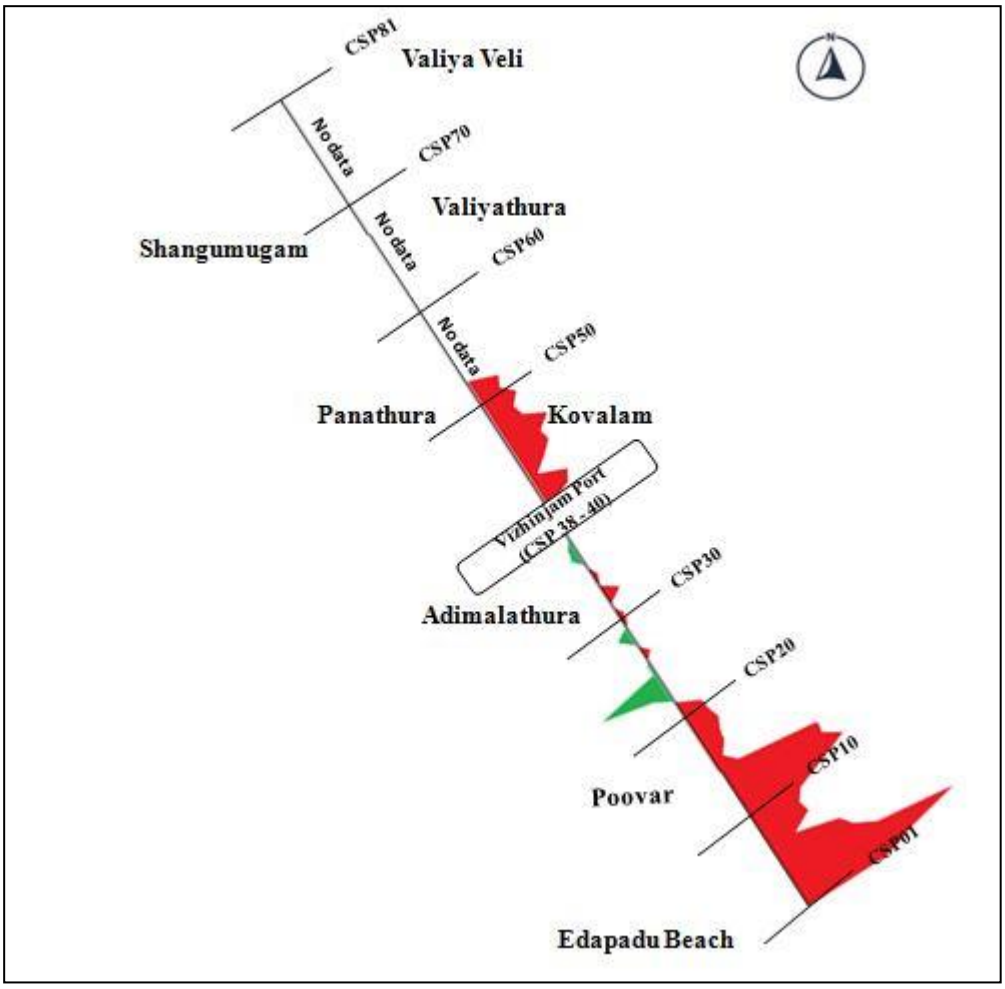


Figure A.31 Beach Volume Changes - February 2015 and February 2024 in m^3/m (onshore)



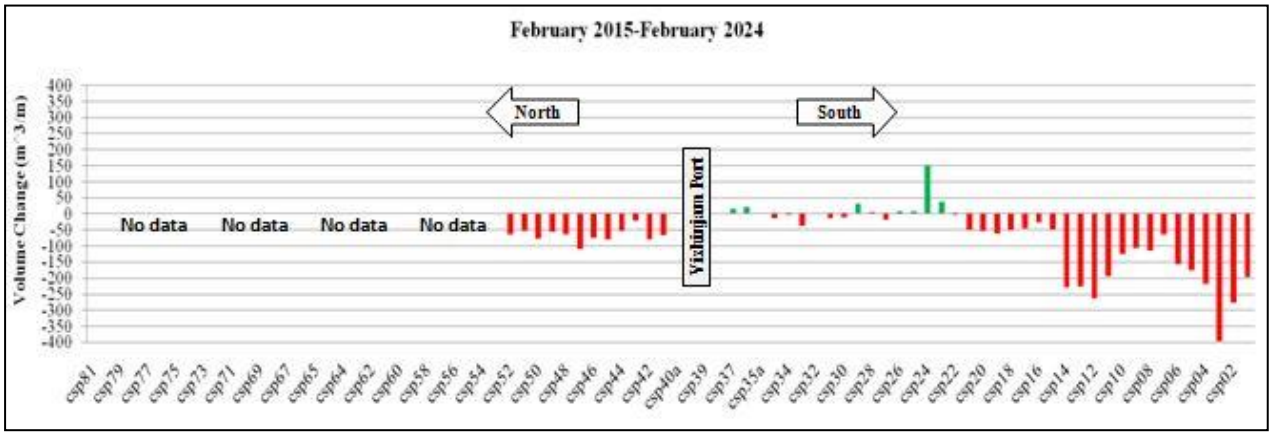


Figure A.32 Beach Volume Changes - February 2015 and February 2024 in m^3/m (offshore)

Table A.6 Beach Volume Changes comparing the inter-annual months of February 2015 and February 2024 (onshore and offshore) m^3/m

CSP NOs.	AREA	February 2015 and February 2024 (onshore)	February 2015 and February 2024 (offshore)
CSP01	SOUTH OF PORT	**Sea wall**	-196.76
CSP02		-104.04	-278.26
CSP03		**Sea wall**	-396.25
CSP04		-62.05	-219.34
CSP05		-56.39	-176.37
CSP06		**Sea wall**	-157.55
CSP07		-28.24	-65.26
CSP08		-25.43	-113.46
CSP09		-30.76	-106.38
CSP10		-60.23	-124.86
CSP11		**Sea wall**	-193.22
CSP12			-262.65
CSP13			-225.44
CSP14			-228.90
CSP15		-10.73	-48.24
CSP16		-4.34	-25.60
CSP17		-35.44	-45.42
CSP18		-41.18	-50.41
CSP19		-19.17	-62.44
CSP20		-16.83	-54.82
CSP21		-4.98	-50.81
CSP22		-0.45	-3.58
CSP23		-	36.87
CSP24		-	151.40
CSP25		-	7.79
CSP26		-	7.19
CSP27		-	-19.23
CSP28		-	4.16
CSP29		-	32.07
CSP30		-	-9.86
CSP31		-76.88	-14.44
CSP32		-99.74	2.49
CSP33		-99.03	-37.30
CSP34		-124.33	-3.37
CSP35		-22.23	-13.87
CSP35A		-	-
CSP36		6.46	19.75
CSP37		8.68	14.65
CSP38	**PORT AREA**		
CSP39			
CSP40			
CSP40A	NORTH OF PORT	-	-
CSP41		**Sea wall**	-65.81
CSP42		-19.37	-79.76
CSP43		-8.95	-21.63
CSP44		-63.19	-52.95
CSP45		-29.07	-80.42
CSP46		-21.56	-75.78
CSP47			-108.63
CSP48			-63.33
CSP49			-56.08
CSP50			-78.24
CSP51			-53.28
CSP52		**Sea wall**	-64.99
CSP53		-	-
CSP54		-60.13	-
CSP55		-28.33	-
CSP56		**Sea wall**	-

CSP57			-
CSP58			-
CSP59			-
CSP60		-16.12	-
CSP61		**Sea wall**	-
CSP62		-28.76	-
CSP63			-
CSP64			-
CSP64A			-
CSP65			-
CSP66		**Sea wall**	-
CSP67		-39.11	-
CSP68		-58.96	-
CSP69		-54.72	-
CSP70		-60.04	-
CSP71		-89.93	-
CSP72		-56.87	-
CSP73		-50.08	-
CSP74		-59.31	-
CSP75		-60.97	-
CSP76		-62.12	-
CSP77		-57.19	-
CSP78		-79.39	-
CSP79		-55.77	-
CSP80		-60.22	-
CSP81		-49.55	-

*Data not considered for analysis
-No data
Note: Volume calculation up to 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 2023 to September 2024 using satellite images that were carried out and presented.

A.2.1 Monthly and OverallShoreline Change from October 2023 to September 2024

The monthly shoreline change analysis from October 2023 to September 2024 has been shown in Figures A.33 to A.55.

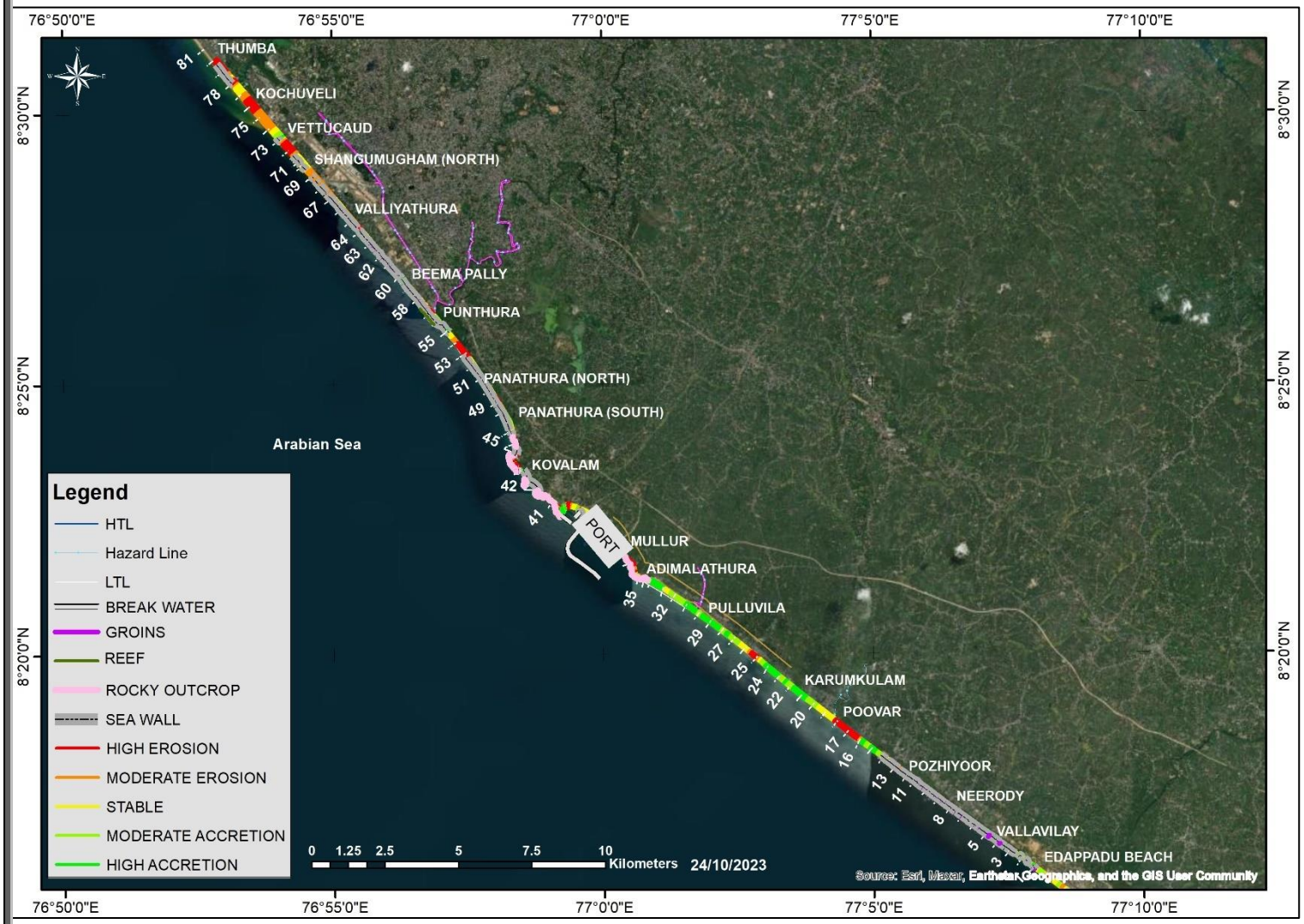


Figure A.33 Shoreline Change Map-October2023

The shoreline analysis for October 2023 shows erosion at Edappadu beach (CSP01), Vallavilay (CSP04), Poovar (CSP16-18), Karumkulam (CSP25), Mullur (CSP36-37), Kovalam (CSP45-46), Panathura (CSP49), Punthura (CSP53-54, 57), Valliyathura (CSP64-65), Shangumugham (CSP68-69), Vettucaud to Thumba (CSP74-81)while accretion at Edapadu (CSP02), Vallavilay (CSP05), Neerody (CSP07), Pozhiyur (CSP11-12), Poovar (CSP15-16), Poovar North to Karumkulam (CSP19-24), Pulluvila to Adimalathura (CSP27-34), Kovalam (CSP42-44), Punthura (CSP55-56), Beemapally to Cheriyathura (CSP59-62), Vettucaud (CSP72-73).

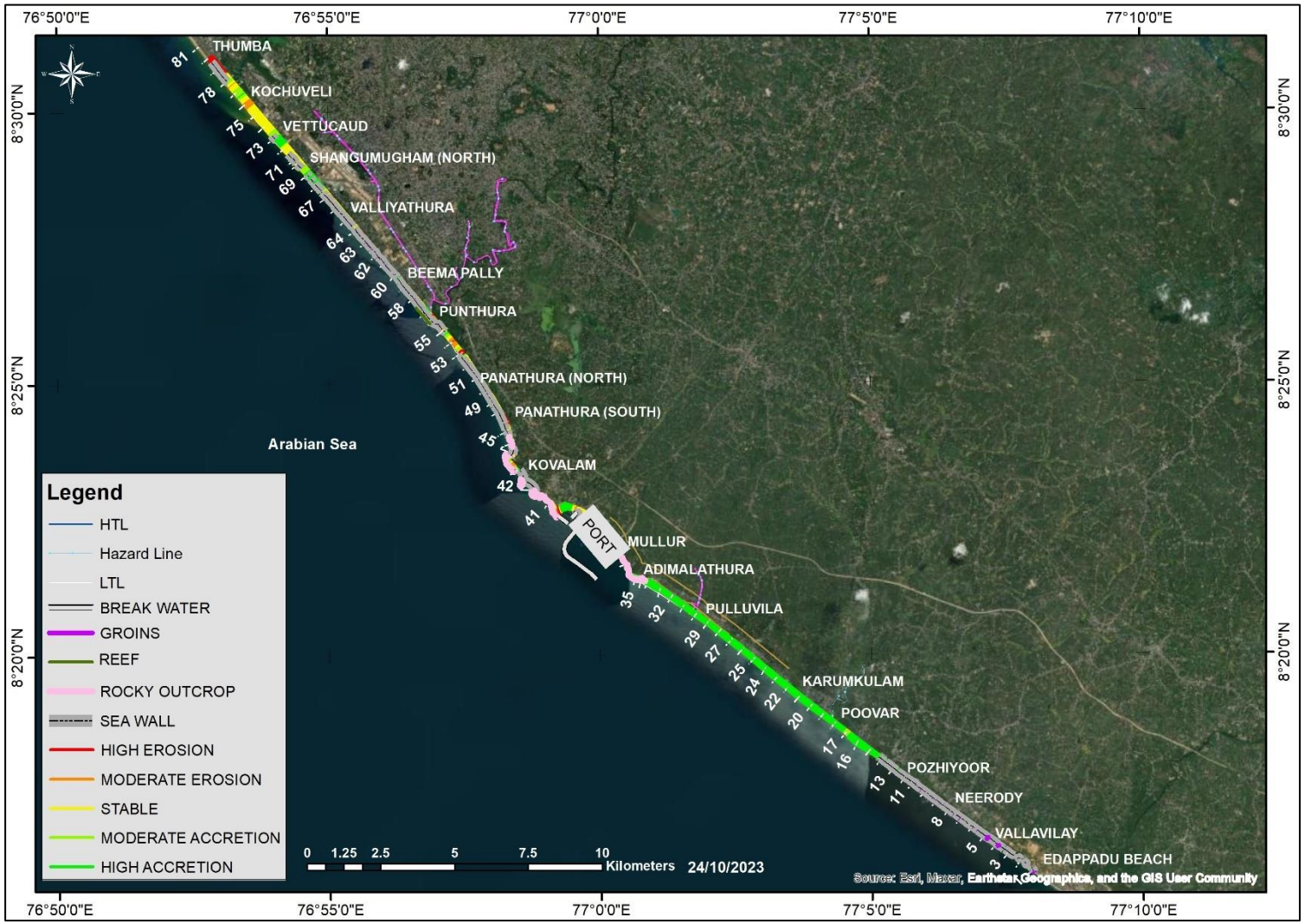


Figure A.34 Shoreline Change Map - November 2023

The shoreline analysis for November 2023 shows erosion at Pannathura (CSP48, 51), Punthura (CSP54-56), Valiyathura (CSP 63-64, 67), Kochuveli (CSP 76), Valiyaveli (CSP79), and Thumba (CSP80-81)while accretion at Edapadu to Adimalathura (CSP01-35), Kovalam (CSP42-44), Punthura (CSP57), Beemapally (CSP59-60), Cheriyathura (CSP 61-62), Shangumugham (CSP68-69), Kochuveli (CSP77), Valiyaveli (CSP78).

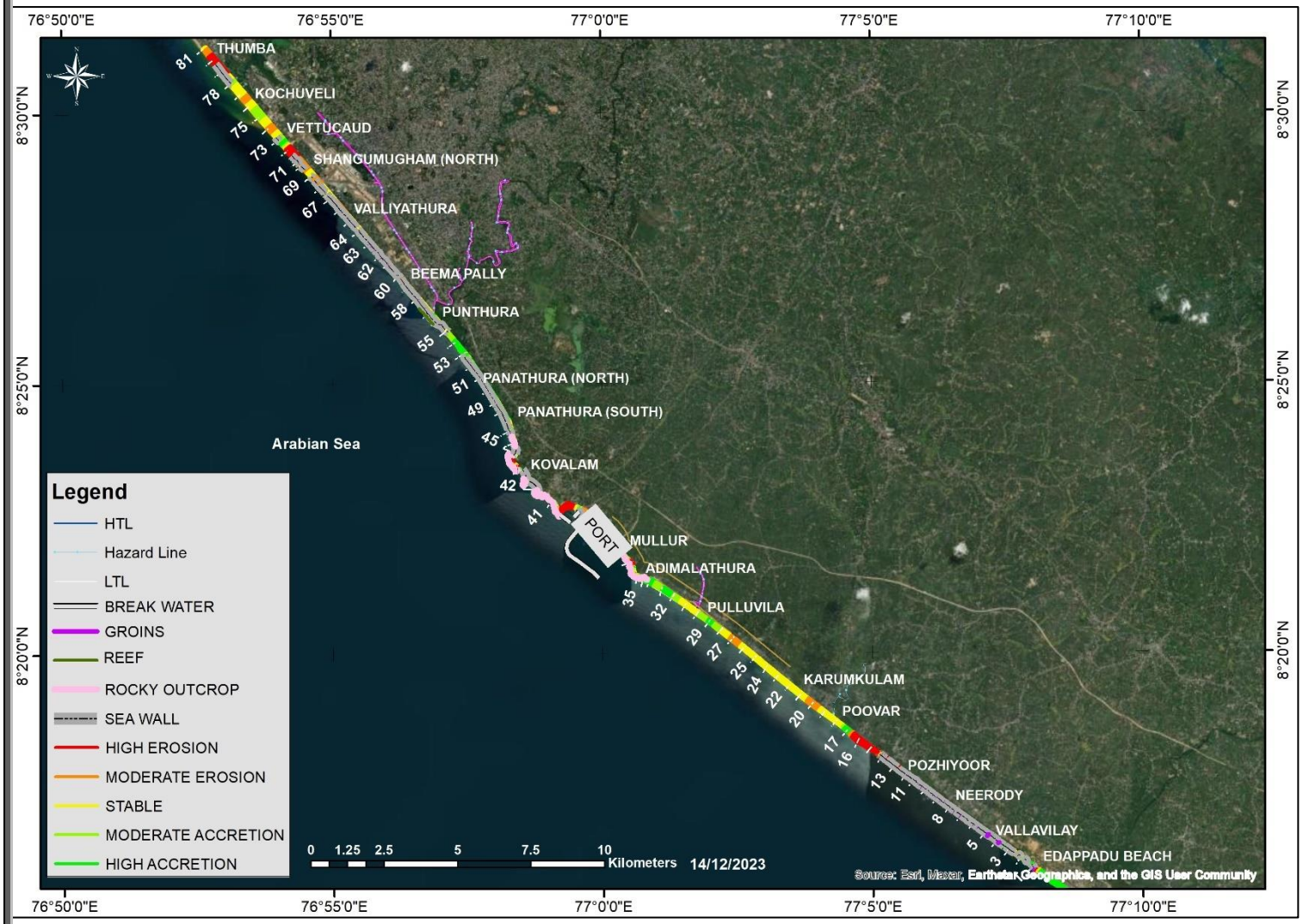


Figure A.35 Shoreline Change Map - December 2023

The shoreline analysis for December 2023 shows erosion at Edapadu (CSP01), Neerody (CSP08-09), Pozhiyur (CSP11-12), Paruthiyoor (CSP14), Poovar South (CSP15-16), Poovar North (CSP20), Pulluvila (CSP27), Mullur (CSP36), Beemapally (CSP60), Valliyathura (CSP66), Shangumugham (CSP68-71), Vettucaud (CSP72, 74), Thumba (CSP79-81)while accretion at Edapadu (CSP03), Vallavilay (CSP04-06) Pulluvila to Adimalathura (CSP28-34), Azhimala (CSP35), Mullur (CSP37), Kovalam (CSP42-47), Pannathura (CSP50-52), Punthura (CSP53-54), Vettucaud (CSP73), Kochuveli (CSP75), Valliyaveli (CSP78).

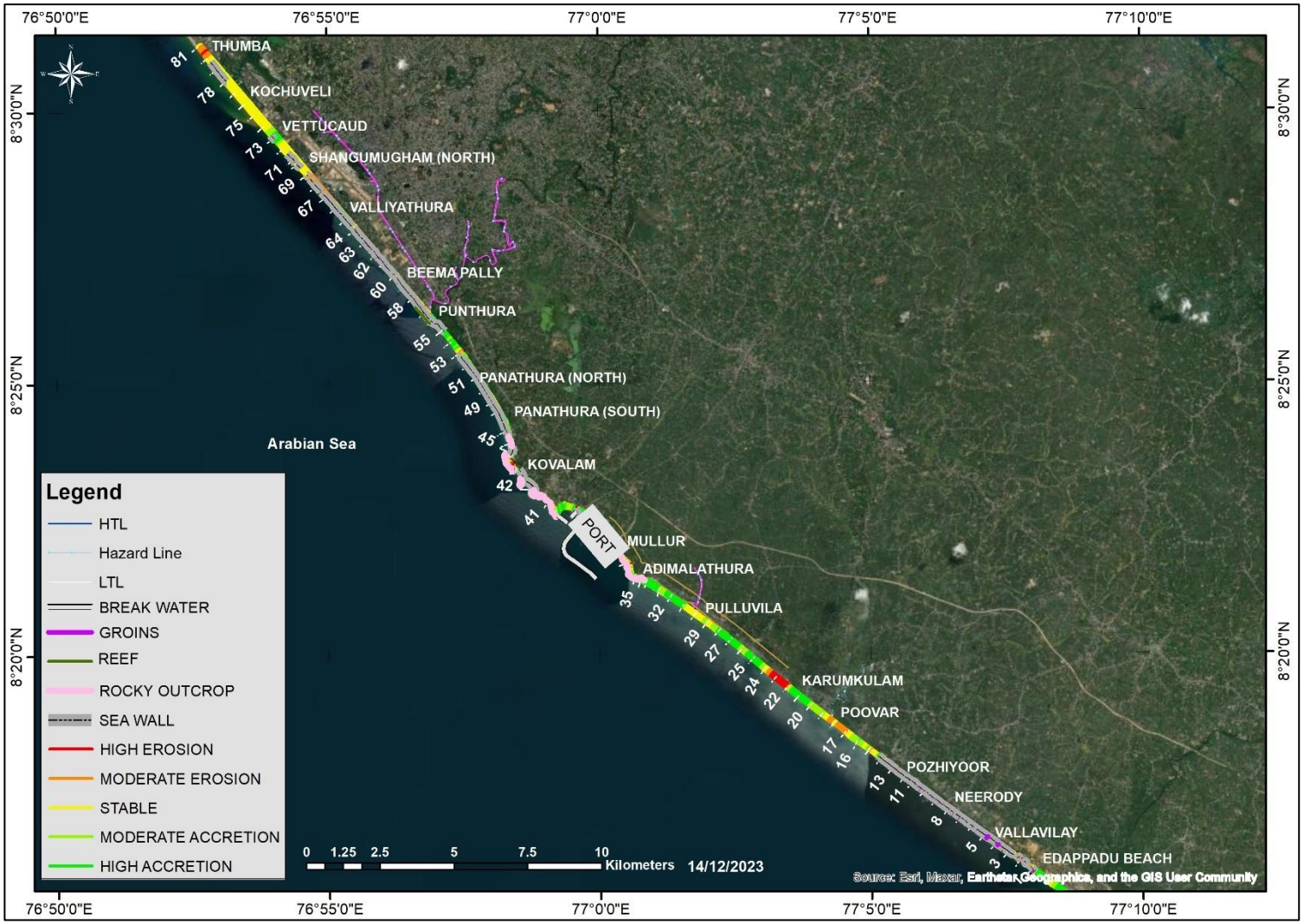


Figure A.36 Shoreline Change Map – January 2024

The shoreline analysis for January 2024 shows erosion at Edapadu (CSP02-03), Neerody (CSP07), Poovar (CSP17), Karumkulam (CSP22-23), Mullur (CSP37), Pannathura (CSP48-52), Punthura (CSP53), Valliyathura (CSP63, 67), Shangumugham (CSP68-69), Thumba (CSP80)while accretion at Edapadu (CSP01), Vallavilay (CSP04-06), Neerody (CSP08-09), Pozhiyur (CSP11), Poovar (CSP15-21), Karumkulam (CSP25-26), Pulluvila to Adimalathura (CSP27-34), Azhimala (CSP35), Kovalam (CSP41-47), Pannathura (CSP48-52), Punthura (CSP55-56), Beemapally to Cheriyathura (CSP59-61), Valliyathura (CSP66), Vettucaud (CSP73).

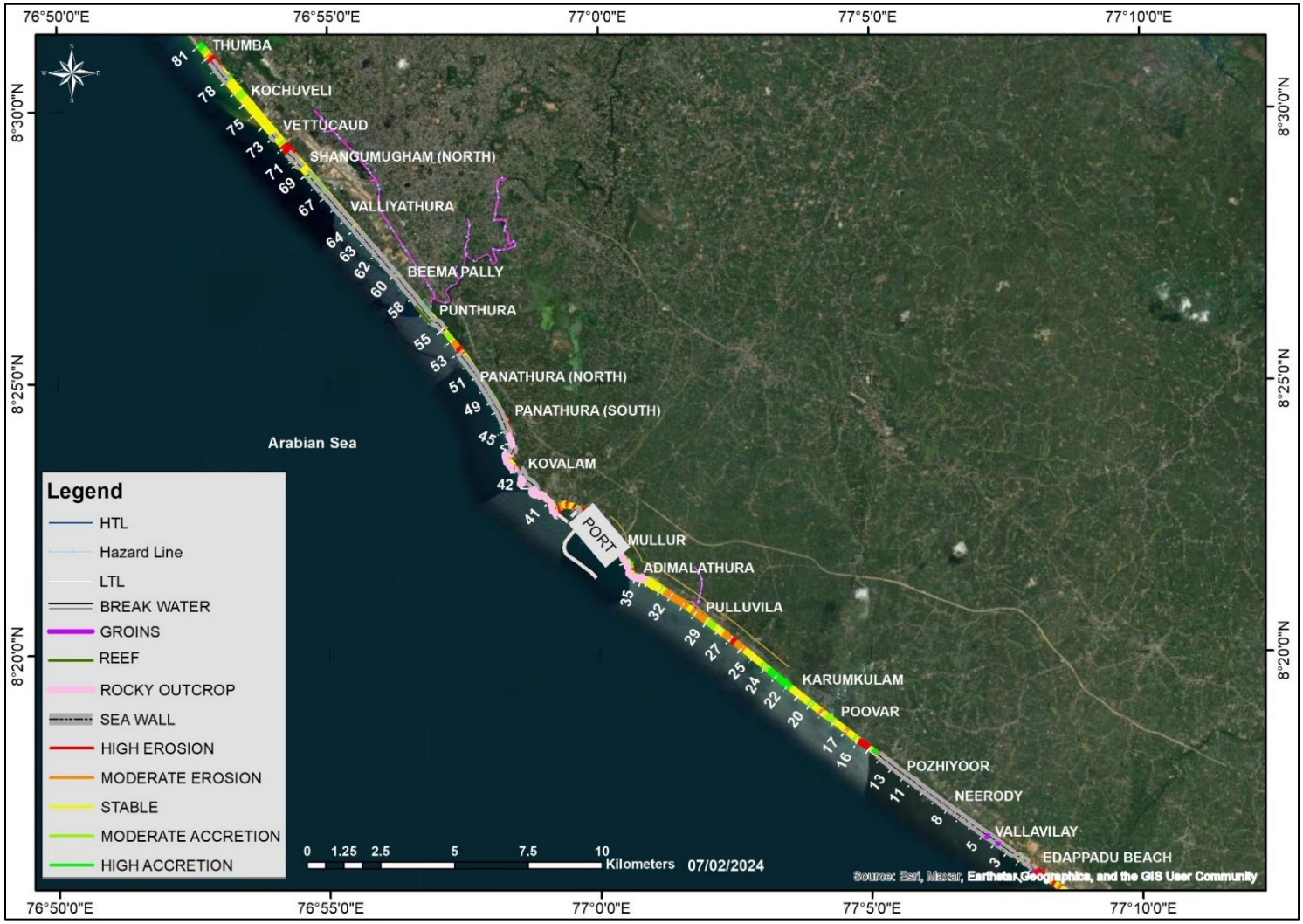


Figure A.37 Shoreline Change Map - February 2024

The shoreline analysis for February 2024 shows erosion at Edapadu (CSP01,03), Vallavilay (CSP04-05), Neerody (CSP08), Pozhiyoor (CSP11-12), Poovar (CSP15), Pulluvila (CSP27), Mullur (CSP36), Kovalam (CSP44-47), Pannathura (CSP48,50), Punthura (CSP53), Cheriyathura (CSP61), Shangumugham (CSP71), Vettucaud (CSP72), Valliyaveli (CSP79), Thumba (CSP80) while accretion at Neerody (CSP07), Pozhiyur (CSP10), Poovar (CSP18), Karumkulam (CSP22-24), Pulluvila (CSP29), Adimalathura (CSP33), Kovalam (CSP41-43), Punthura (CSP54,57), Cheriyathura (CSP62), Valliyathura (CSP63,66), Shangumugham (CSP68-69), Valliyaveli (CSP78), Thumba (CSP81).

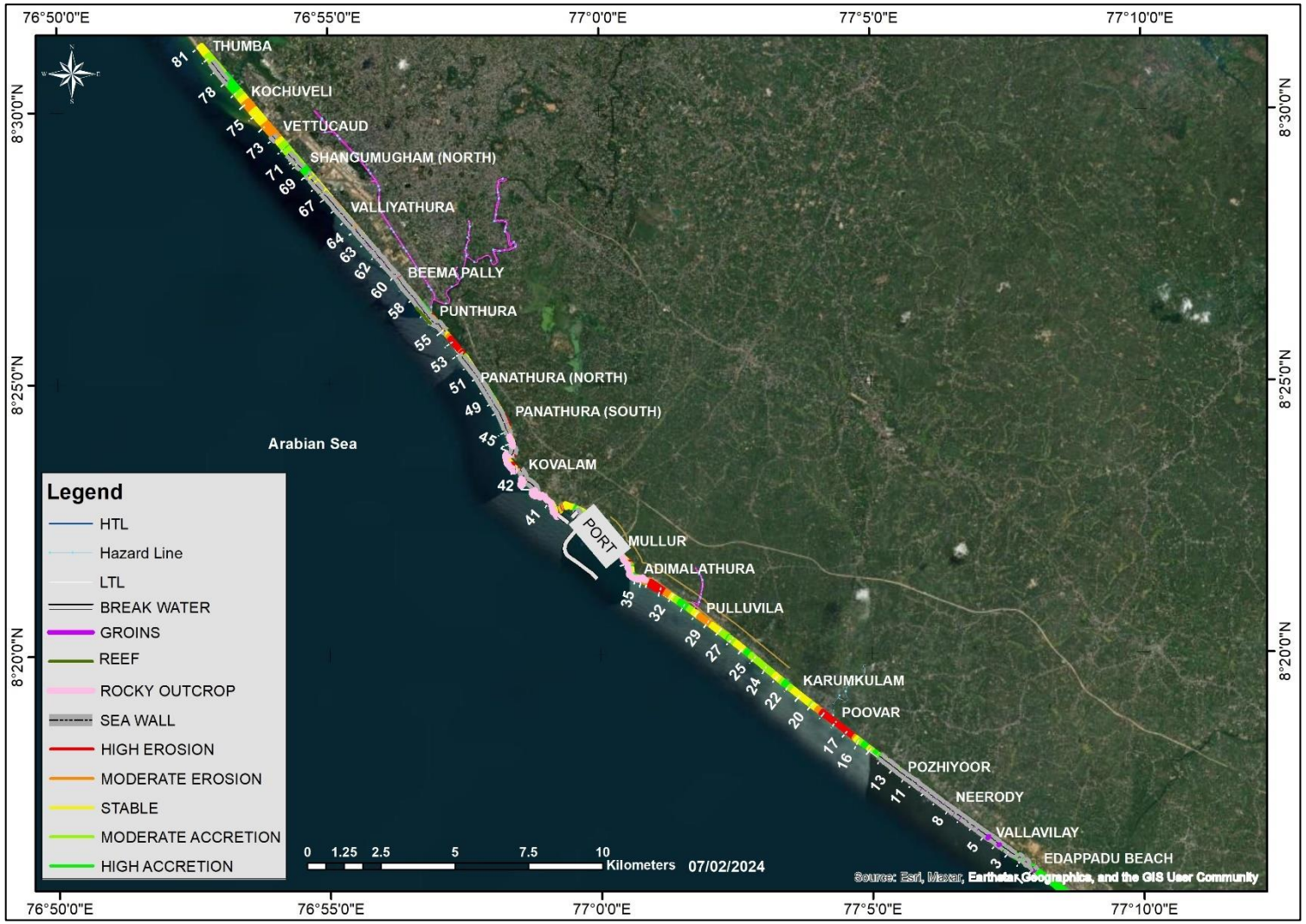


Figure A.38 Shoreline Change Map - March 2024

The shoreline analysis for March 2024 shows erosion at Poovar (CSP17-19), Pulluvila (CSP29), Adimalathura (CSP31), Mullur (CSP33-34), Kovalam (CSP44-47), Pannathura (CSP51), Punthura (CSP53-56), Beemapally (CSP60), Valliyathura (CSP64,66), Vettucaud (CSP73-74)while accretion at Poovar (CSP17-19), Pulluvila (CSP29), Adimalathura (CSP31), Mullur (CSP33-34), Kovalam (CSP44-47), Pannathura (CSP51), Punthura (CSP53-56), Beemapally (CSP60), Valliyathura (CSP64,66), Vettucaud (CSP73-74).

The monthly shoreline change analysis for April 2024 indicates erosion at Edappadu beach (CSP01-02), Vallavilay (CSP04-06), Paruthiyoor (CSP13-14), Poovar (CSP15-21), Karumkulam (CSP23-26), Adimalathura (CSP31,34), Azhimala (CSP35), Mullur (CSP37), Kovalam (CSP41,44-46), Pannathura (CSP48-50), Punthura (CSP53-56), Beemapally (CSP58,60), Cheriyathura (CSP61-62), Valiyathura (CSP64-67), Shangumugham (CSP68-71), Vettucaud (CSP72-74), Kochuveli (CSP75), Kochuveli to Valiyaveli (CSP77-79) and CSP80 (Thumba) while accretion at Edappadu beach (CSP03), Neerody (CSP07,09), Pozhiyoor (CSP10-11), Karumkulam (CSP22), Adimalathura (CSP32-33), Mullur (CSP36), Kovalam (CSP47), Punthura (CSP57), Thumba (CSP81).

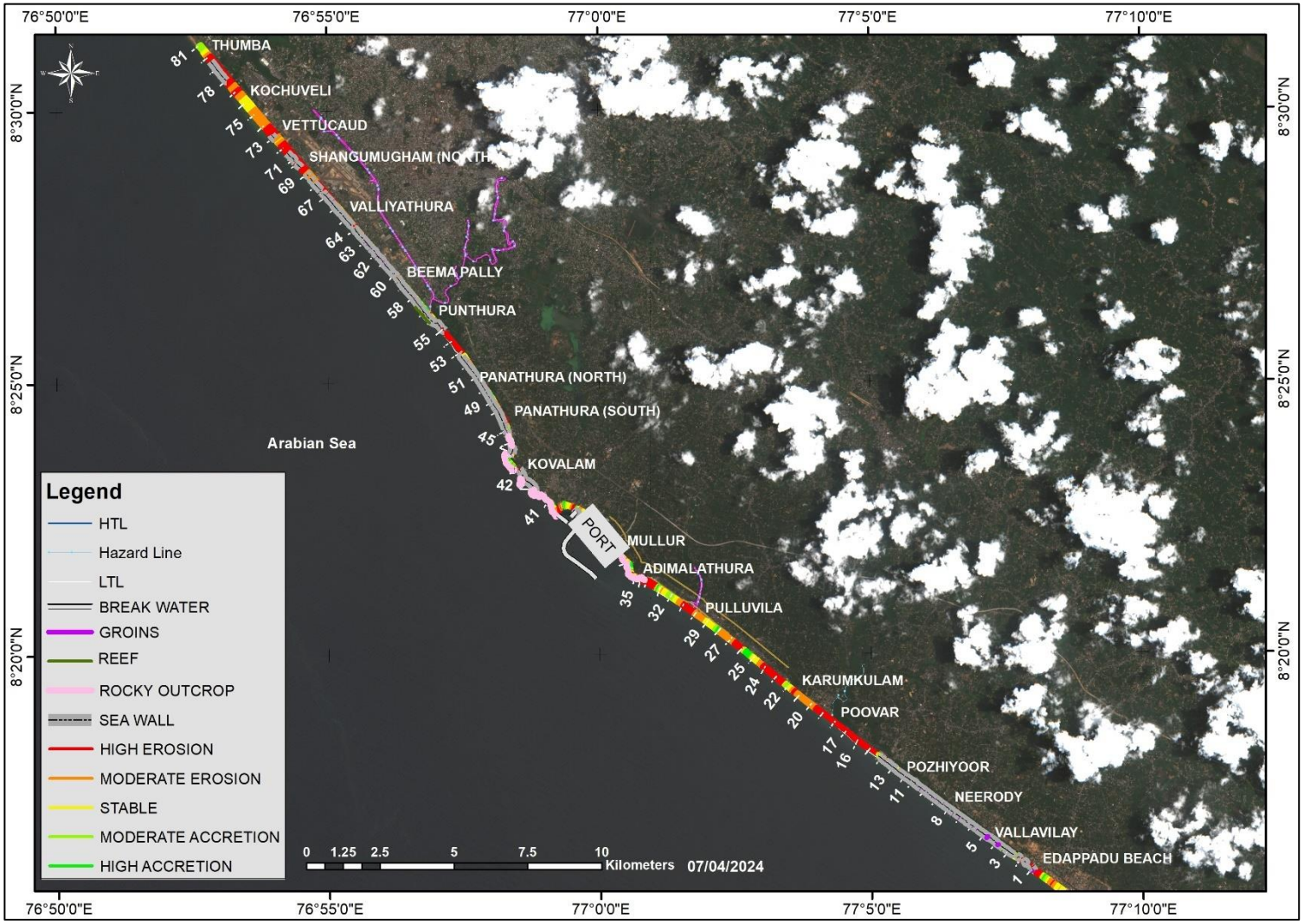


Figure A.39 Shoreline Change Map - April 2024

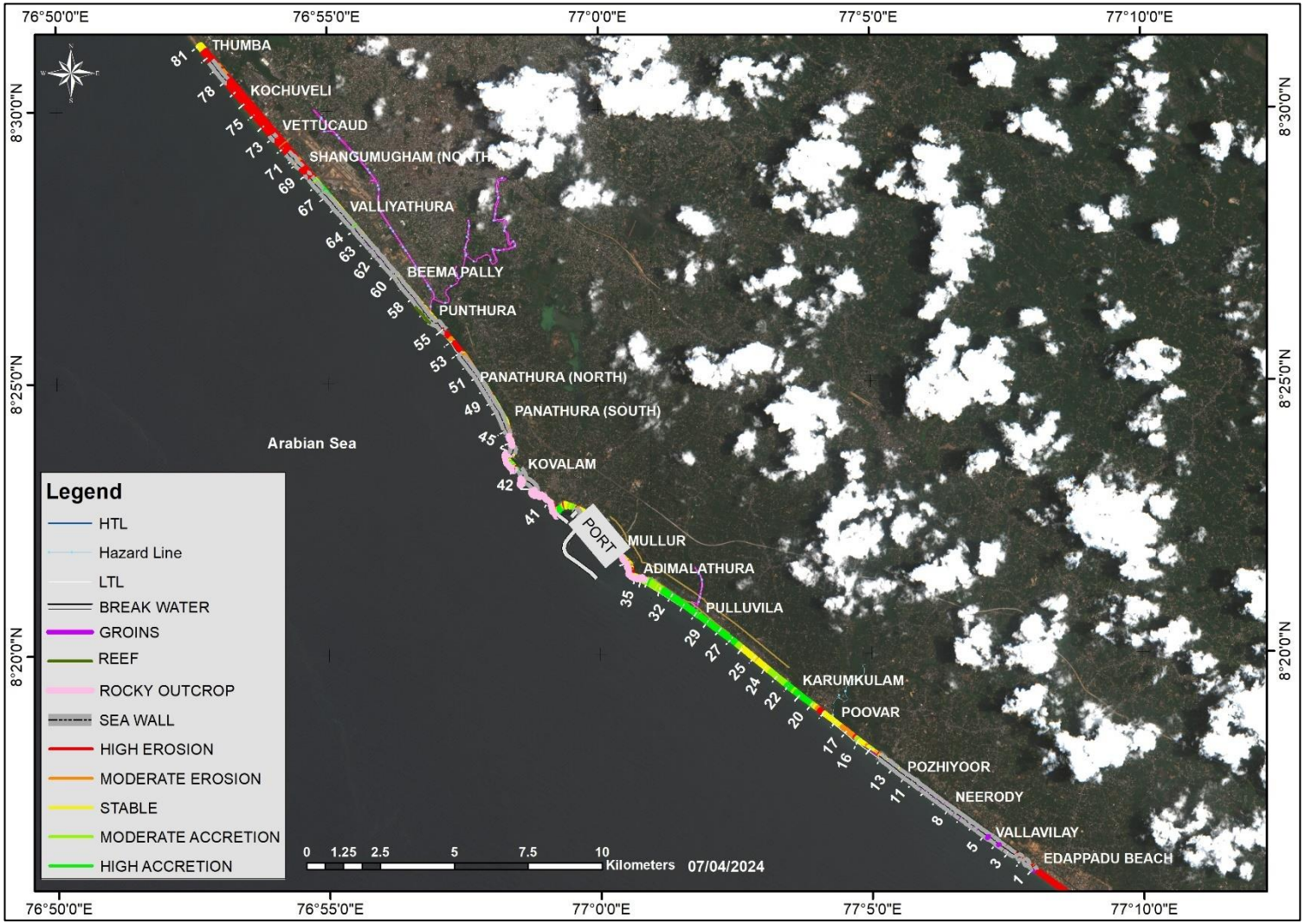


Figure A.40 Shoreline Change Map - May 2024

The monthly shoreline change analysis for May 2024 exhibits erosion at Edappadu beach to Pozhiyoor (CSP01-10), Poovar south (CSP17), Poovar (CSP19), Mullur (CSP36-37), Kovalam (CSP41,47), Panathura north (CSP51-52), Punthura (CSP53-57), Shangumugham (CSP69-71), and Vettucaud to Thumba (CSP72-80)while accretion at Poovar north (CSP15-21), Karumkulam (CSP22,23,26), Pulluvila (CSP27-30), Adimalathura (CSP31-34), Kovalam (CSP44,46), Panathura (CSP48-49), Valiyathura (CSP64, 65, 67), Shangumugham (CSP68).

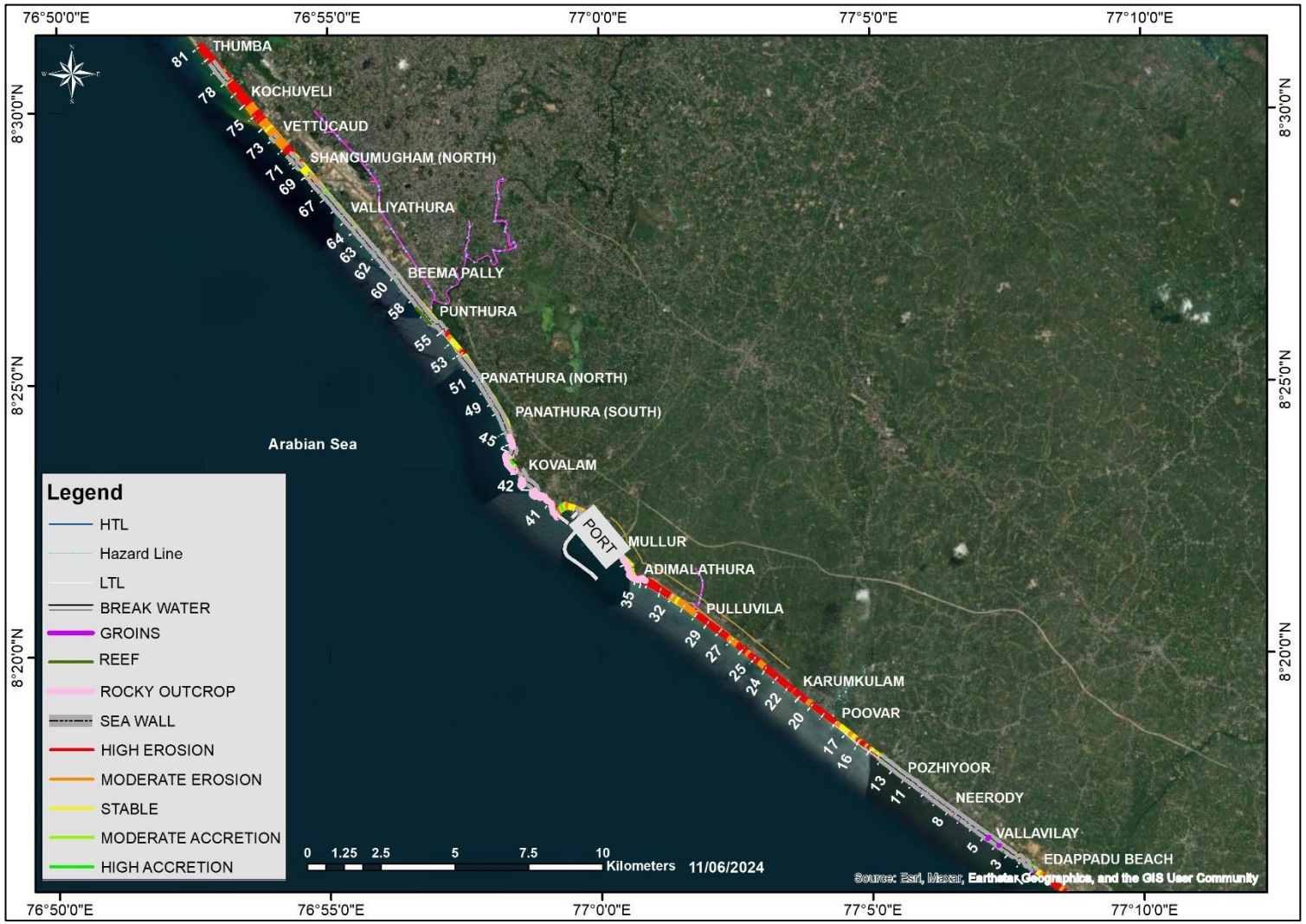


Figure A.41 Shoreline Change Map - June 2024

For June 2024, the shoreline change analysis shows accretion at Edappadu beach (CSP01), Vallavilay (CSP06), Mullur (CSP36-37), Pannathura (CSP49, 51), Valliyathura (CSP63, 67)while erosion occurs at Edappadu beach (CSP02), Neerody (CSP08,09), Pozhiyoor (CSP10), Poovar (CSP15-16, 18-21), Karumkulam (CSP22-26), Pulluvila (CSP27-30), Adimalathura (CSP31-34), Azhimala (CSP35), Kovalam (CSP41-46), Panathura (CSP48, 50), Punthura (CSP53,55), Beemapally (CSP58, 60), Cheriyathura (CSP61-62), Shangumugham (CSP68, 70), Vettucaud to Thumba (CSP72-81).

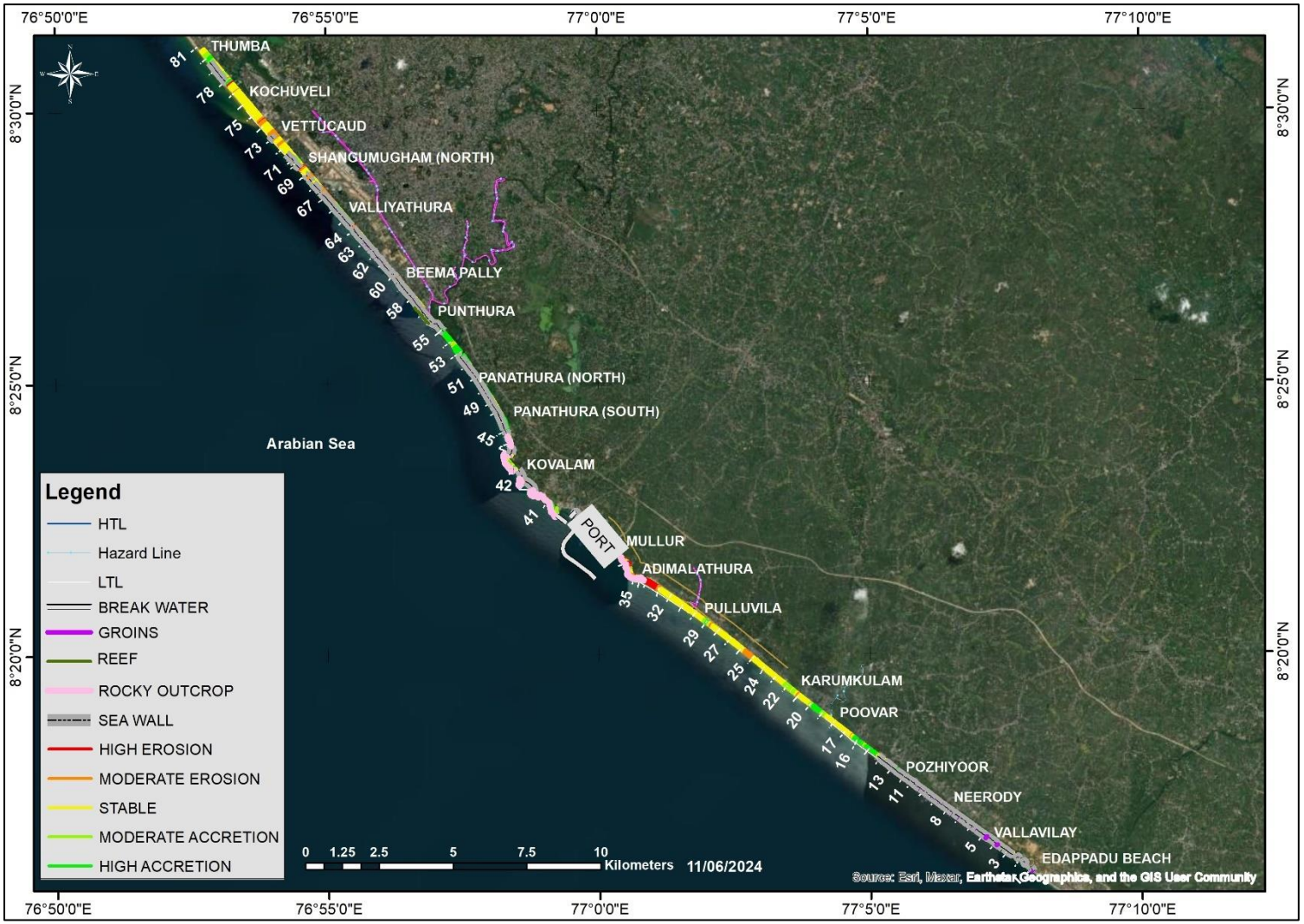
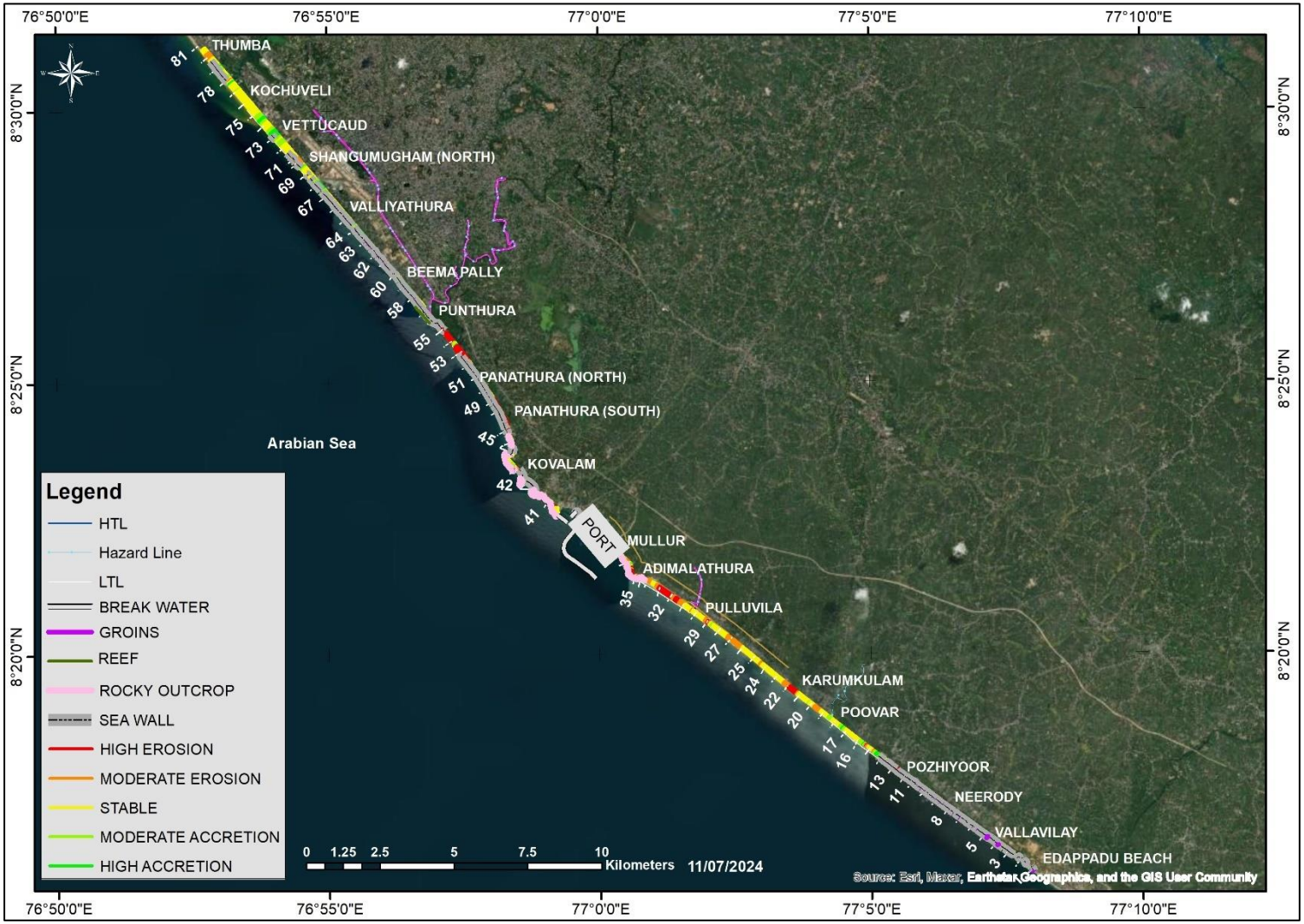


Figure A.42 Shoreline Change Map - July 2024

For July 2024, the shoreline change analysis shows erosion at Vallavilay (CSP04, 06), Neerody (CSP08,09), Poovar (CSP21), Adimalathura (CSP33-34), Mullur (CSP36-37), Kovalam (CSP45), Punthura (CSP57), Beemapally (CSP58, 60), Cheriyathura (CSP62), Valliyathura (CSP63-64, 67), Shangumugham (CSP69), Vettucaud (CSP73-74) and Valiyaveli (CSP78)while accretion at Edappadu beach (CSP01-03), Pozhiyoor (CSP12), Poovar (CSP15-16, 19-20), Kovalam (CSP41-43, 46-47), Pannathura (CSP 48, 50, 52), Punthura (CSP53-55), Valliyathura (CSP65-66), Shangumugham (CSP70-71).



The monthly shoreline change analysis for August 2024 indicates accretion at Edappadu beach (CSP01-03), Pozhiyoor (CSP10), Poovar (CSP17), Mullur (CSP37), Beemapally (CSP58-60), Shangumugham South (CSP68), Vettucaud (CSP73), Kochuveli (CSP75) and Valiyaveli (CSP79)while erosion at Vallavilay (CSP04-05), Neerody (CSP07, 09), Karumkulam (CSP22), Adimalathura (CSP31-34), Kovalam (CSP47), Panathura (CSP48-50), Punthura (CSP53-55), Cheriyathura (CSP61-62), Shangumugham (CSP70), Thumba (CSP80).

Figure A.43 Shoreline Change Map - August 2024

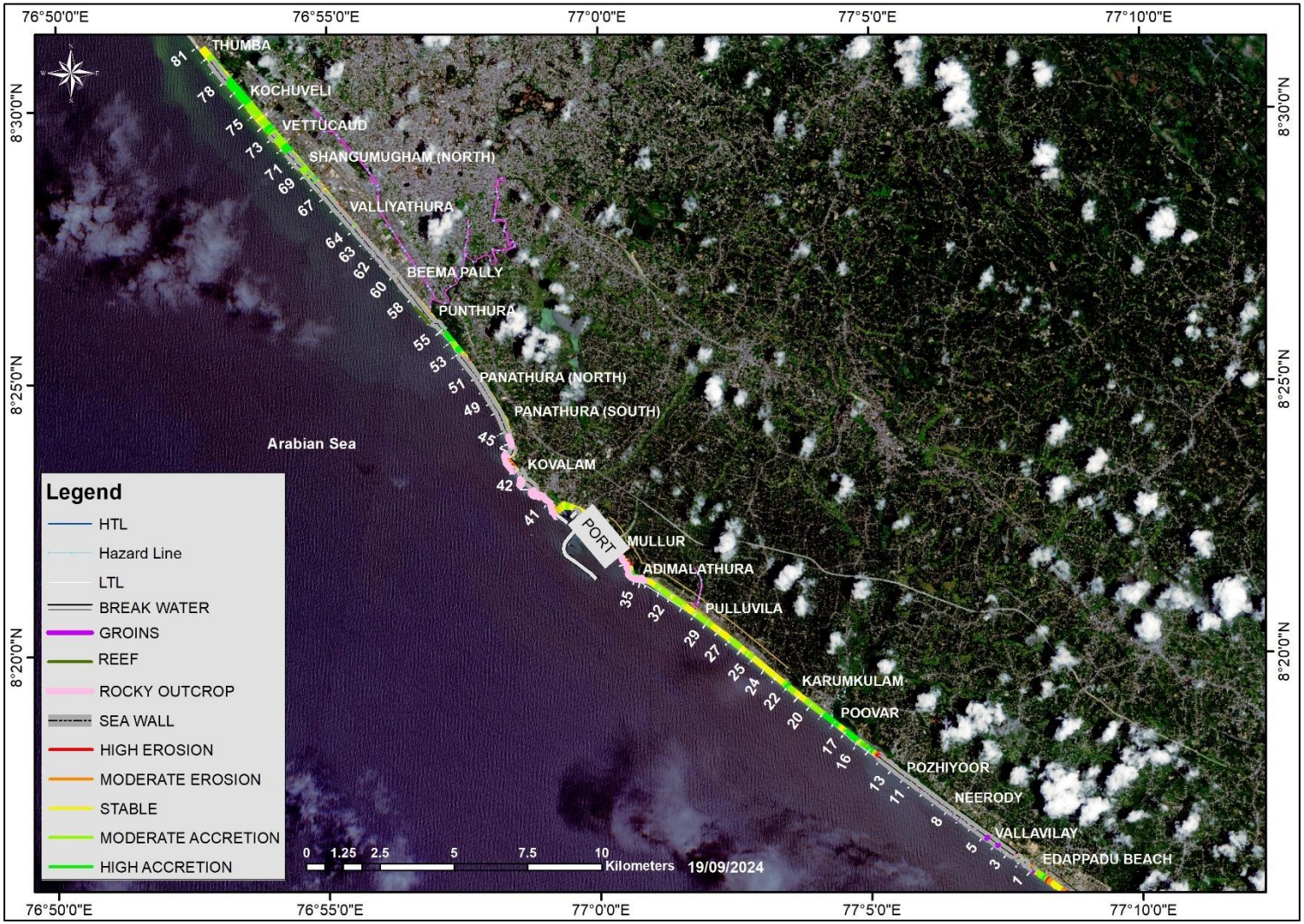


Figure A.44 Shoreline Change Map -September 2024

The monthly shoreline change analysis for September 2024 indicates erosion at Edappadu Beach (CSP01, 03), Mullur (CSP36-37), Kovalam (CSP41), Panathura (CSP50-51), Beemapally (CSP58-59), Valliyathura (CSP63, 65-66), Shangumugham north (CSP68)while accretion at Poovar (CSP15-20), Karumkulam (CSP22,26), Pulluvila (CSP29-30), Adimalathura (CSP32-35), Kovalam (CSP46), Panathura (CSP49), Punthura (CSP53-55), Shangumugham to Thumba (CSP69-80).

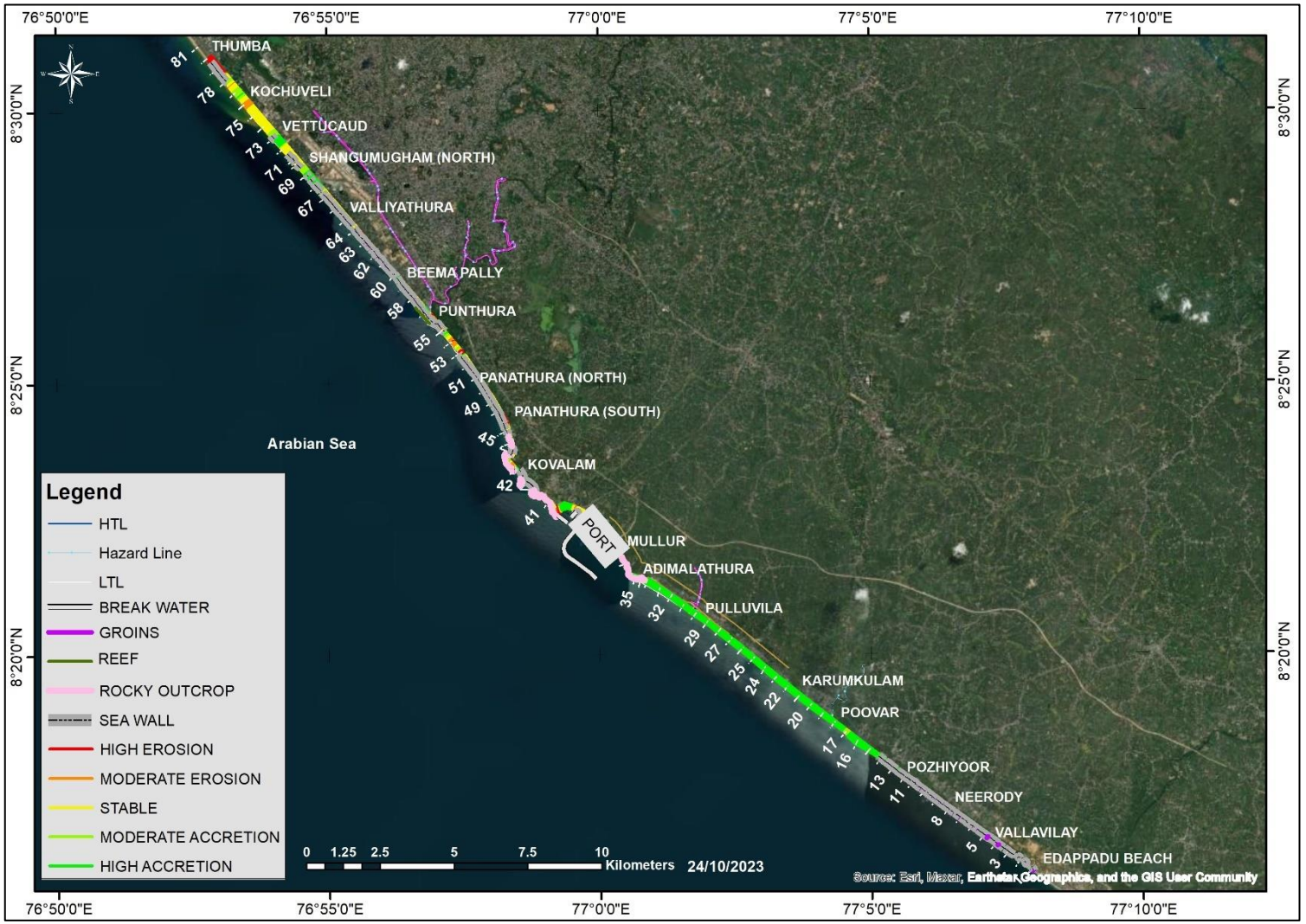


Figure A.45 Shoreline Change Analysis - Post Monsoon Period (October 2023-November 2023)

A.2.2 Seasonal and Overall Shoreline Change Analysis from October 2023 to September 2024

Post Monsoon Period (October 2023-November 2023)

The shoreline change analysis map shows erosion at Pannathura (CSP48, 51), Punthura (CSP54-56), Valiyathura (CSP 63-64, 67), Kochuveli (CSP 76), Valiyaveli (CSP79), and Thumba (CSP80-81) while accretion at Edapadu to Adimalathura (CSP01-35), Kovalam (CSP42-44), Punthura (CSP57), Beemapally (CSP59-60), Cheriyathura (CSP 61-62), Shangumugham (CSP68-69), Kochuveli (CSP77), Valiyaveli (CSP78).

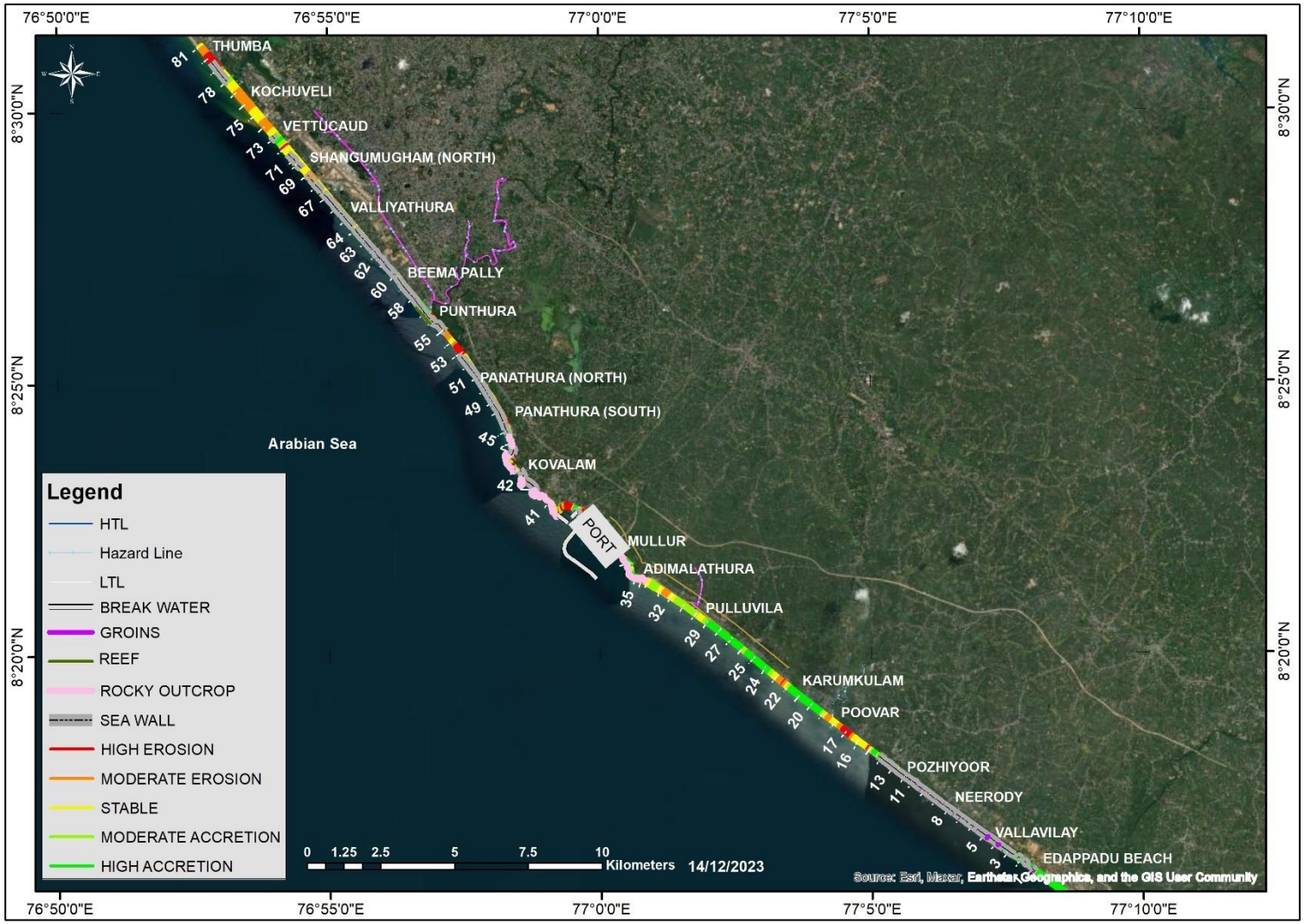


Figure A.46 Shoreline Change Analysis -Fair Weather Period (December 2023 -March 2024)

Fairweather Period (December 2023-March 2024)

The shoreline change analysis map shows accretion at Edapadu (CSP02), Poovar to Karumkulam (CSP19-22), Pullavila to Adimalathura(CSP24-31, 33), Punthura to Valliyathura (CSP57-61), Shangumugham (CSP70-71), Vettucaud (CSP73), Valliyaveli (CSP78),whileerosionatPoovar (CSP16-18), Karumkulam (CSP22-23), Adimalathura (CSP34), Mulur (CSP37), Punthura (CSP 57), Valiyathura (CSP64), Shangumugam (CSP67-69), Vettucaud to Kochuveli (CSP73-77), Thumba (80-81)for the fair weather period.

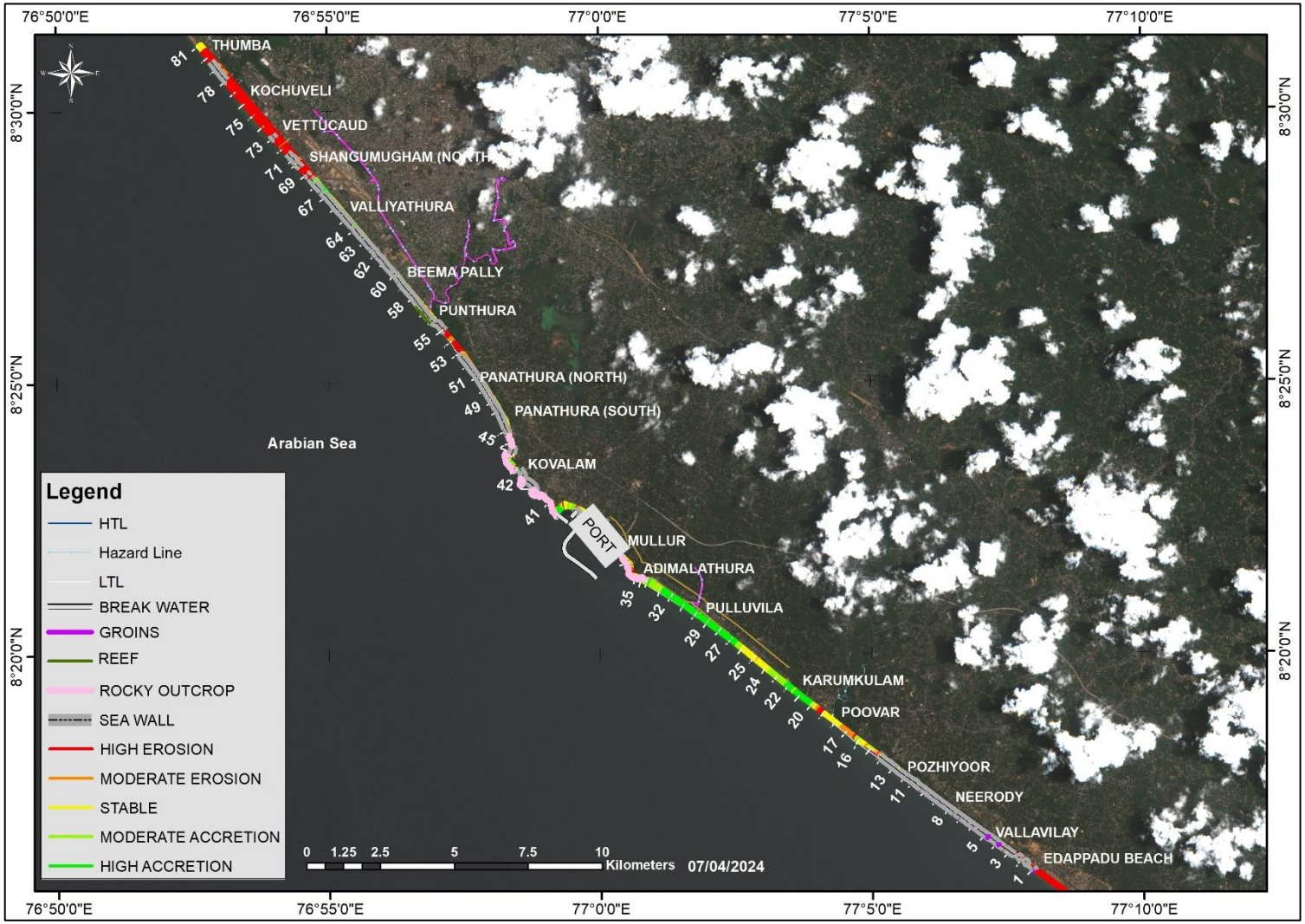


Figure A.47 Shoreline Change Analysis - Pre-Monsoon Period (April 2024-May 2024)

Pre Monsoon Period (April 2024 to May 2024)

Pre-monsoon period (April 2024 to May 2024) exhibits erosion at Edappadu beach to Pozhiyoor (CSP01-10), Poovar south (CSP17), Poovar (CSP19), Mullur (CSP36-37), Kovalam (CSP41,47), Panathura north (CSP51-52), Punthura (CSP53-57), Shangumugham (CSP69-71), and Vettucaud to Thumba (CSP72-80)while accretion at Poovar North (CSP15-21), Karumkulam (CSP22,23,26), Pulluvila (CSP27-30), Adimalathura (CSP31-34), Kovalam (CSP44,46), Panathura (CSP48-49), Valiyathura (CSP64, 65, 67), Shangumugham (CSP68).

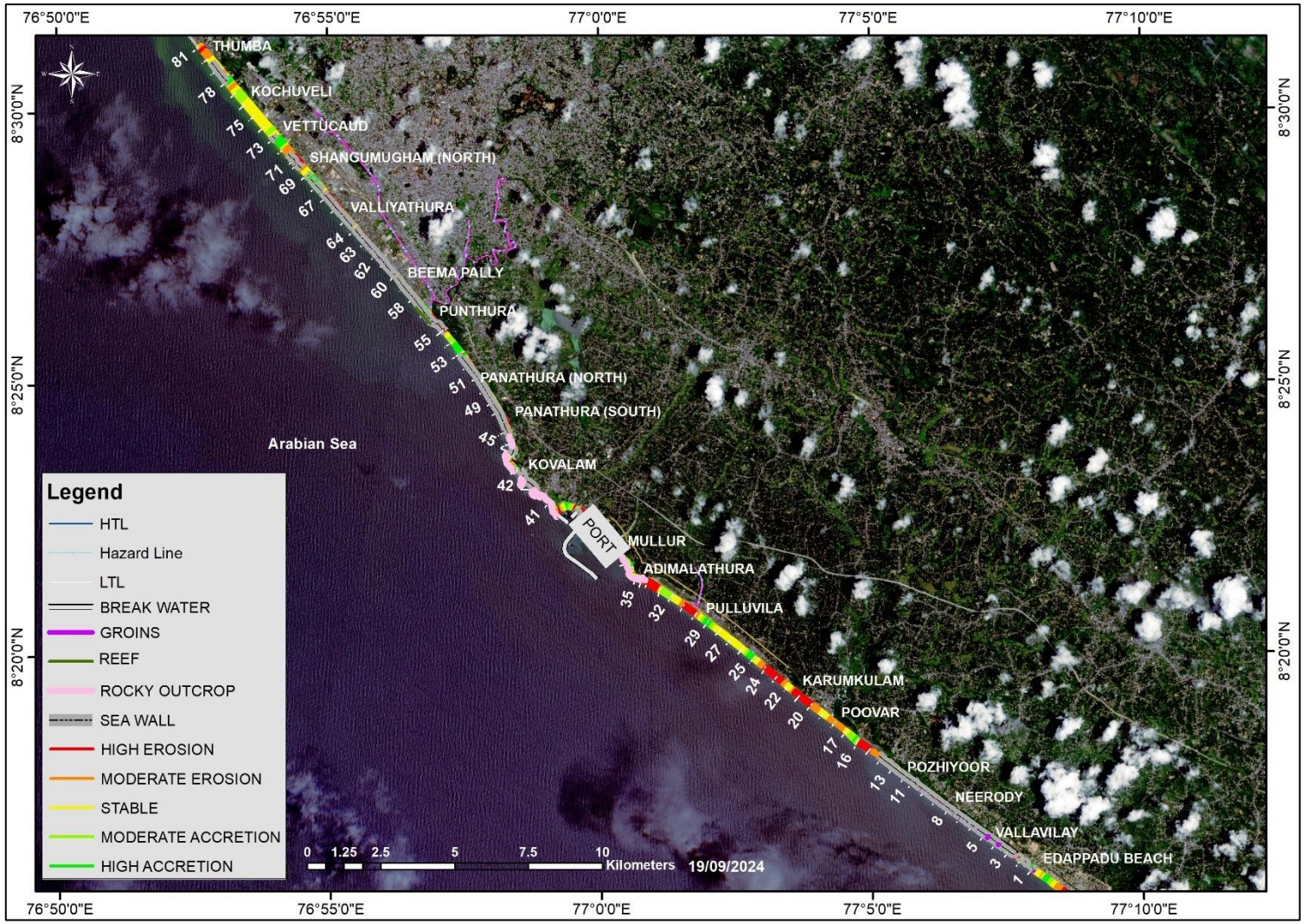


Figure A.48 Shoreline Change Analysis - Monsoon Period (June 2024 - September 2024)

Monsoon Period (June 2024 to September 2024)

Monsoon period for 2024 indicates erosion along the coast at Edapadu Beach (CSP01, 03), Adimalathura to Poovar (CSP20-34, 16), Kovalam (CSP42-45), Valliyathura (CSP65-66), Thumba (CSP80-81) while accretion is noticed at Edapadu beach (CSP02), Poovar (CSP14-17), Mullur (CSP37), Punthura (CSP 53-55), Shangumugham to Vettucaud (CSP66-73).

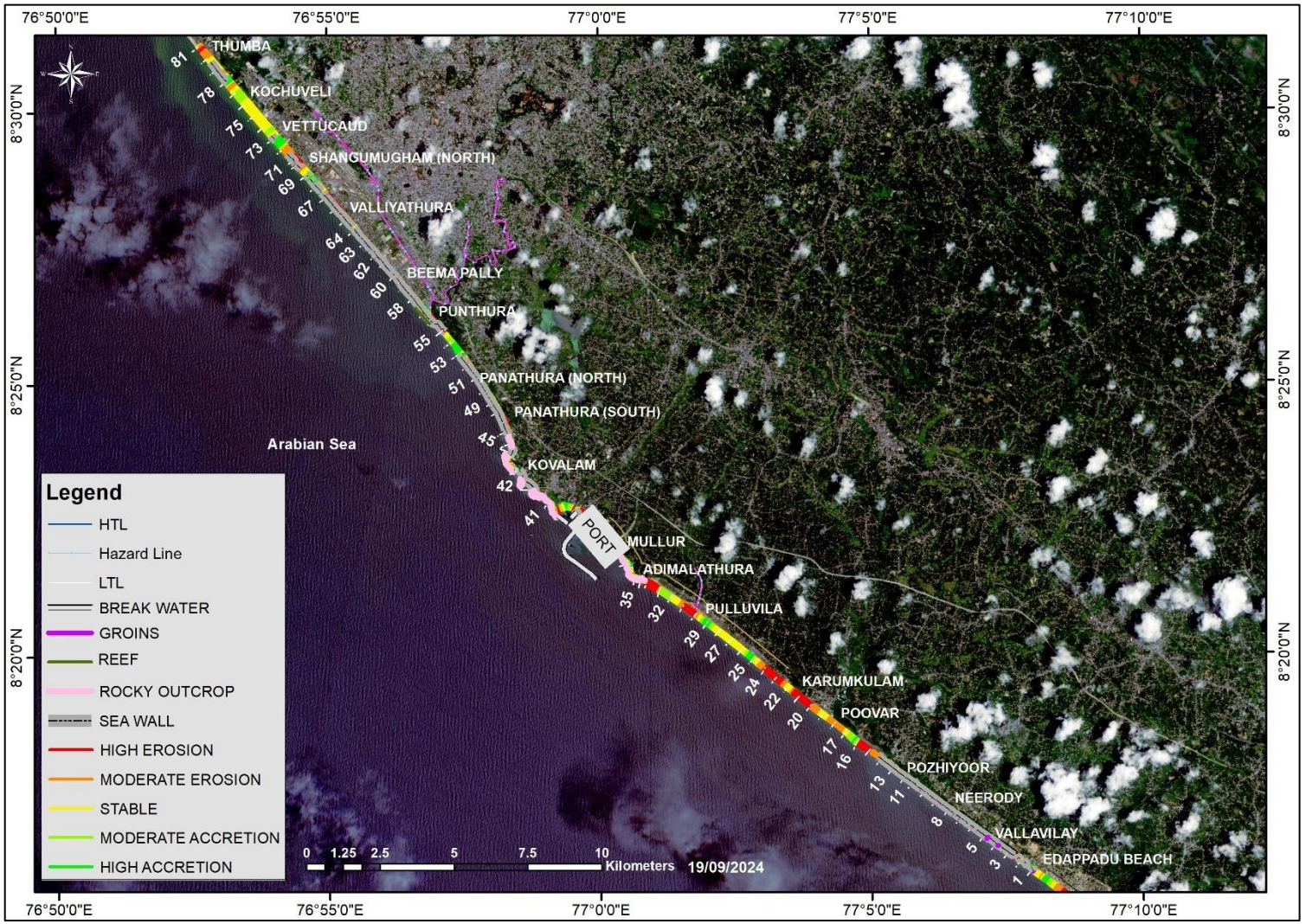


Figure A.49 Overall Shoreline Change Map for October 2023- September 2024

Overall Shoreline Changes for October 2023- September 2024

Erosion is noticed 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)while accretion is noticed 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).

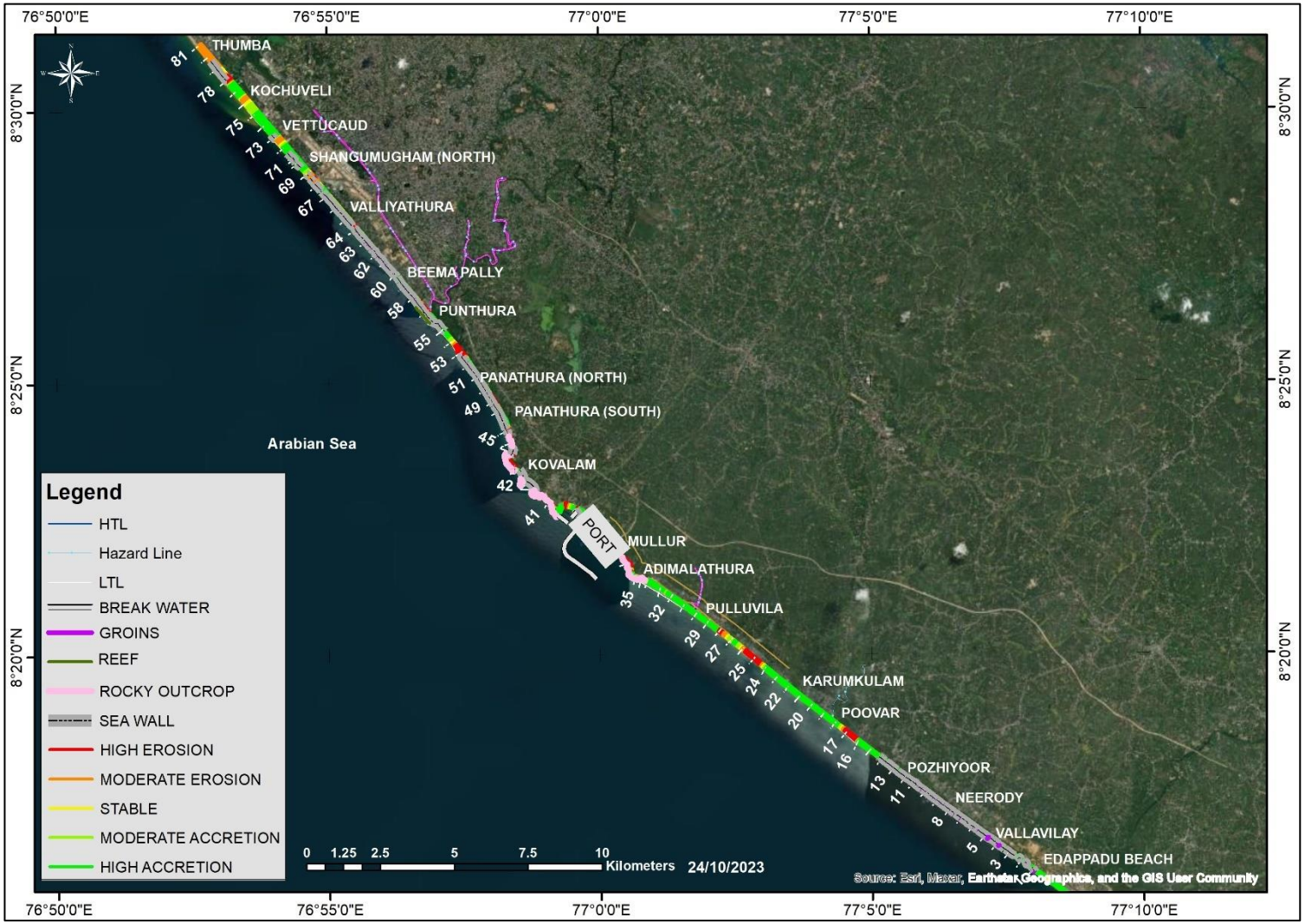


Figure A.50 Shoreline Change Map for October 2022-October 2023

A.2.3 Shoreline comparison for the period October 2022-September 2023 and October 2023- September 2024

Shoreline comparison between October 2022 and October 2023

Erosion is noticed at Poovar (CSP16-17), Karumkulam (CSP25-26), Pulluvila (CSP28), Mullur (CSP37), Kovalam (CSP45), Punthura (CSP53,57), Valliyathura (CSP66) and Thumba (CSP 78-81) whileaccretion isnoticed atEdapadu Beach (CSP02), Poovar (CSP18-24), Adimalathura to Pulluvila (CSP 29-34), Panathura North (CSP51), Punthura (CSP53-54) and Vettucaud (CSP69-75).

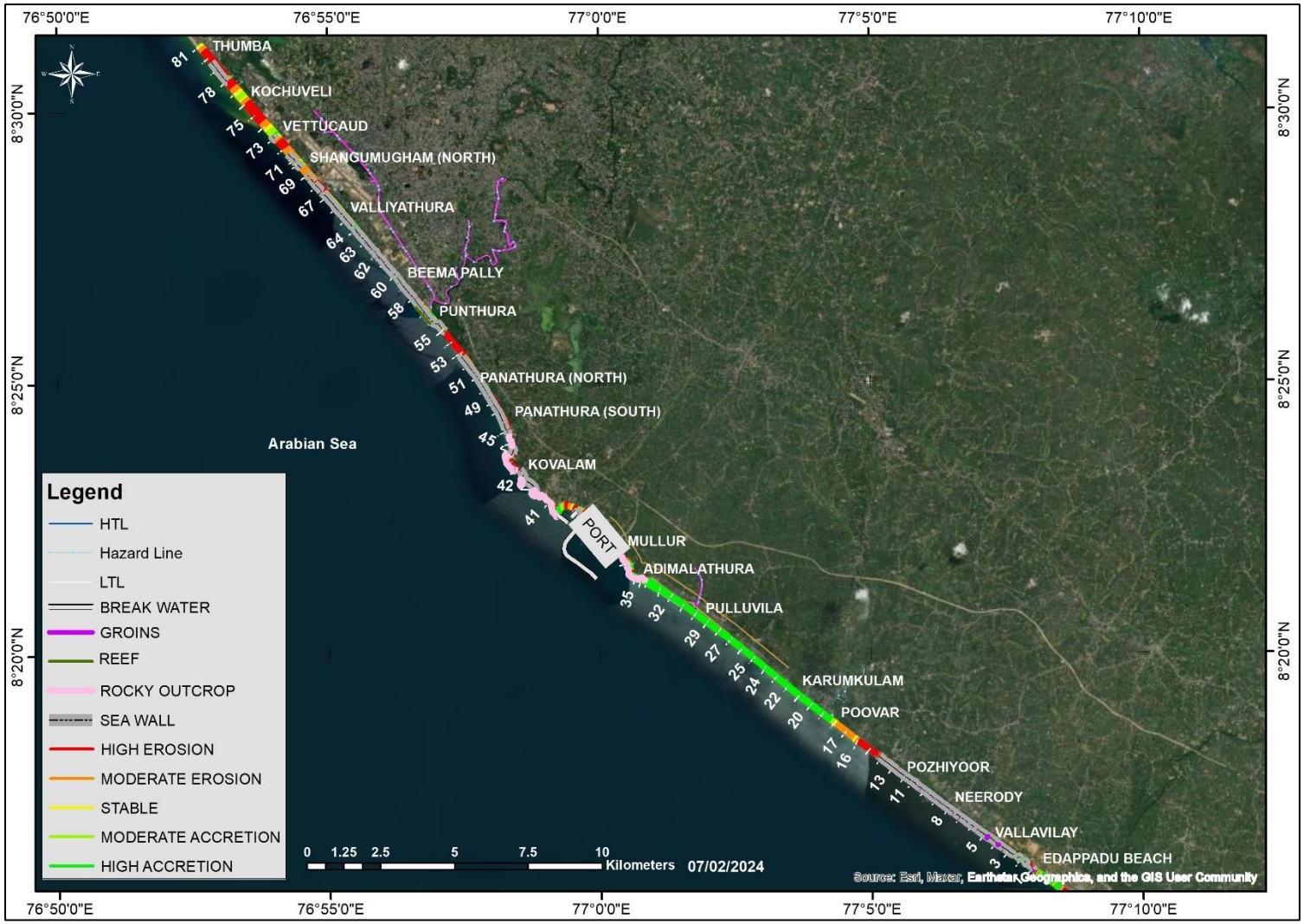


Figure A.51 Shoreline Change Map for February 2023- February 2024

Shoreline comparison between February 2023 and February 2024

The shoreline comparison shows accretion at Edapadubeach(CSP02), Poovar to Adimalthura (CSP20-34), Mullur (CSP37), Punthura to Valliyathura (CSP55-64), Vettucaud(CSP73), and Valliyaveli (CSP79)whileerosionatPoovar (CSP13-19), Punthura (CSP 53-54), Shangumugamto Valliyathura (CSP65-71), Kochuveli (CSP75) and Thumba (CSP79-81).

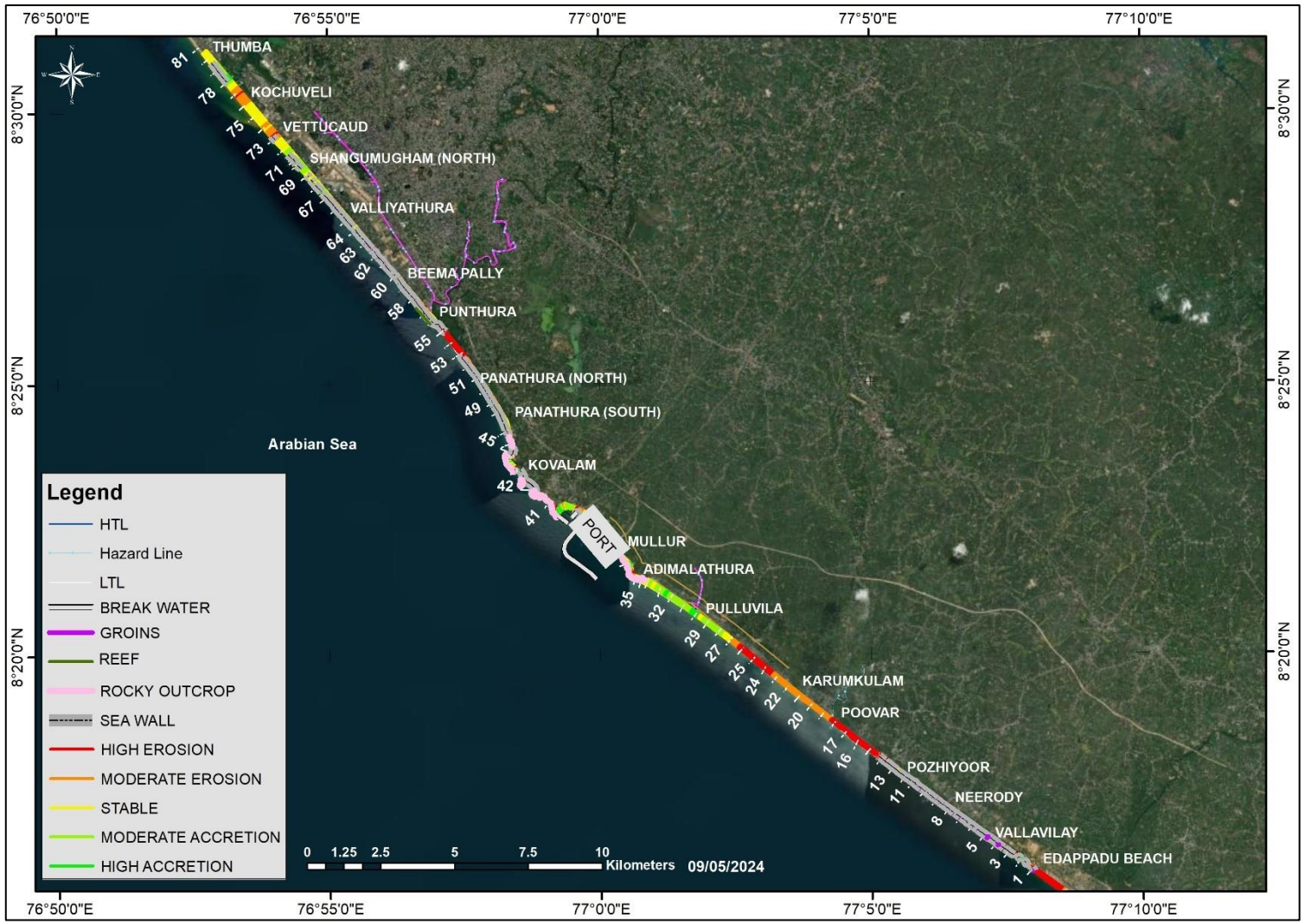


Figure A.52 Shoreline Change Map -May 2023 and May 2024

Shoreline comparison between May 2023 and May 2024

Accretion is noticed at EdapaduBeach(CSP02), Pulluvila to Adimalathura (CSP27-34), Mullur (CSP37), Shangumugham north (CSP68-71),and Thumba (CSP80-81) while erosion is noticed at Edapadu beach (CSP01, 03), (CSP04-10), Poovar to Pulluvila (CSP13-26), Mullur (CSP35), Kovalam (CSP42,44,45), Pannathura (CSP48-49, 51-52), Punthura (CSP53-55), Cheriyathura (CSP61-62), Valliyathura (CSP63-64, 66), Vettucaud (CSP73-74), Kochuveli (CSP76-77).

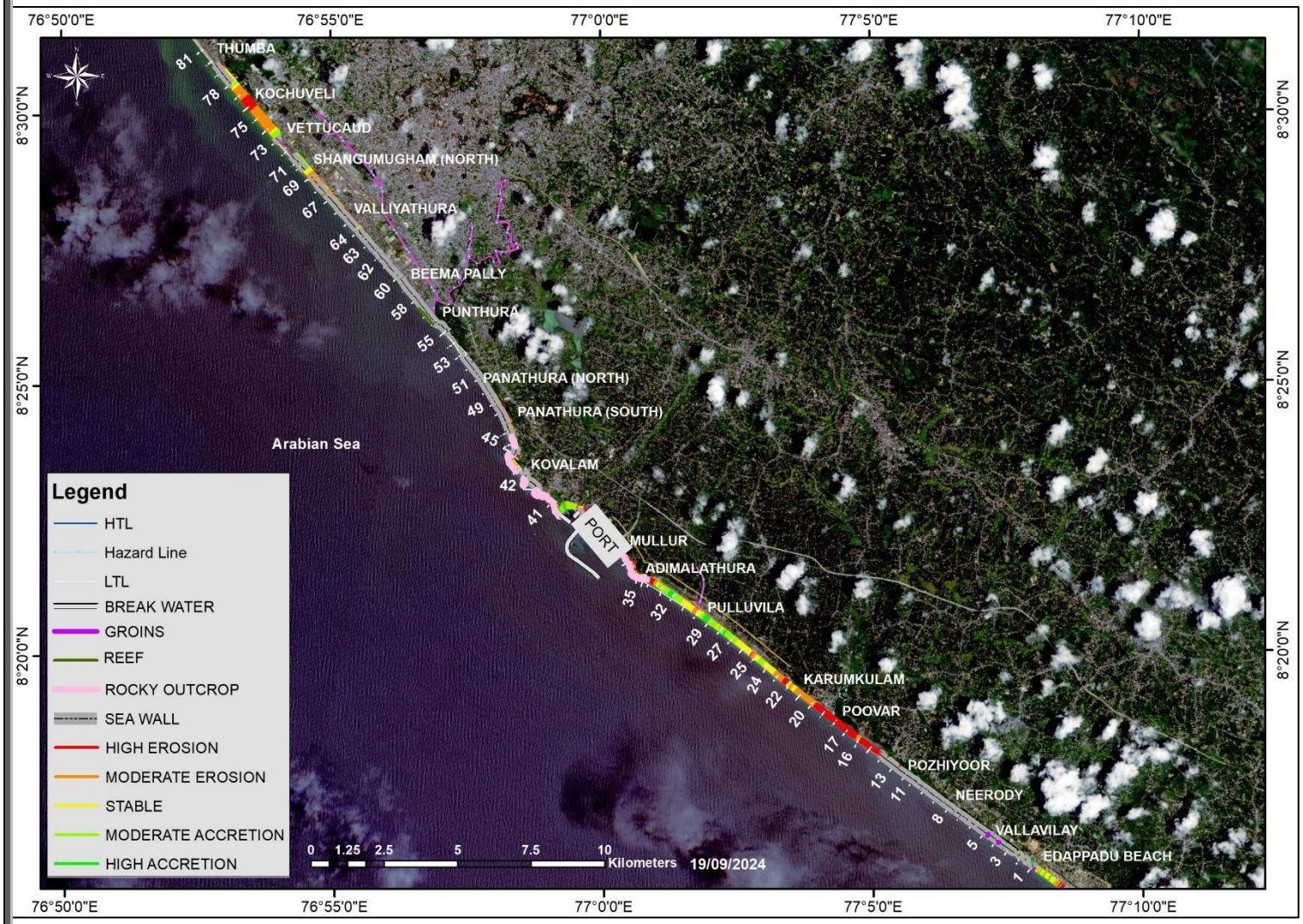


Figure A.53 Shoreline Change Map -September 2023 and September 2024

Shoreline comparison between September 2023 and September 2024

Accretion is noticed at Edappadu beach to Neerody (CSP01-09), Pulluvila to Adimalathura (CSP26-33), Kovalam (CSP40-44), Shangumugham north to Vettucaud (CSP71-73), Valiyaveli (CSP78-79) while erosion at Pozhiyoor to Karumkulam (CSP10-23), Pullavila (CSP30), Adimalathura to Mullur (CSP33-36), Pannathura (CSP47-50), Valliyathura to Shangumugham (CSP64-69), Vettucaud to Kochuveli (CSP74-77), Thumba (CSP80).

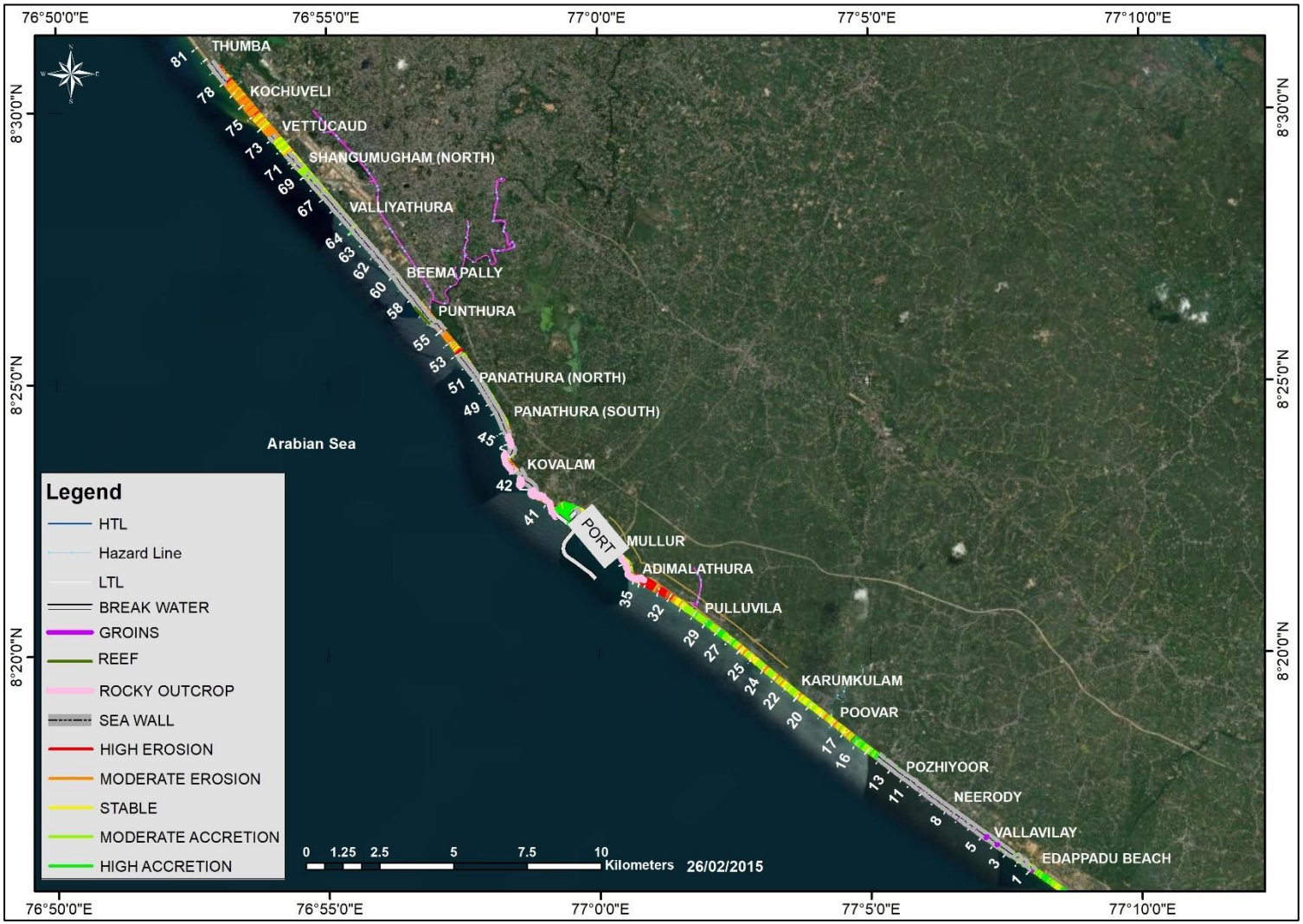


Figure A.54 Shoreline Change Comparison- 2012 to 2015

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 (CSP 25), Pullavila (CSP27), Shangumugham (CSP69).

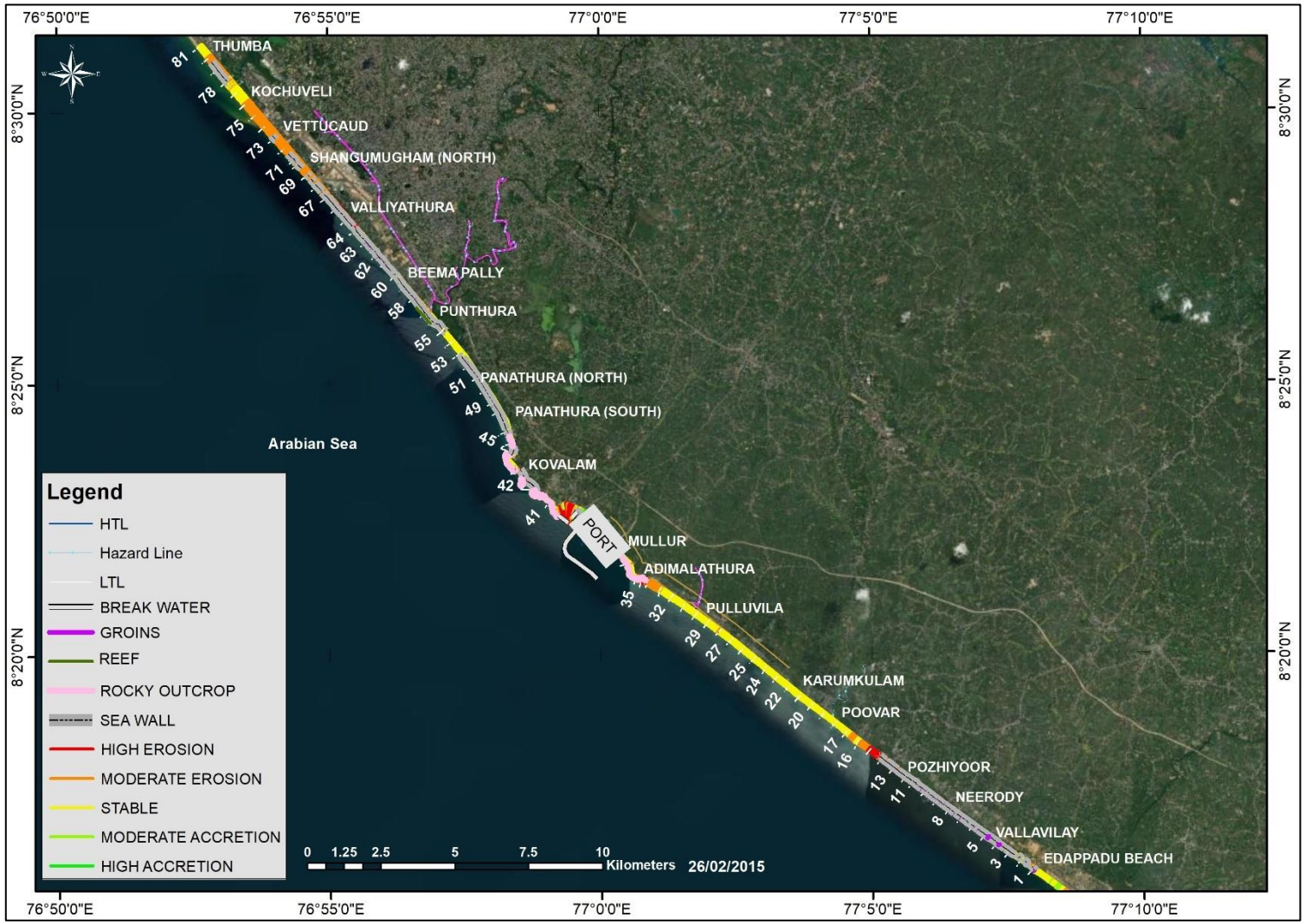


Figure A.55 Shoreline Change Map- 2015 to 2024

The comparison of the February 2015 shoreline with February 2024 using satellite images has been presented in Figure 4.50. The comparison shows erosion at Edapadu beach (CSP01,03), Poovar (CSP14-15), Azhimala (CSP34-35), Kovalam (CSP44), Punthura (CSP57), Valliyathura to Shangumugham (CSP63-75), Thumba (CSP79-80) while Edapadu beach (CSP02), Vallavilay to Pozhiyoor (CSP04-10), Poovar to Adimalathura (CSP16-32), (CSP43-52), Beemapally (CSP58-60), Valliyaveli and Thumba (CSP77-78,81) shows stable and accretion at Mullur (CSP36-37), Panathura north (CSP53), Cheriyathura (CSP61-62).

Figure A.56 Shoreline Change Map - October 2023

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

A.3.1 Monthly and Overall Shoreline Change from October 2023 to September 2024

The shoreline analysis for October 2023 shows erosion at Edappadu beach (CSP01), Pozhiyur (CSP10), Poovar beach (CSP16), Kovalam, (CSP 42,44,46), Punthura (CSP53-54), Valliyathura (CSP64) and Valliyaveli (CSP78)while accretion at Vallavilay (CSP05), Poovar beach (CSP15, 18-19), Mullur (CSP36-38), Punthura (CSP55), Beemapally (CSP60), Cheriyathura (CSP62), Valliyathura (CSP67), Shanguham to Kochuveli (CSP67-77) and Thumba (CSP81). No data from CSP23 to CSP35.

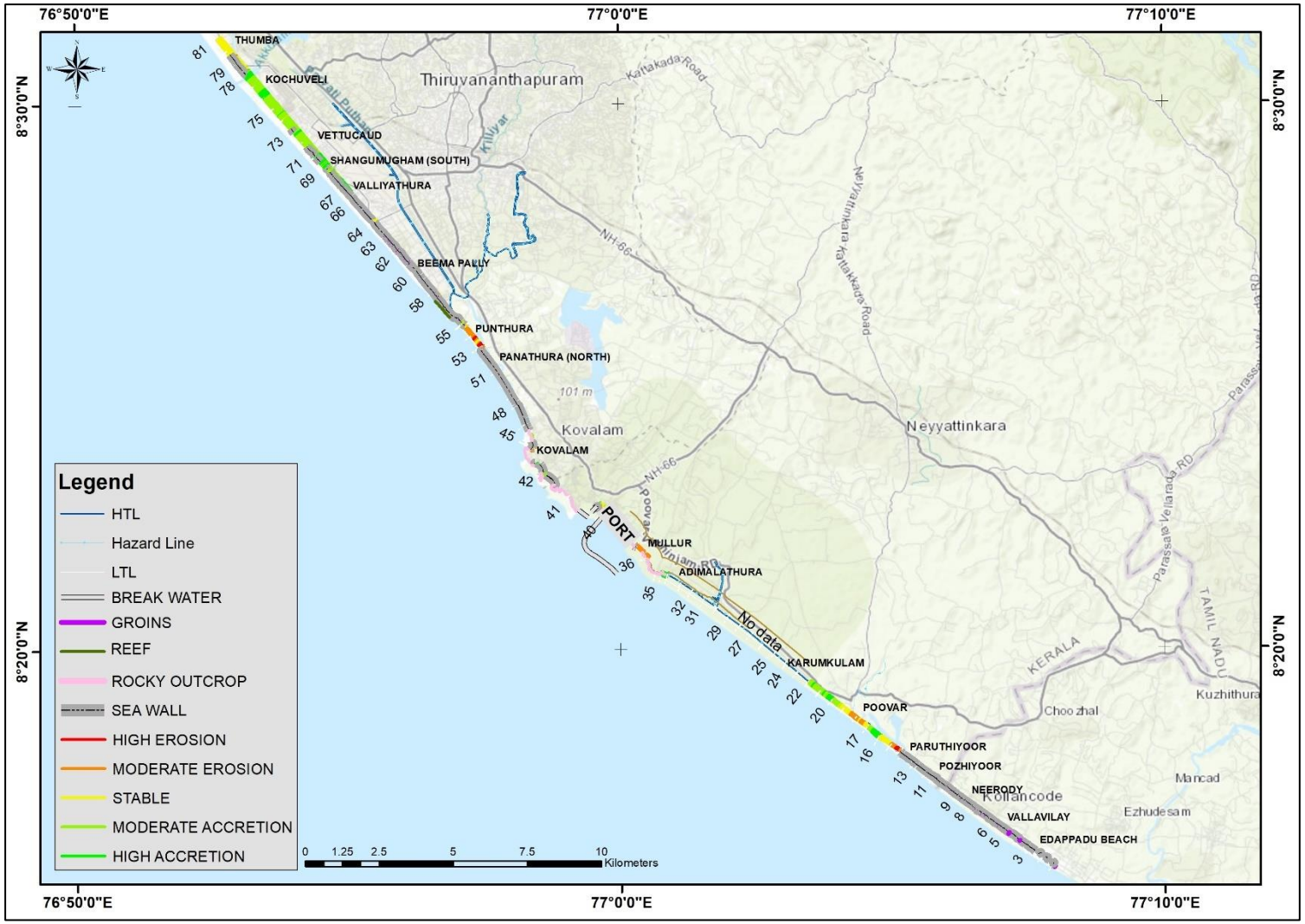
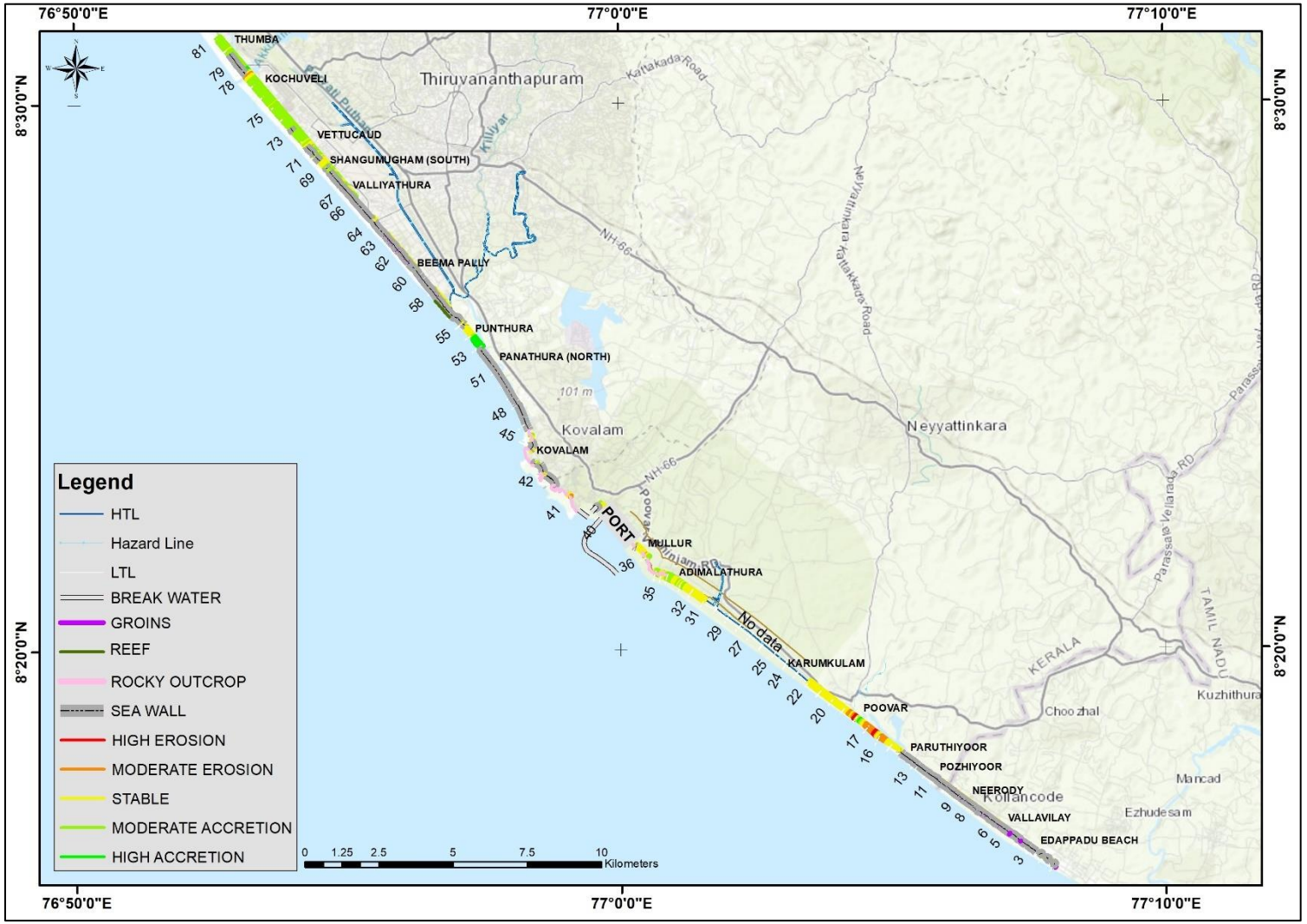


Figure A.57 Shoreline Change Map - November 2023

The shoreline analysis for November 2023 shows erosion at Poovar (CSP15, 18), Mullur (CSP36-37), Punthura (CSP53-54)while accretion at Edapadu (CSP02), Vallavilay to Neerody (CSP04-09), Pozhiyur (CSP10), Poovar (CSP16, 20-21), Karumkulam (CSP22), Adimalathura (CSP34), Azhimala (CSP35), Kovalam (CSP42-44, 46), Beemapally (CSP58), Cheriyathura (CSP61-62), Valliyathura to Valliyaveli (CSP67-78).

Figure A.58 Shoreline Change Map - December 2023

The shoreline analysis for December 2023 shows erosion at Vallavilay (CSP04), Poovar (CSP15-16), Cheriyathura (CSP61), Valliyathura to Shangumugham (CSP67-70), Kochuveli (CSP76)while accretion at Edapadu (CSP02), Neerody (CSP07), Poovar (CSP17-18), Adimalathura (CSP34), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP42-43), Punthura (CSP54), Valliyaveli (CSP78).



The shoreline analysis for January 2024 shows erosion at Poovar (CSP16-18)while accretion at Edapadu (CSP01), Vallavilay (CSP04), Adimalathura (CSP33-34), Azhimala (CSP35), Mullur (CSP36), Kovalam (CSP44-46), Punthura (CSP53), Beemapally to Cheriyathura (CSP60-61), Valliyathura to Thumba (CSP67-81).

Figure A.59 Shoreline Change Map-January 2024

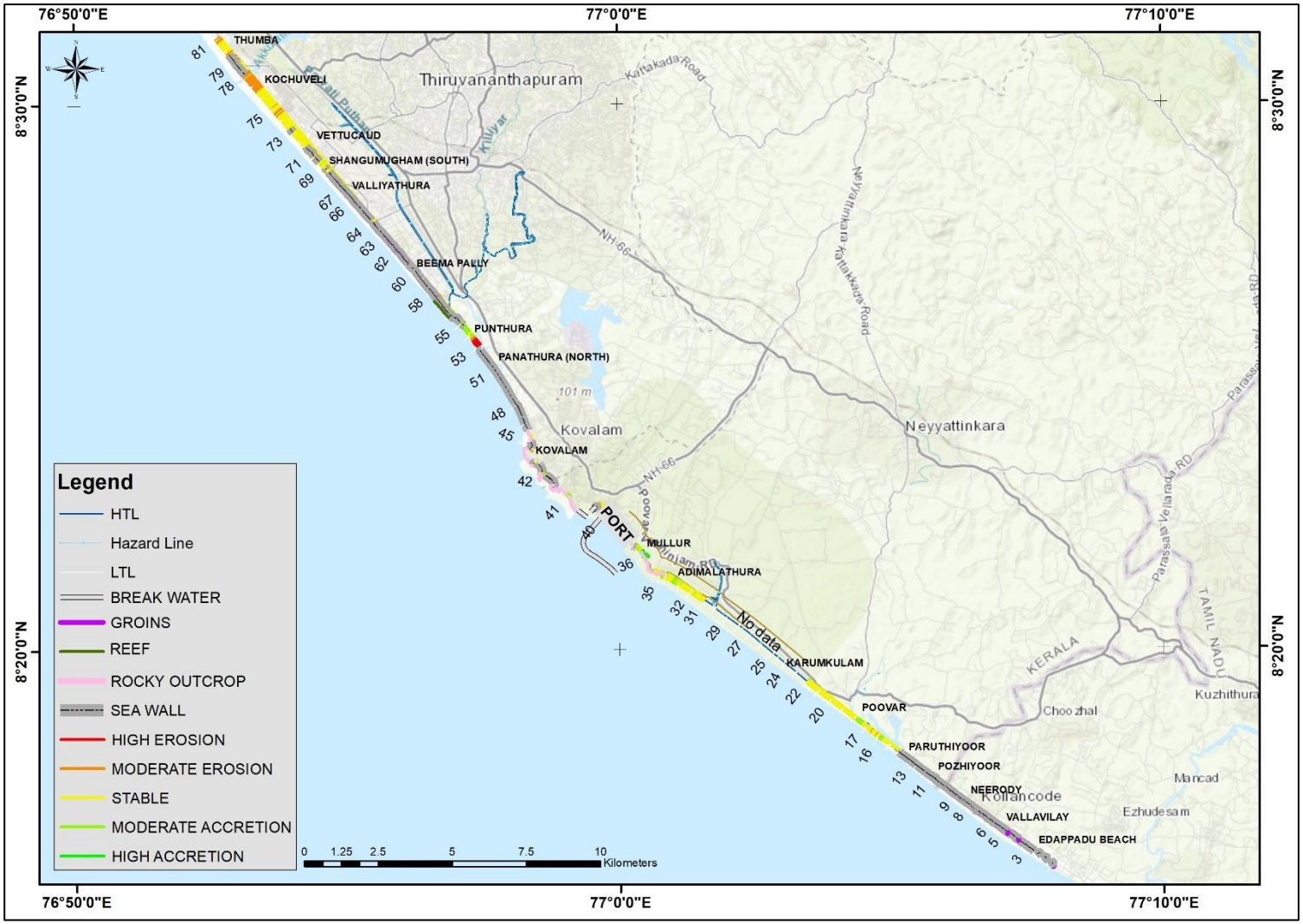


Figure A.60 Shoreline Change Map - February 2024

The shoreline analysis for February 2024 shows erosion at Vallavilay (CSP04), Punthura (CSP53), Cheriyathura (CSP61-62), Valliyathura (CSP63), Kochuveli (CSP75, 77), Valliyaveli (CSP78-79), Thumba (CSP81)while accretion at Poovar (CSP18), Adimalathura (CSP34), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP41-43), Punthura (CSP54-56).

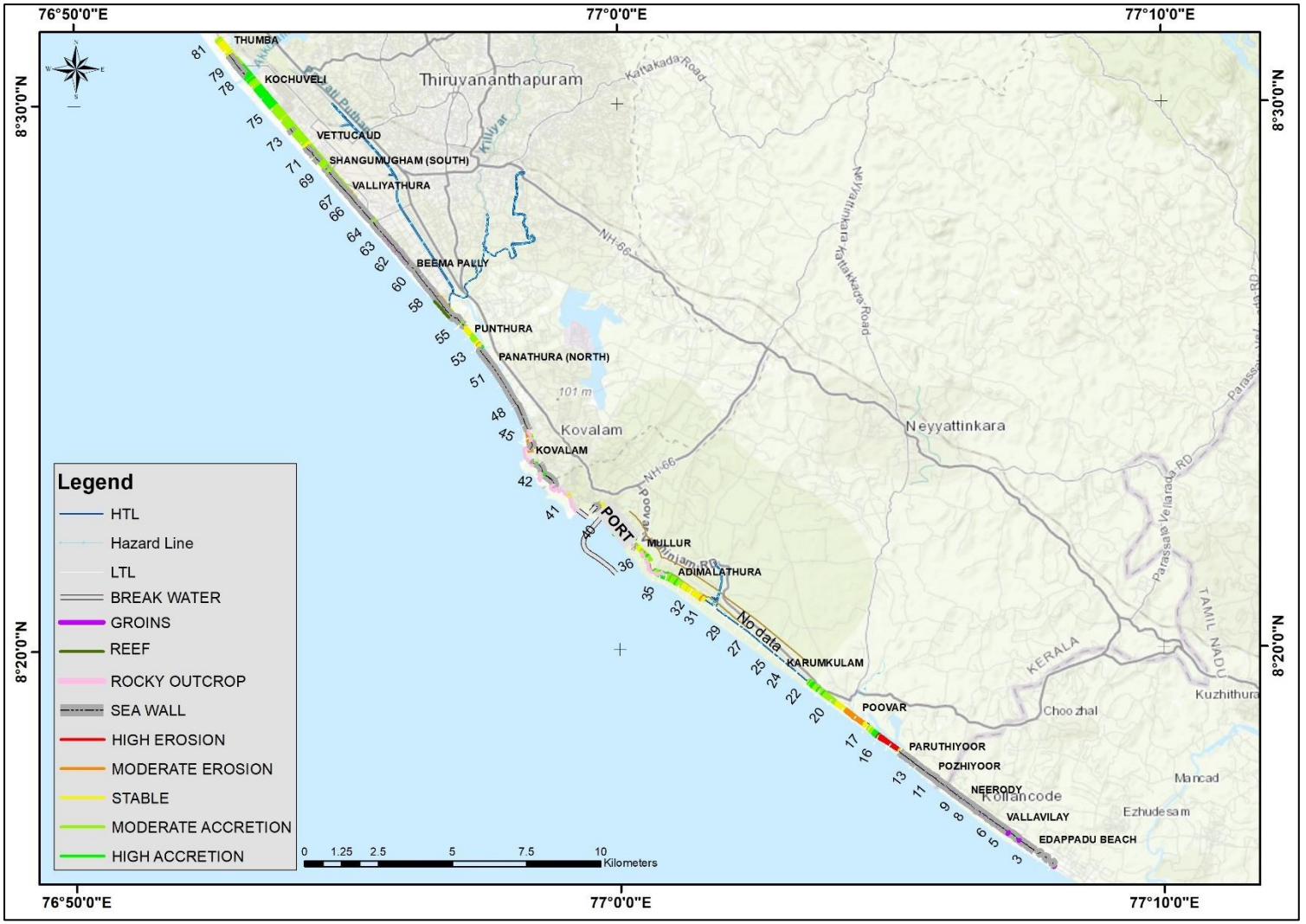


Figure A.61 Shoreline Change Map - March 2024

The shoreline analysis for March 2024 shows erosion at Poovar (CSP15,18), Punthura (CSP57)while accretion at Edappadu beach to Poovar (CSP01-14, 20-21), Adimalathura (CSP33-34), Azhimala (CSP35), Mullur (CSP36-37), Kovalam (CSP42-44), Punthura (CSP54-55), Beemapally to Cheriyathura (CSP60-62), Valliyathura to Valiyaveli (CSP67-79).

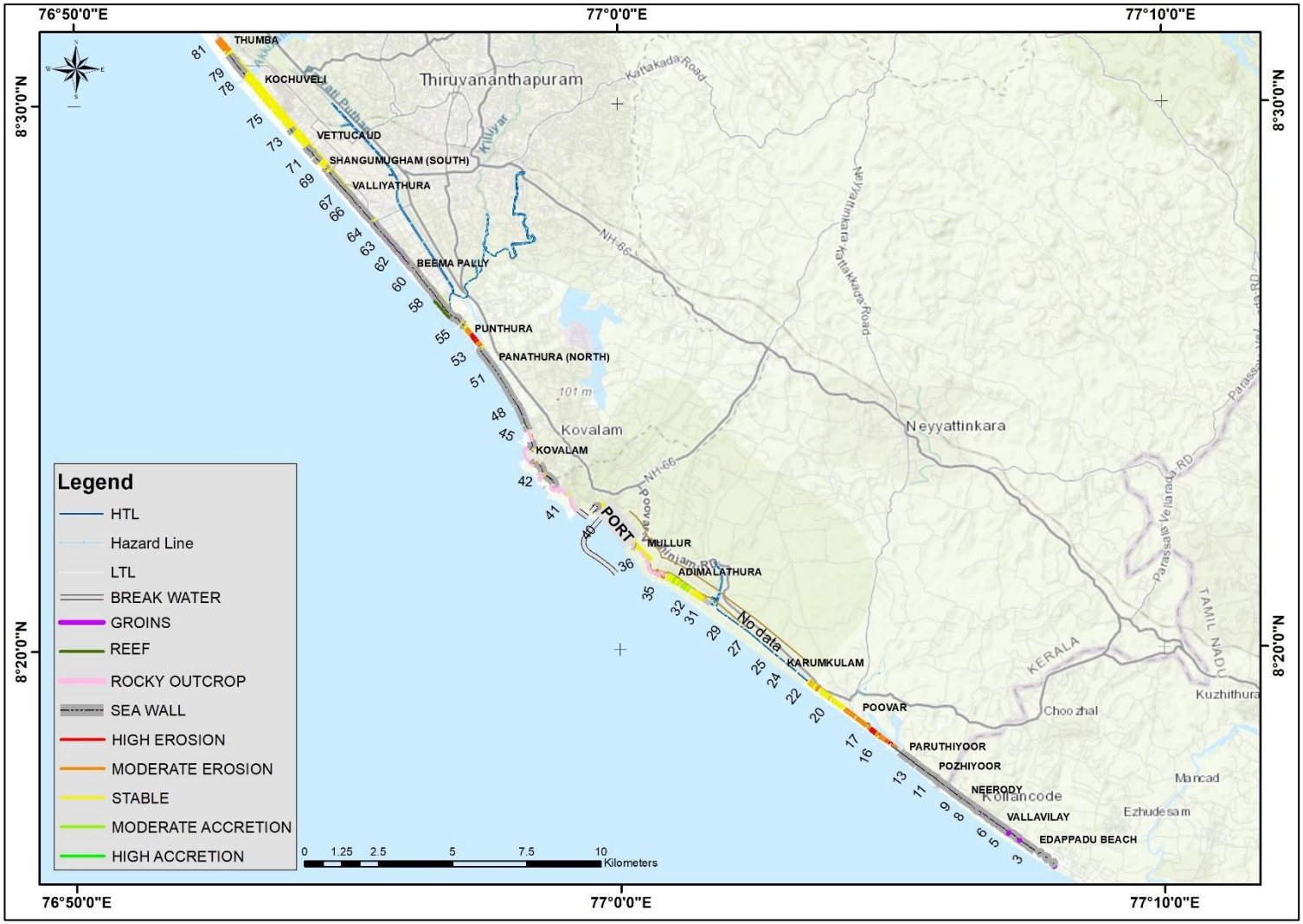


Figure A.62 Shoreline Change Map - April 2024

The monthly shoreline change analysis for April 2024 indicates erosion at Poovar (CSP15-18), Adimalathura (CSP34), Azhimala (CSP35), Kovalam (CSP43-46), Punthura (CSP53-54), Valiyaveli to Thumba (CSP79-81)while accretion at Adimalathura (CSP33) and stable from Shangumugham to Kochuveli (CSP67-77).

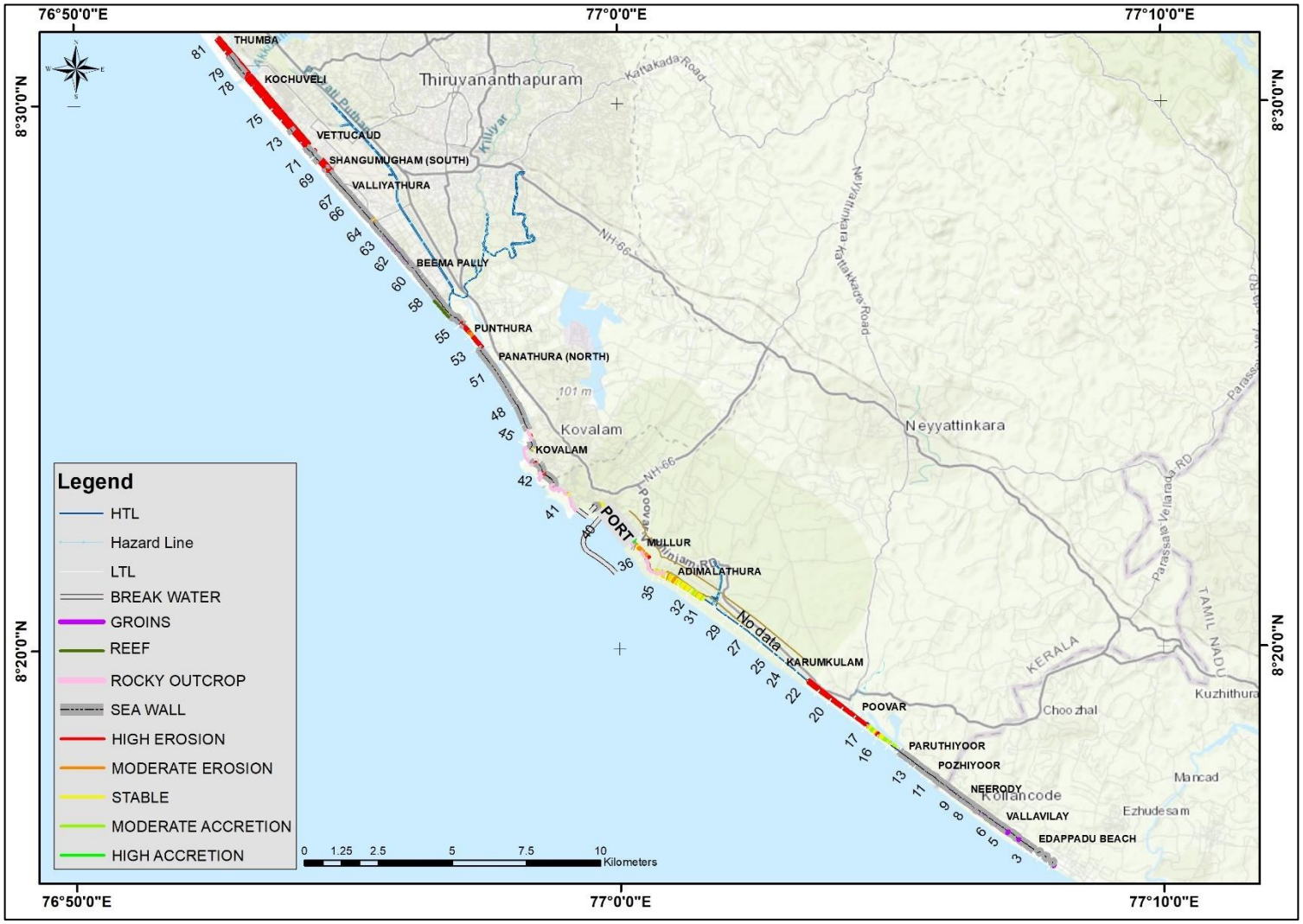
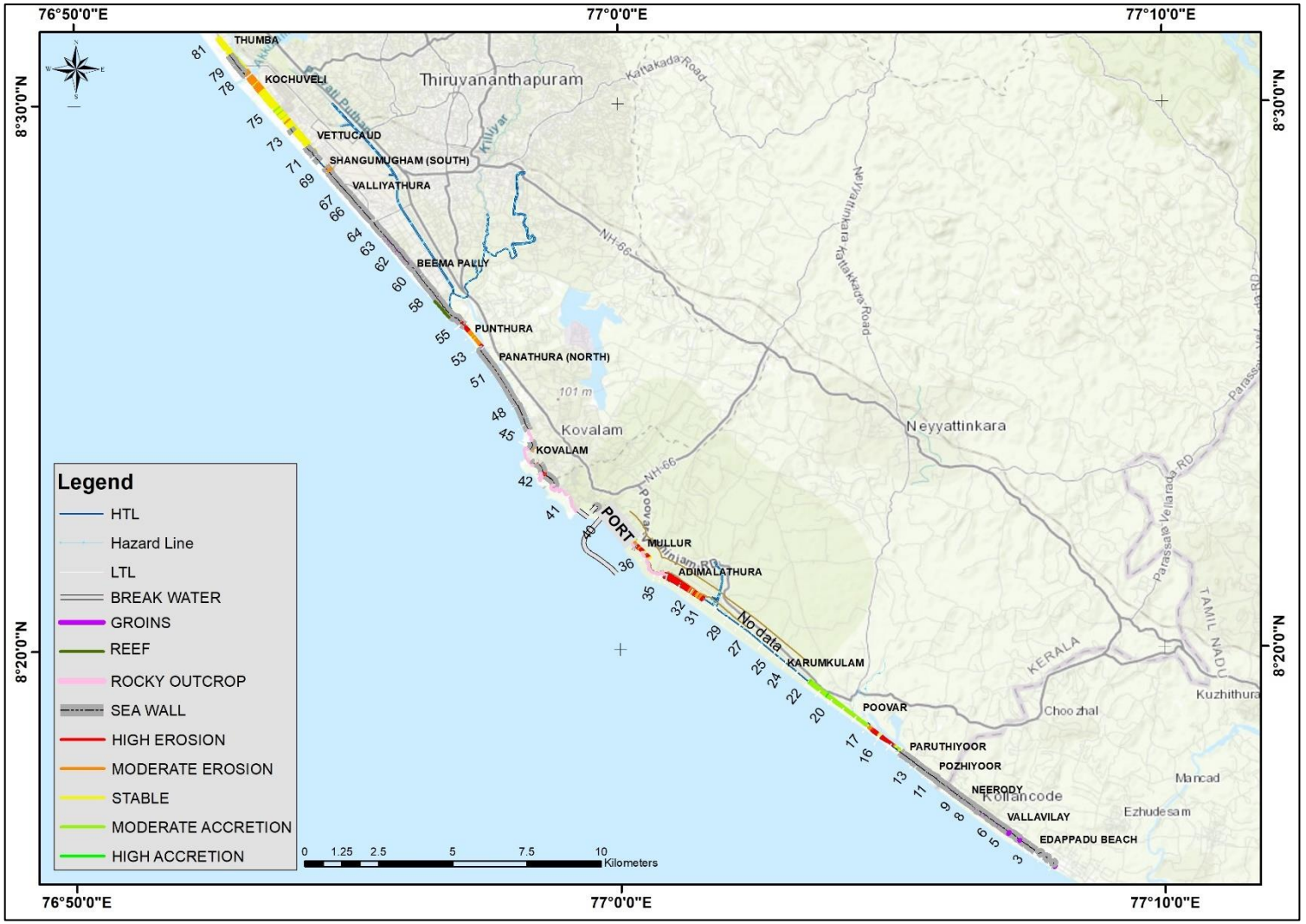


Figure A.63 Shoreline Change Map - May 2024

The monthly shoreline change analysis for May 2024 exhibits erosion at Poovar (CSP16, 18-21), Adimalathura (CSP34), Mullur (CSP36-37), Kovalam (CSP43-46), Punthura (CSP53-55), Shangumugham to Thumba (CSP69, 71-81)while accretion at Poovar (CSP15, 17), Adimalathura (CSP31-33), Azhimala (CSP35), Kovalam (CSP41).

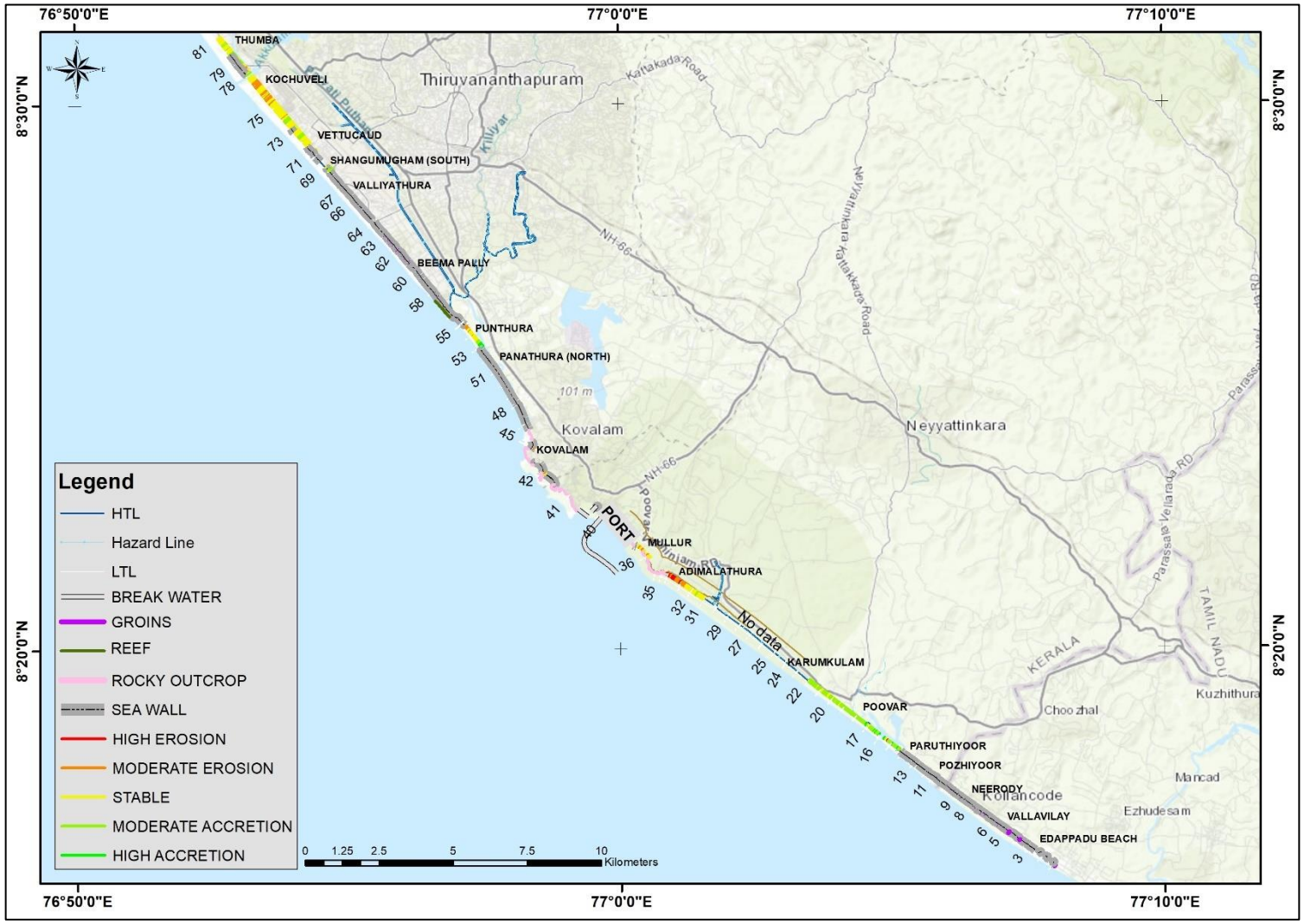


For June 2024, the shoreline change analysis shows accretion at Poovar (CSP17-21) while erosion occurs at Poovar (CSP15-16), Adimalathura (CSP31-34), Mullur (CSP36-37), Kovalam (CSP42-45), Punthura (CSP53-55), Shangumugham (CSP69), Vettucaud (CSP74), Kochuveli (CSP77), Valiyaveli (CSP78).

Figure A.64 Shoreline Change Map - June 2024

Figure A.65 Shoreline Change Map - July 2024

For July 2024, the shoreline change analysis shows erosion at Poovar (CSP18-21), Adimalathura (CSP31-34), Kovalam (CSP42), Punthura (CSP57)while accretion at Poovar (CSP15-16), Punthura (CSP53-54) and stable from Valliyathura to Thumba (CSP69-81).

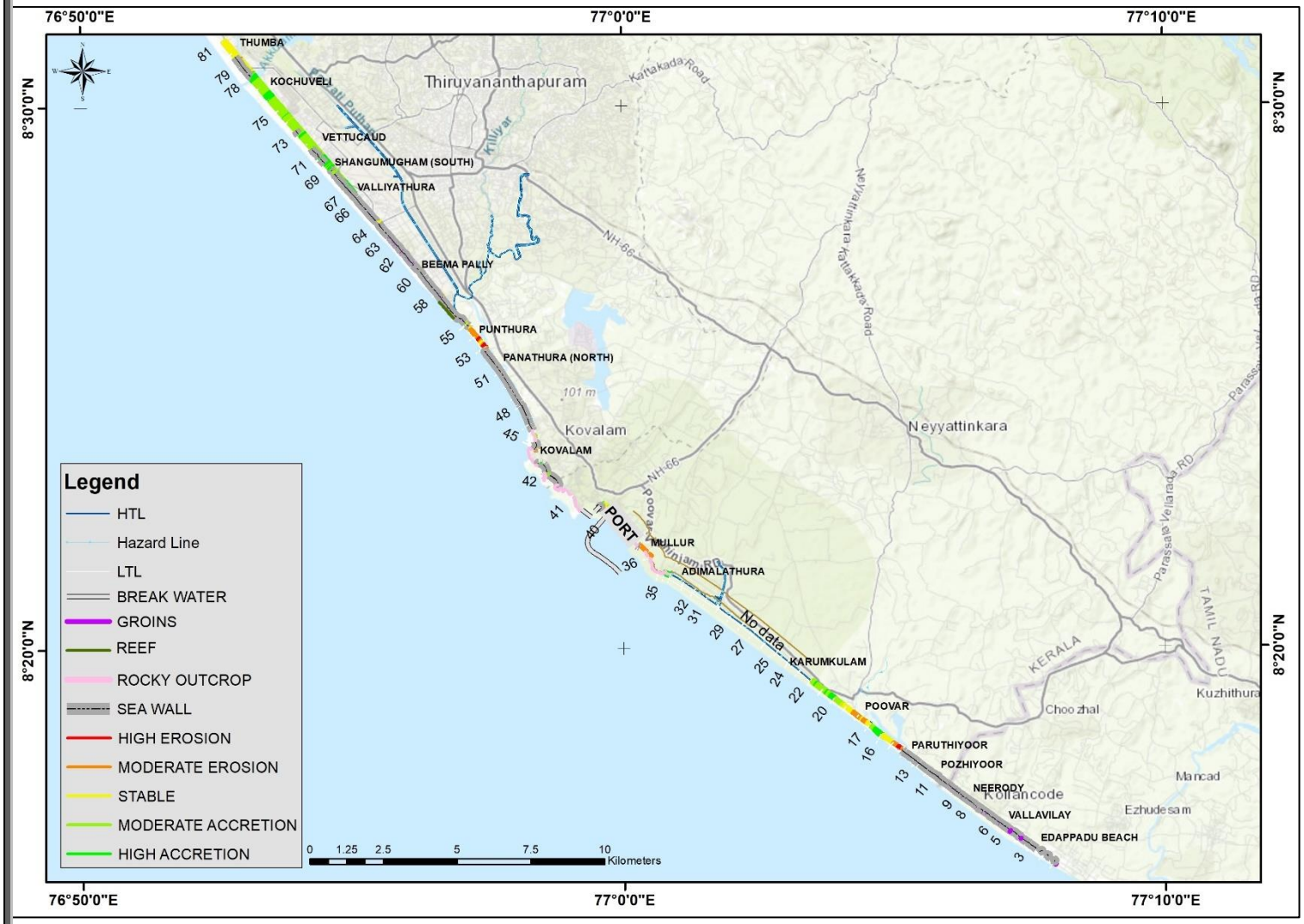


The monthly shoreline change analysis for August 2024 indicates accretion at Poovar (CSP15-21), Vettucaud (CSP72), Valiyaveli (CSP79) and Thumba (CSP80) while erosion at Adimalathura (CSP33-34), Mullur (CSP36), Kovalam (CSP45), Punthura (CSP55), Kochuveli (CSP76-77).

Figure A.66 Shoreline Change Map - August 2024

Figure A.67 Shoreline Change Map -September 2024

The monthly shoreline change analysis for September 2024 indicates accretion at Poovar (CSP15-20), Karumkulam (CSP22,26), Pulluvila (CSP29-30), Adimalathura (CSP32-35), Kovalam (CSP46), Panathura (CSP49), Punthura (CSP53-55), Shangumugham to Thumba (CSP68-80). No data from CSP01-10, CSP56-67.



A.3.2 Seasonal and Overall Shoreline Change Analysis from October 2023 to September 2024

Post Monsoon Period (October 2023-November 2023)

The shoreline change analysis map shows erosion at Poovar (CSP15, 18), Mullur (CSP36-37), Punthura (CSP53-54)while accretion at Edapadu (CSP02), Vallavilay to Neerody (CSP04-09), Pozhiyur (CSP10), Poovar (CSP16, 20-21), Karumkulam (CSP22), Adimalathura (CSP34), Azhimala (CSP35), Kovalam (CSP42-44, 46), Beemapally (CSP58), Cheriyathura (CSP61-62), Valliyathura to Valliyaveli (CSP67-78).

Figure A.68 Shoreline Change Analysis-Post Monsoon Period (October 2023-November 2023)

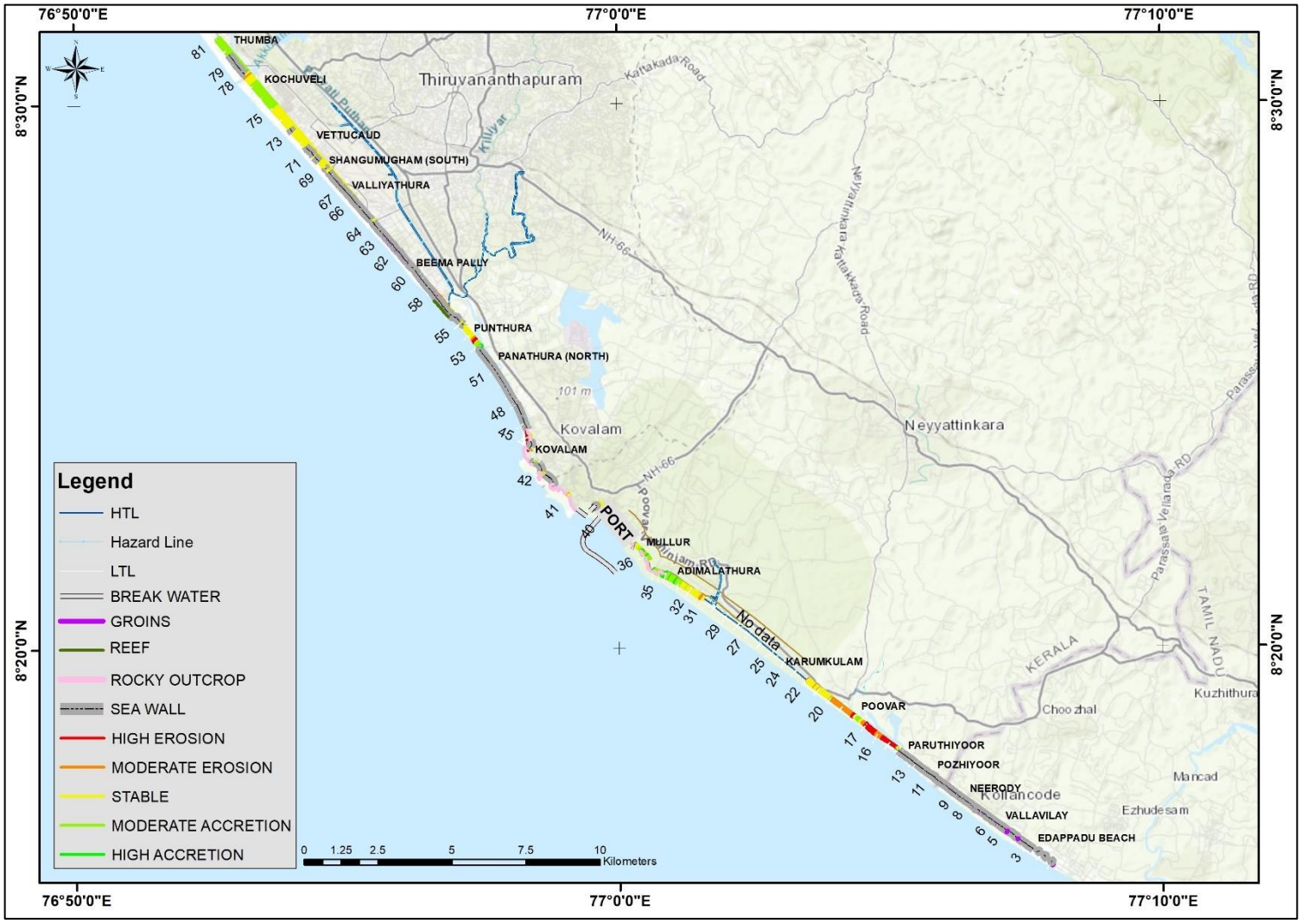


Figure A.69 Shoreline Change Analysis -Fair Weather Period (December 2023 -March 2024)

Fairweather Period (December 2023-March 2024)

The shoreline change analysis map shows accretion at Adimalathura (CSP34), Mullur (CSP37), Vettucaud to Kochuveli (CSP73-77), Thumba (80-81)whileerosionatPoovar (CSP15-20), Adimalathura (CSP31), Punthura (CSP54).

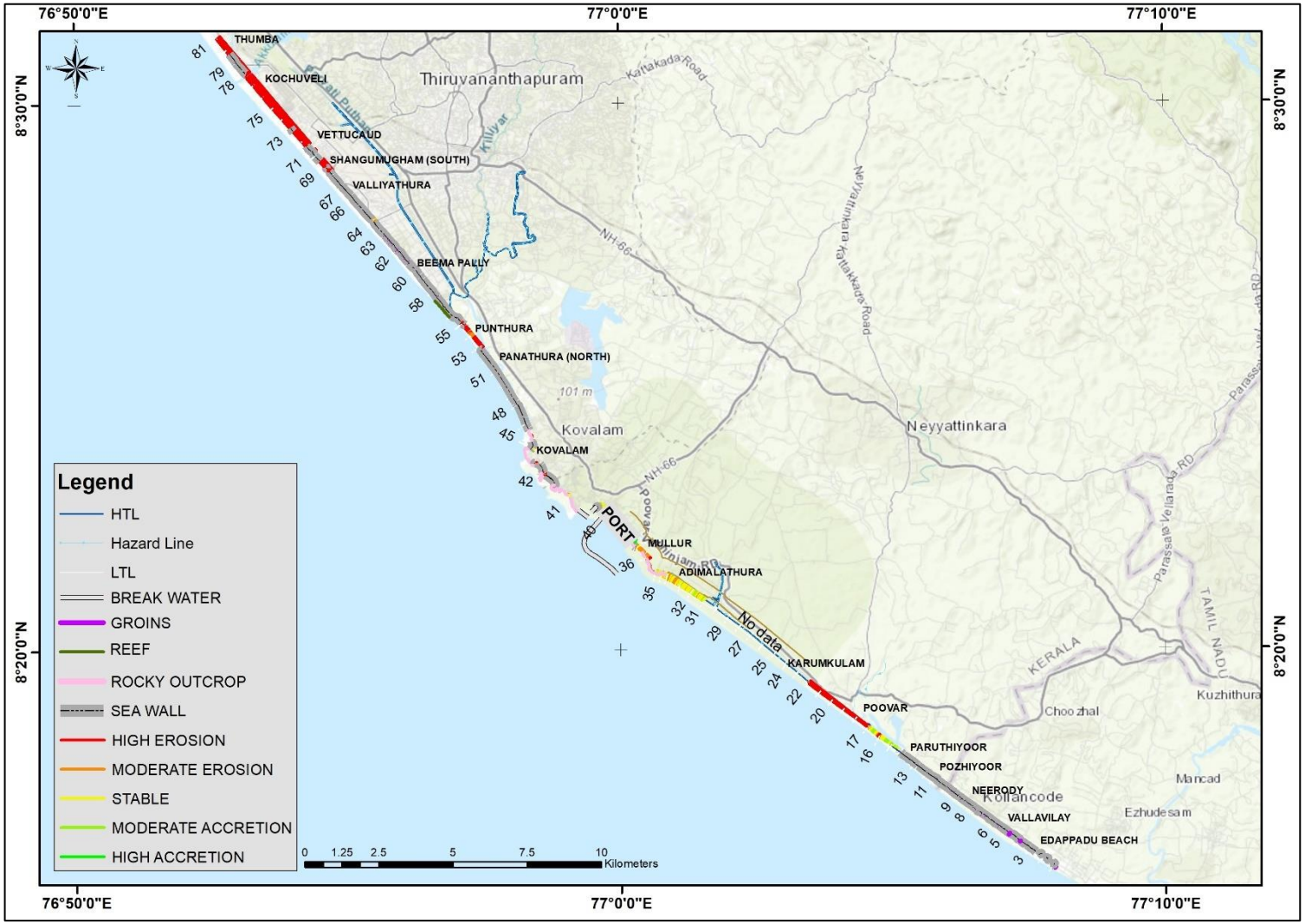


Figure A.70 Shoreline Change Analysis - Pre-Monsoon Period (April 2024-May 2024)

Pre Monsoon Period (April 2024 to May 2024)

Pre-monsoon period (April 2024 to May 2024) exhibits erosion at Poovar (CSP16, 18-21), Adimalathura (CSP34), Mullur (CSP36-37), Kovalam (CSP43-46), Punthura (CSP53-55), Shangumugham to Thumba (CSP69, 71-81)while accretion at Poovar (CSP15, 17), Adimalathura (CSP31-33), Azhimala (CSP35), Kovalam (CSP41).

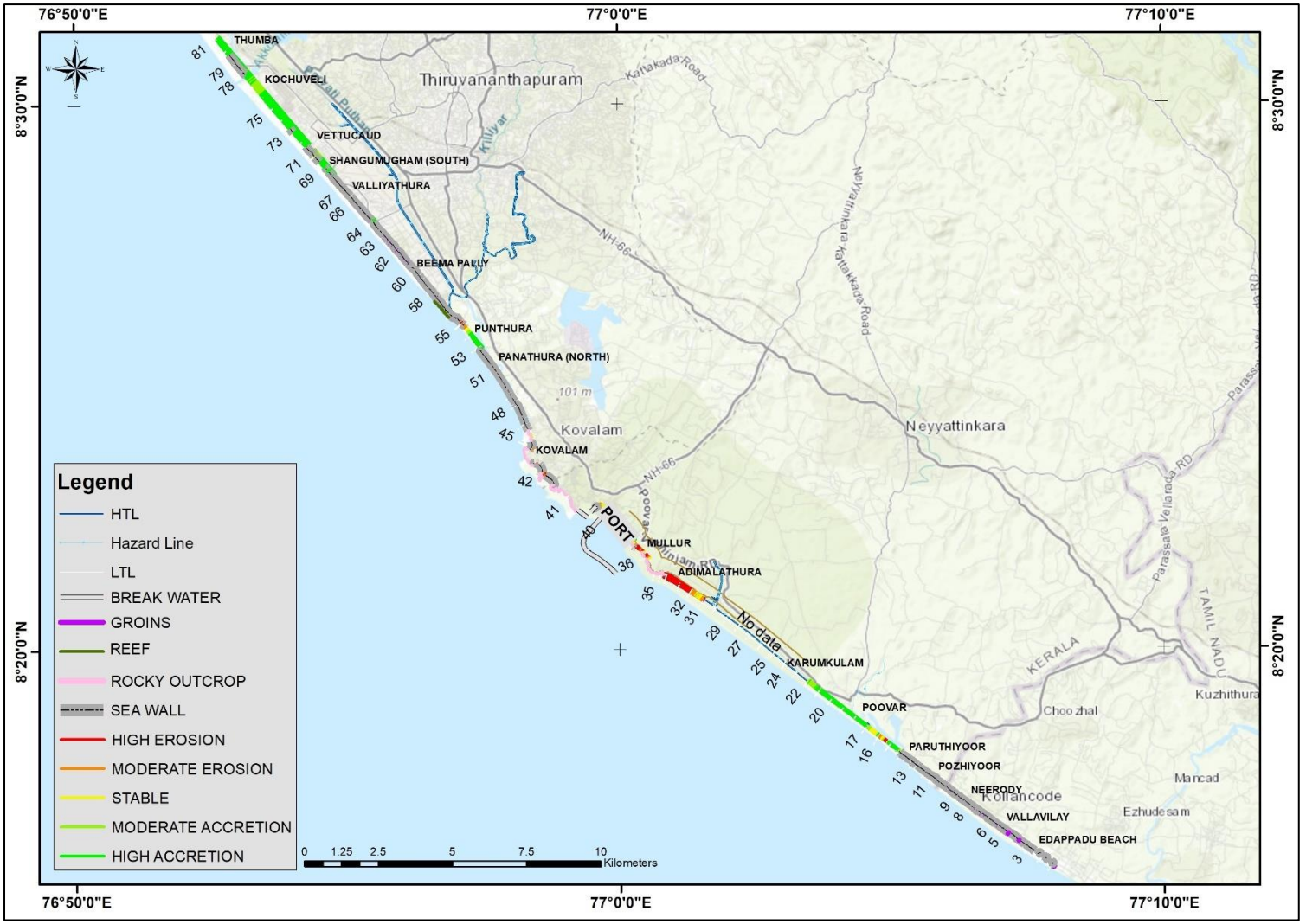
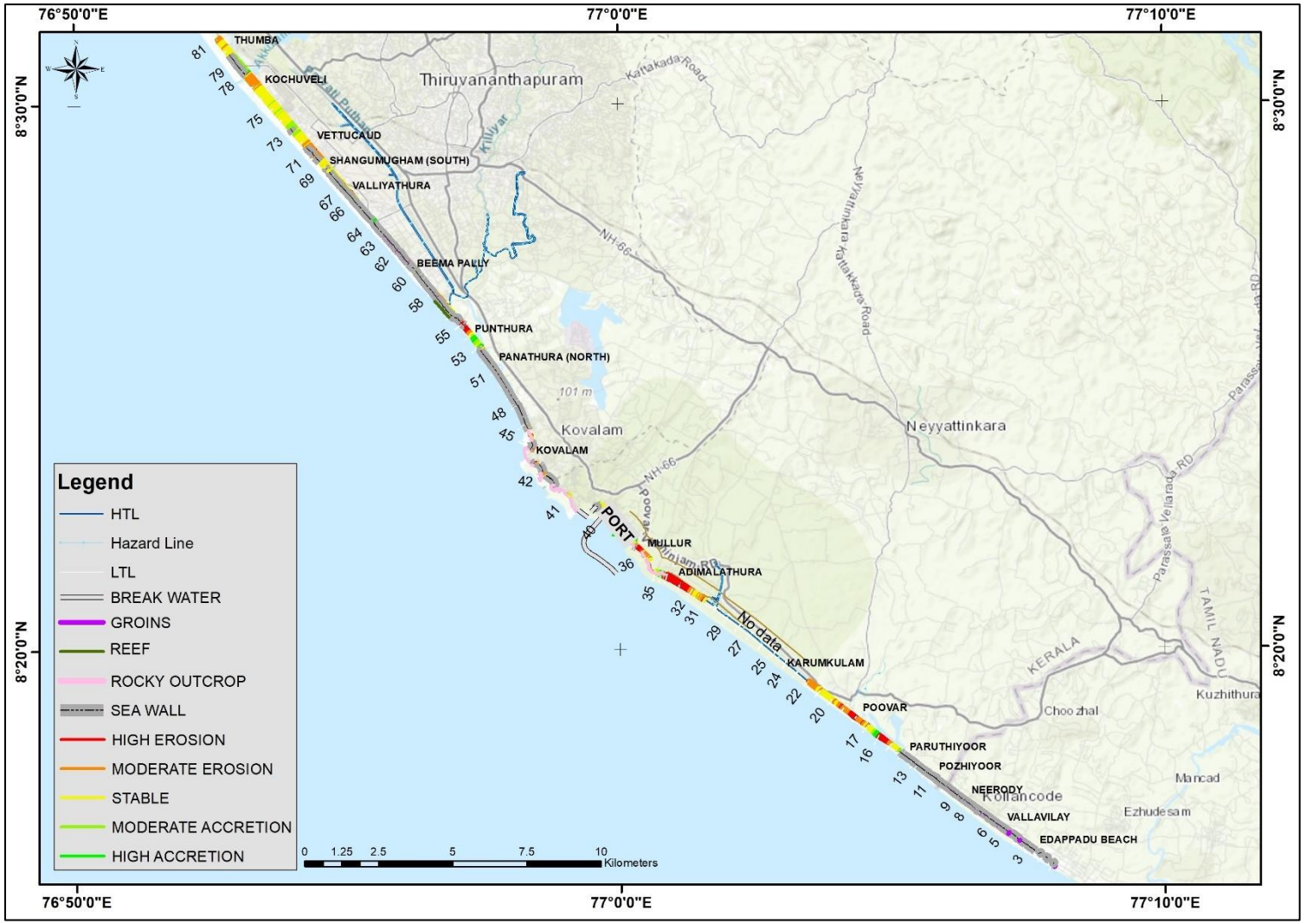


Figure A.71 Shoreline Change Analysis - Monsoon Period (June 2024 - September 2024)

Monsoon Period (June 2024 to September 2024)

Monsoon period for 2024 indicates erosion along the coast at Poovar (CSP16), Adimalathura to Mullur (CSP31-36), Punthura (CSP55) while accretion is noticed at Poovar (CSP14-15, 17-22), Mullur (CSP37), Punthura (CSP 53-54), Shangumugham to Thumba (CSP66-81).



Overall Shoreline Changes for October 2023- September 2024

Erosion is noticed at Poovar (CSP15-19, 21), Karumkulam (CSP22), Adimalathura (CSP-34), Mullur (CSp36-37), Kovalam (CSp45-46), Pannathura (CSP48), Punthura (CSP55,57), Valliyathura (CSP63,67), Shanmugham (CSP70-71), Kochuveli (CSP77), Thumba (CSP81)while accretion is noticed at Edapadu beach (CSP01, 03), Vallavilay to Neerody (CSP04-09), Azhimala (CSP35), Kovalam (CSP41-44), Punthura (CSP53-54, 57), Shangumugham (CSP68-69), Vettucaud (CSP72-74), Kochuveli (CSP75-76) and Valliyaveli (CSP78).

Figure A.72 Overall Shoreline Change Map for October 2023- September 2024

A.3.3 Shoreline comparison for the period October 2022-September 2023 and October 2023- September 2024

Shoreline comparison between October 2022 and October 2023

Erosion is noticed at Shangumugham (CSP68-71) and Thumba (CSP 78-79), while accretion is noticed at Vettucaud (CSP69-75) and Thumba (CSP 80-81).

Figure A.73 ShorelineChangeMapforOctober2022-October 2023

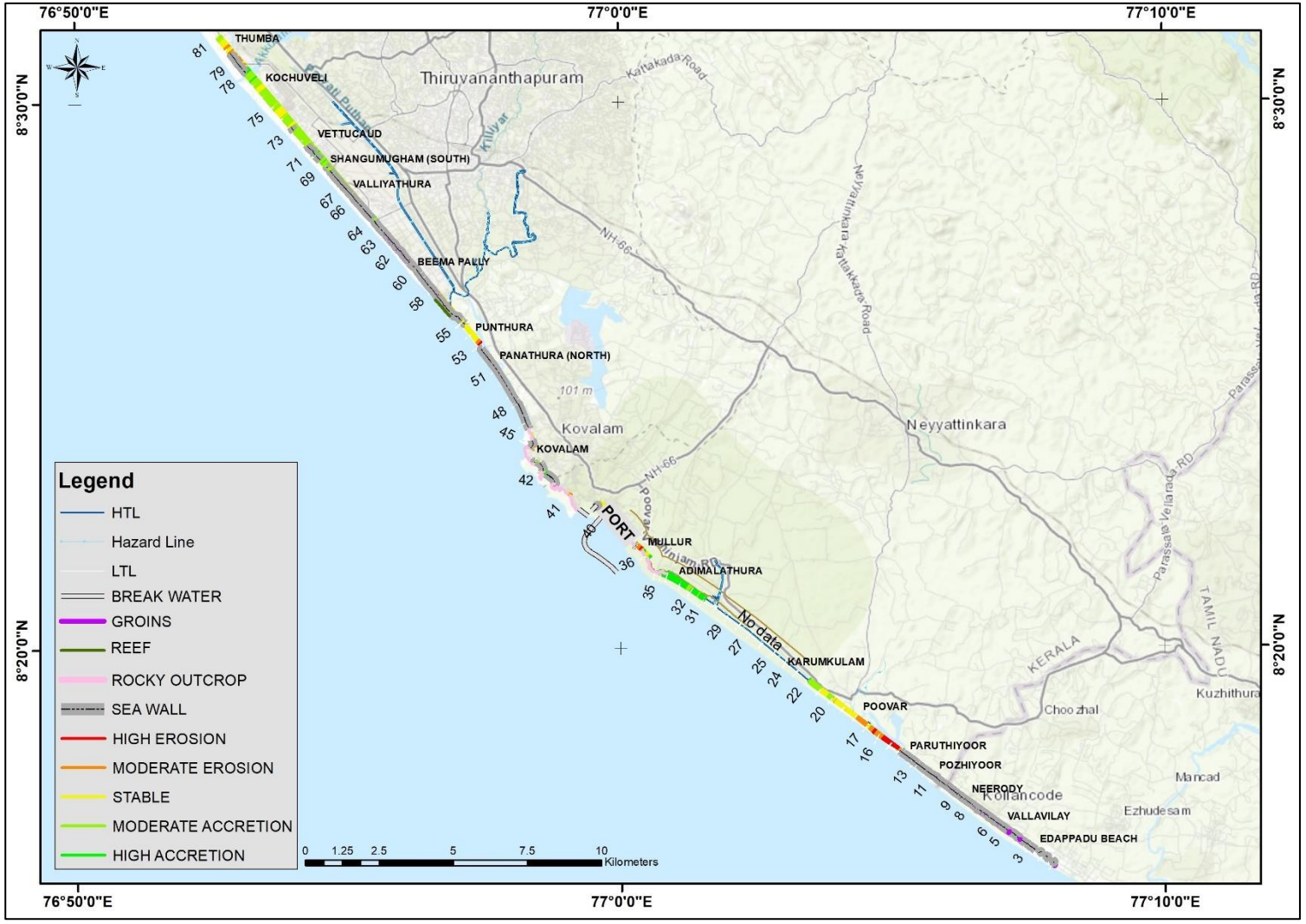
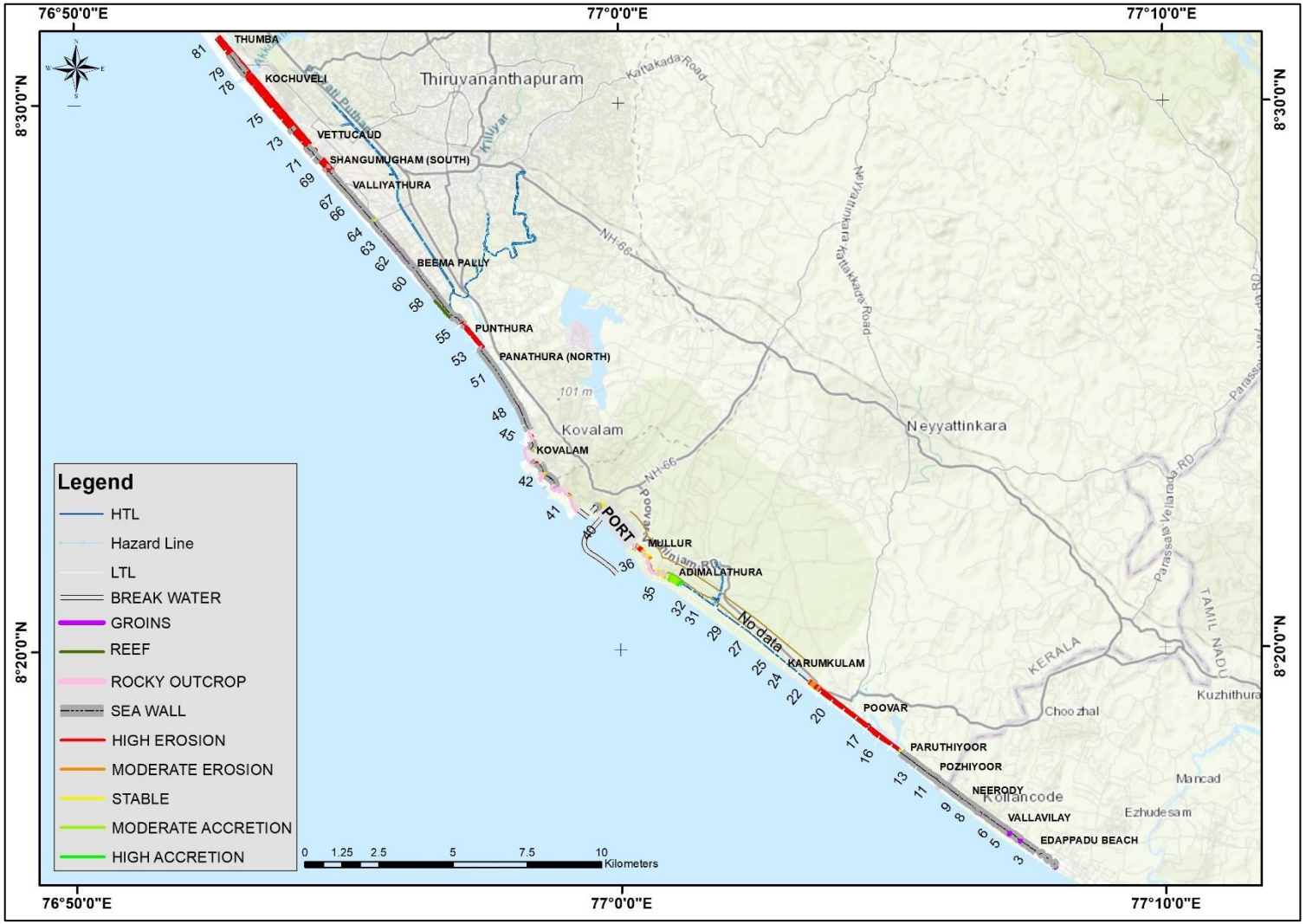


Figure A.74 Shoreline Change Map for February 2023- February 2024

Shoreline comparison between February 2023 and February 2024

The shoreline comparison shows accretion at Poovar (CSP19-22), Admalathura (CSP31-35), Shangumugham to Thumba (CSP68-79,81)whileerosionatPoovar (CSP13-18), Mullur (CSP36), Punthura (CSP 53), and Thumba (CSP80).



Shoreline comparison between May 2023 and May 2024

Accretion is noticed at Adimalathura (CSP32-34), while erosion is noticed at Poovar (CSP13-22), Mullur (CSP35), Kovalam (CSP42,44,45), Punthura (CSP53-55), Shangumugham to Thumba (CSP68-81).

Figure A.75 Shoreline Change Map -May 2023 and May 2024

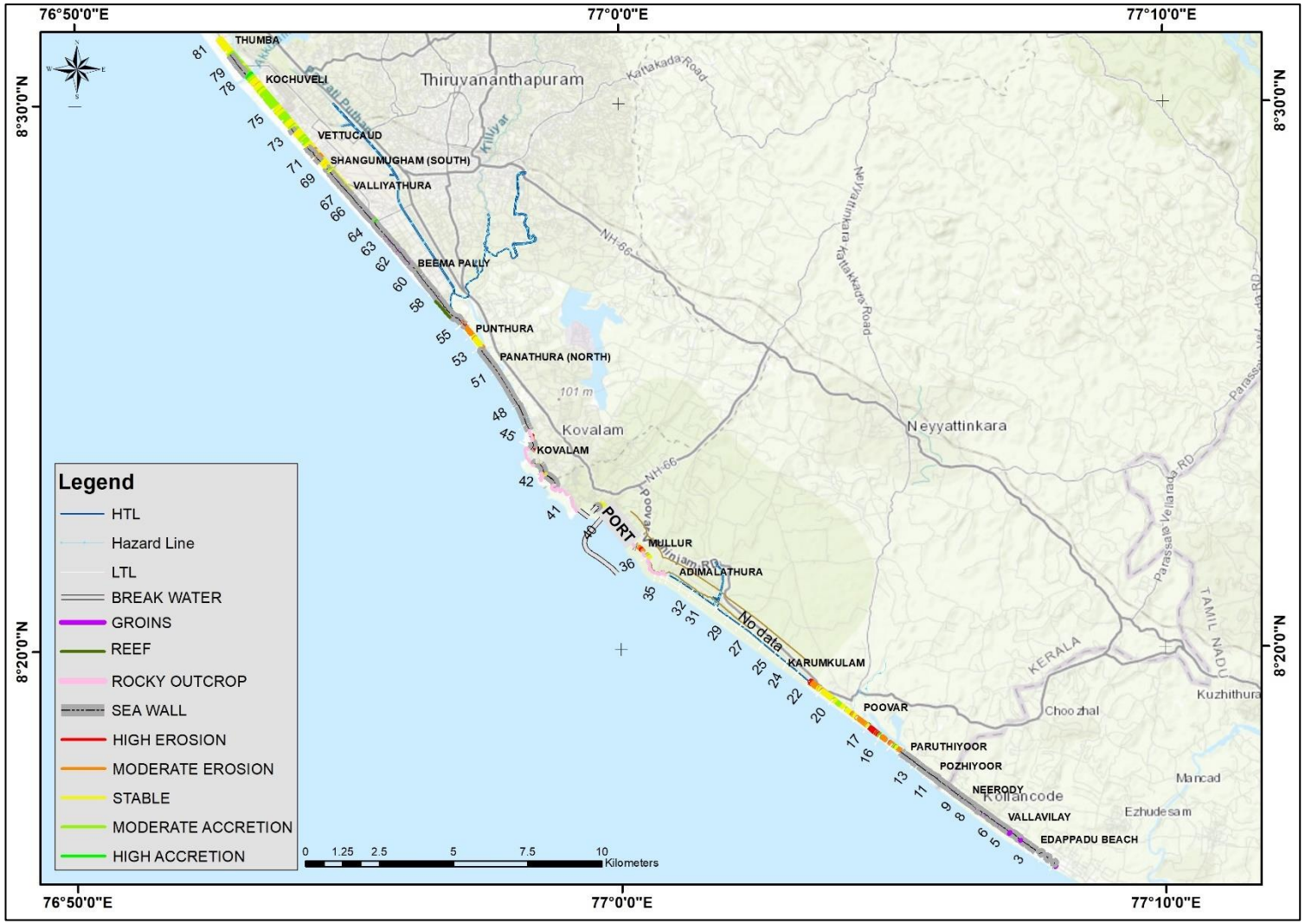


Figure A.76 Shoreline Change Map -September 2023 and September 2024

Shoreline comparison between September 2023 and September 2024

Accretion is noticed at Poovar (CSP20), Shangumugham (CSP69), Vettucaud (CSP72-73), Kochuveli (CSP75-76), Valiyaveli (CSP78-79), while erosion at Poovar (14-18, 22), Mullur (CSP36), Punthura (CSP54-55).

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