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

ANNUAL REPORT
(October 2019 to September 2020)

FOR

ADANI VIZHINJAM PORT PVT LIMITED

PREPARED BY

Coastal and Environmental Engineering Division

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Report Summary

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CONTENTS

1 INTRODUCTION 1

2 OBJECTIVES 1

3 METHODOLOGY & DATA USED 1

3.1 Shoreline change analysis from Satellite images 2

3.1.1 Short Term Shoreline change analysis 2

3.1.2 Long Term Shoreline change analysis 3

3.1.3 Satellite image used in shoreline change analysis 4

3.2 Beach Profile Analysis 4

3.3 Analyzing Beach Profiles in SANDS 8

3.3.1 Profile Analysis by Level 9

3.3.2 Profile Analysis by Chainage 9

4 RESULTS AND ANALYSIS 10

4.1 Results from Beach Profile Analysis 10

4.1.1 Monthly Beach Volume variations – October 2019 to September2020 11

4.1.2 Seasonal Beach Volume variations from October 2019 to September 2020 24

4.1.3 Overall beach volume variation during October 2019 to September 2020 29

4.1.4 Overall Beach volume variation during February 2015 and February 2020 31

4.2 Results for Shoreline Change Analysis from Satellite images 33

4.2.1 Monthly Shoreline Change Analysis from October 2019 to September 2020 33

4.2.2 Seasonal Shoreline Change from October 2019 to September 2020 41

4.2.3 Overall Shoreline Change from October 2019 to September 2020 44

4.2.4 Seasonal Shoreline Change comparison between 2018-2019 and 2019-2020 45

4.2.5 Shoreline Change comparison between January 2015 and January 2020 49

4.3 Validation and Comparison of results 50

5 VETTING OF REPORTS/ DATA 52

5.1 Methodology adopted for verifying various monitored data 53

6 CONCLUSION 55

References:..... 56

LIST OF FIGURES

Figure 3.1Flowchart of the methodology adopted 2
Figure 3.2Calculation of Short Term Shoreline change analysis 3
Figure 3.3Calculation of Long Term (LRR) Shoreline change analysis 3
Figure 3.4Beach Profiles lines 5
Figure 3.5 Sample beach profile graph of CSP 28(Pullavila) using SANDS software 8
Figure 3.6 Work Flow in SANDS 8
Figure 3.7 Profile Analysis by Level 9
Figure 3.8 Profile Analysis by Chainage 9
Figure 4.1 Monthly Beach Volume Changes in October 2019 in m^3/m 12
Figure 4.2 Monthly Beach Volume Changes in November 2019 in m^3/m 13
Figure 4.3 Monthly Beach Volume Changes in December 2019 in m^3/m 14
Figure 4.4 Monthly Beach Volume Changes in January 2020 in m^3/m 15
Figure 4.5 Monthly Beach Volume Changes in February 2020 in m^3/m 16
Figure 4.6 Monthly Beach Volume Changes in March 2020 in m^3/m 17
Figure 4.7 Monthly Beach Volume Changes in April 2020 in m^3/m 18
Figure 4.8 Monthly Beach Volume Changes in May 2020 in m^3/m 19
Figure 4.9 Monthly Beach Volume Changes in June 2020 in m^3/m 20
Figure 4.10 Depth to elevation difference for 81 profiles for the month of August 2020 and September 2020 21
Figure 4.11 CSP Profile for Karumkulam (CSP-26) 22
Figure 4.12 CSP Profile for Vettucaud (CSP-74) 22
Figure 4.13 Seasonal Beach Volume Changes during Post Monsoon in m^3/m 25
Figure 4.14 Seasonal Beach Volume Changes during Fair weather period in m^3/m 26
Figure 4.15 Seasonal Beach Volume Changes during Pre-Monsoon Period 2020 in m^3/m 27
Figure 4.16 Seasonal Beach Volume Changes during Monsoon Period 2020 in m^3/m 28
Figure 4.17 Overall Beach Volume Changes - October 2019 to September 2020 in m^3/m 29
Figure 4.18 Beach Volume Changes - February 2015 and February 2020 in m^3/m 32
Figure 4.19 Shoreline Change Map -October 2019 35
Figure 4.20 Shoreline Change Map - November 2019 35
Figure 4.21 Shoreline Change Map - December 2019 36

Figure 4.22 Shoreline Change Map -January 2020 36
Figure 4.23 Shoreline Change Map - February 2020 37
Figure 4.24 Shoreline Change Map -March 2020 37
Figure 4.25 Shoreline Change Map -April 2020 38
Figure 4.26 Shoreline Change Map - May 2020 38
Figure 4.27 Shoreline Change Map - June 2020 39
Figure 4.28 Shoreline Change Map –July 2020 39
Figure 4.29 Shoreline Change Map - August 2020 40
Figure 4.30 Shoreline Change Map - September 2020 40
Figure 4.31 Shoreline Change Map –Post Monsoon 2019 41
Figure 4.32 Shoreline Change Map –Fair Weather Period2019 42
Figure 4.33 Shoreline Change Map –Pre-Monsoon Period 2019 43
Figure 4.34 Shoreline Change Map –Monsoon Period 2020 44
Figure 4.35 Overall Shoreline Change Map October 2019 to September2020 45
Figure 4.36 Shoreline Change Map October 2018 and October 2019 46
Figure 4.37 Shoreline Change Map January 2019 and January 2020 47
Figure 4.38 Shoreline Change Map April 2019 and April 2020 48
Figure 4.39 Shoreline Change Map September 2019 and September 2020 49
Figure 4.40 Shoreline Change Map- January 2015 to January 2020 50
Figure 4.41 Comparison of Shoreline data from satellite images of different spatial resolution 51
Figure 4.42 Comparison of Shoreline data from satellite images of different spatial resolution, beach profile data, LTL, Hazard line with field shoreline from Vettucaud to Valliyathura 51

LIST OF TABLES

Table 3.1Satellite image data used for shoreline change analysis 4

Table 3.2 Landmark, places names and site condition around each CSP lines 6

Table 4.1 Monthly Beach Volume Changes during the months from October 2019 to June 2020 in m^3/m 23

Table 4.2 Seasonal and Overall Beach Volume Changes in m^3/m.....30

Table 4.3 Comparison of Erosion spots since 2000 using high resolution satellite images 52

Table 5.1 Data Status October 2019 to September 2020 53

Executive Summary

This report includes the study on shoreline change assessment along Vizhinjam coast about 40km stretch for the period from October 2019 to September 2020 using available high resolution satellite images and field measured beach profile data.

In the previous Annual reports for the period October 2017 to September 2018 and October 2018 to September 2019, the result from the shoreline change analysis using high resolution satellite images carried out for 2000-2018 and annual variation for the years 2015-2016, 2016-2017, 2017-18 has been presented and the spots of erosion listed from the above analysis using high resolution satellite images are Valliyathura (CSP63 to CSP67), Punthura (CSP53 to CSP57), Poovar to Edapadu (CSP01 to CSP09) and the same has been compared with the spots of erosion from 2nd annual shoreline analysis from October 2018 to September 2019.

The zones of erosion and accretion have been derived from the available high resolution satellite images (10m and 5m) for the months from October 2019 to September 2020 and it indicates erosion is noticed at Thumba to Valliyathura, Punthura, Karumkulam to Edapadu beach and accretion at Cheriyathura, Pannathura, Kovalam, Mullur to Pullavila and south of Edapadu beach.

AVPPL has provided the monthly beach profile data collected (for the entire stretch of 40Km at 81 transect) by the surveying agency for the period from October 2019 to September 2020. These have been analyzed, QA and QC have been carried out and final data sets were made. Due to Covid-19 protocol restriction, offshore profiles for the month of July 2020 have not been collected. The August 2020 and September 2020 data cross shore profile data are not suitable for analysis as the depth to elevation difference and distance difference from the onshore and offshore points are high. The other data sets after removing the sea wall locations have been used for analysis of beach changes on monthly, seasonally, yearly and inter-annually basis which has been included in the report. The overall beach volume change shows accretion all along the beach.

As a part of the scope of work, following reports has been submitted by NIOT:

- I Quarterly report, October 2019 to December 2019 have been submitted in February 2020.
- II Quarterly report, January 2020 to March 2020 has been submitted in June 2020.
- III Quarterly Report April 2020 to June 2020 has been submitted in August 2020.

- IV Quarterly report, June 2020 to September 2020 has been submitted in December 2020.
- In this final report comprising of one year study including available high resolution satellite imageries, beach profile and other related measurement has been analyzed and reported for the period October 2019 to September 2020.

In addition, NIOT has provided a wave rider buoy which is deployed / installed and periodically maintained with the help of AVPPL and the data received by NIOT are evaluated. Monthly and half yearly reports of the periodical data analysis (water quality, oceanographic and bathymetric data) has been received from M/s Shankar and Co., data and modeling report for the period March 2018 to February 2019 by LNTIEL and various measurement reports submitted by AVPPL from January 2019 has been received and vetted by NIOT till September 2020.

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. NIOT has carried out the study on shoreline change analysis using beach profiles and available satellite images for the years October 2017-September 2018 and October 2018-September 2019.

With reference to the mail dated 16/01/2020, to continue the same exercise, NIOT has been approached to submit the techno-commercial proposal for the year October 2019 to September 2020. Subsequently, NIOT has received the confirmation of the work order (mail dated 22/02/2020) to carry out the study on shoreline change analysis using beach profiles and available satellite images for the study duration October 2019 to September 2020. Accordingly, NIOT procured the latest available satellite data from National Remote Sensing Centre (NRSC) and obtain field measured data sets (beach profile) from AVPPL to study the shoreline changes analysis for 40 km stretch along Vizhinjam coast.

This report consists of the study on shoreline change analysis carried out over 40 km stretch keeping Vizhinjam Port as center, using latest available satellite images and beach profile data for the period from October 2019 to September 2020.

2 OBJECTIVES

i) To assess the shoreline change over the 20 km coastline on either side Vizhinjam port using satellite images and beach profile data for the year October 2019 to September 2020.

ii) To identify the erosion and accretion hotspots using available moderate and high resolution multispectral images acquired by remote sensing satellites and Field measured beach profile data for the year October 2019 to September 2020.

iii) Vetting of reports on oceanographic, hydrographic, bathymetric field measured data and numerical model studies provided by AVPPL.

3 METHODOLOGY & DATA USED

The methodology flowchart is shown in Figure 3.1. The shoreline change analysis has been carried out using satellite images to estimate the rate of change in terms of distance eroded or accreted and the rate of change estimated using cross shore profile in terms of area and volume. From the satellite images, the shoreline has been extracted after rectification and co-registration. The shoreline change rate from October 2019 to September 2020 has been

analysed, and the trend has been compared with beach profile data. Digital shoreline change analysis system (DSAS) is a software application that works within the Geographic Information System (ArcGIS) software. DSAS computes rate-of-change statistics for a time series of shoreline vector data. It is also useful for computing rates of change for other boundary change conditions that incorporate a clearly-identified feature position at discrete times.

Similarly, the beach profile data perpendicular to the shoreline for 40 km stretch at intervals of 500m, using RTK or total station landward up to 100m distance from HTL or +2m elevation w.r.t. HTL and using shallow-draft boats, sled or any other suitable techniques seaward down to 10m CD collected monthly (4 CSP lines carried out upto 20m in the months of January 2020, May 2020 and August 2020 as per Shoreline Monitoring Cell MoM dated 13th February 2019). 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 this report.

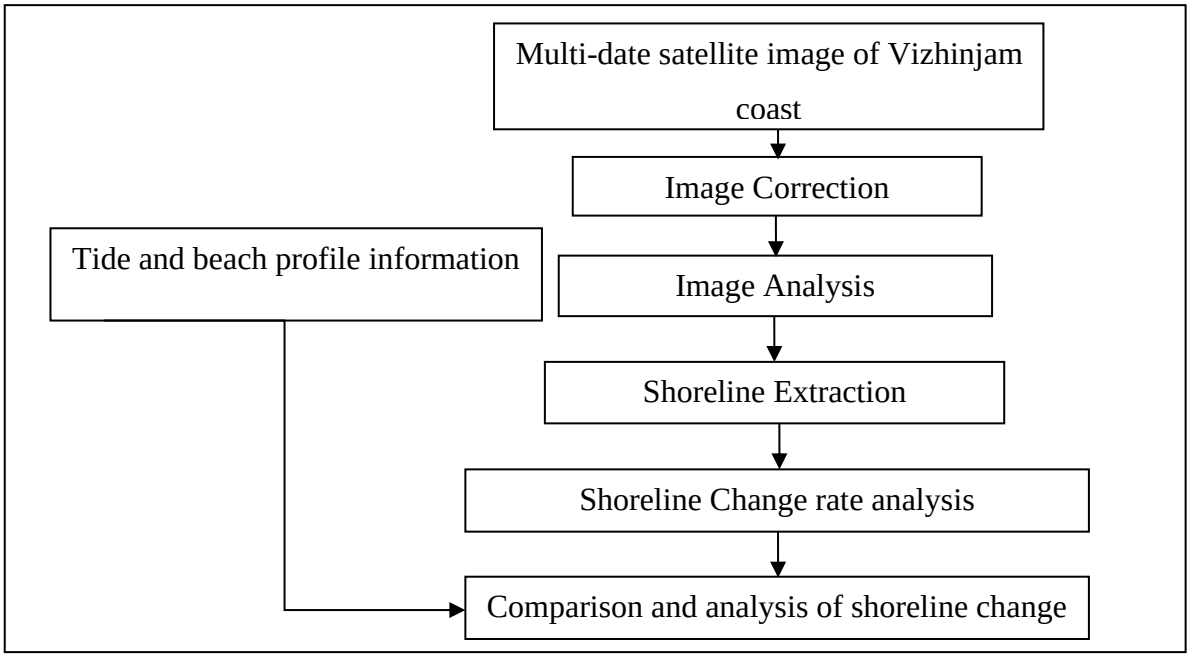


Figure 3.1Flowchart of the methodology adopted

3.1 Shoreline change analysis from Satellite images

3.1.1 Short Term Shoreline change analysis

The end point rate (EPR) is calculated by dividing the distance of shoreline movement by the time elapsed between the oldest and the most recent shoreline (Figure3.2). The major advantages of the EPR are the ease of computation and minimal requirement of only two

shoreline dates. The major disadvantage is that in cases where more data are available, the additional information is ignored.

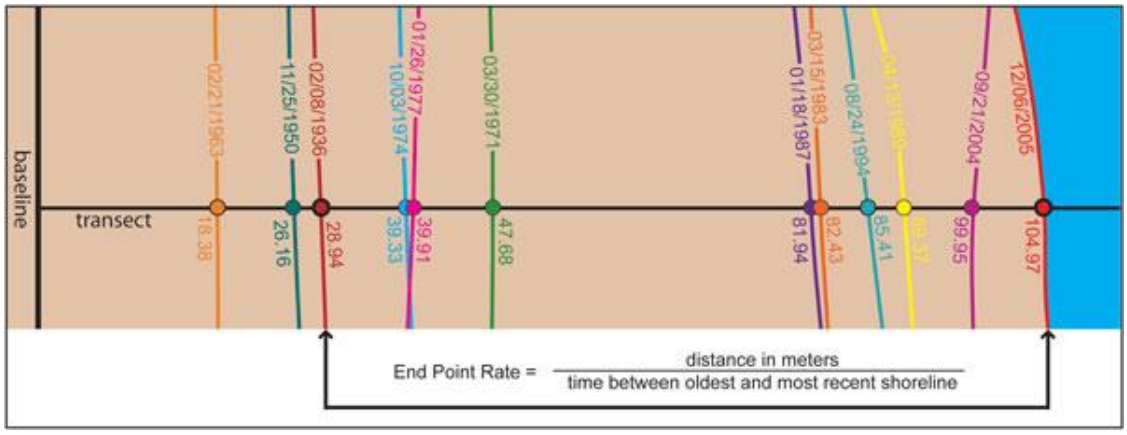


Figure 3.2Calculation of Short Term Shoreline change analysis (Sample image source: Thieler et al., 2017)

3.1.2 Long Term Shoreline change analysis

A linear regression rate-of-change (LRR) statistic is determined by fitting a least-squares regression line to all shoreline points for a particular transect Figure 3.3. 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 minimized. The linear regression rate is the slope of the line. However, the linear regression method is susceptible to outlier effects and also tends to underestimate the rate of change relative to other statistics.

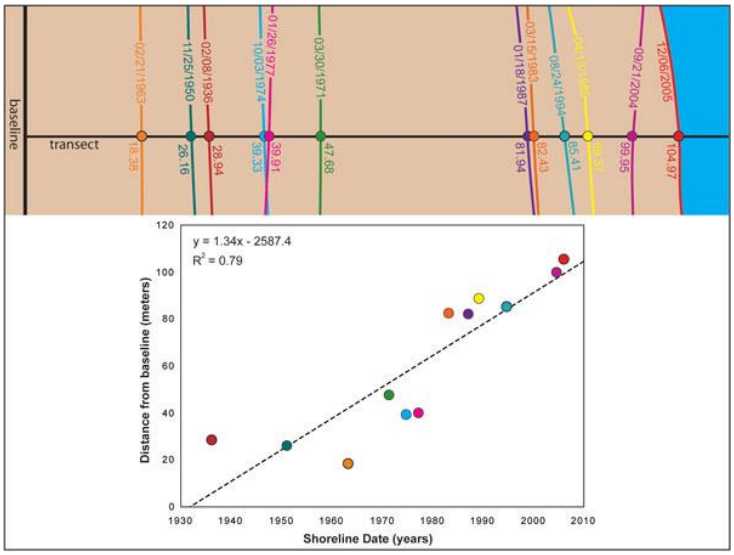


Figure 3.3Calculation of Long Term (LRR) Shoreline change analysis (Sample image source: Thieler et al., 2017)

3.1.3 Satellite image used in shoreline change analysis

The input image has been acquired from the European Space Agency for Sentinel 2A MSI images to study monthly and seasonal change in shoreline for the period from October 2019 to September 2020. The satellite images have been co-rectified, and the available high resolution satellite images for the period from October 2019 to September 2020 are provided in Table 3.1. During the study period, satellite images of higher resolution viz. 2.5m resolution have not been procured due to non-availability of the same for the study region. The image has been geo-rectified using the field collected ground control points (GCP) during the field visit carried out during 3rd July 2018 to 5th July 2018. *Note:* For shoreline analysis, the satellite images have been selected without cloud cover along the coast.

Table 3.1Satellite image data used for shoreline change analysis

Satellite	Date	Sensor	Resolution (m)
SENTINEL	04-01-2019	2B	10
	21-09-2019		
	05-11-2019		
	10-12-2019		
	09-04-2019		
	09-01-2020		
	08-02-2020		
	14-03-2020		
	03-04-2020		
	03-05-2020		
	12-06-2020		
	07-07-2020		
	16-08-2020		
	10-09-2020		
R2A	10-10-2019	LISS4	5
	27-11-2020		
	14-01-2020		
	02-03-2020		
	19-04-2020		
	03-01-2015		

3.2 Beach Profile Analysis

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 every month at 81 profile lines along a stretch of 40 km covering the area of

approximately 20 km south and 20 km north of the proposed Vizhinjam port (Since February 2015 to till date). The locations of the CSP lines are shown in Figure 3.4, and the corresponding landmarks and location names are given in Table 3.2. However, due to Covid-19 restrictions and rough sea condition along the Vizhinjam coast, offshore profiles for the months from July 2020 have not been collected. The offshore profiles collected for the month of August 2020 and September 2020 (due to high depth to elevation difference between the onshore and offshore point) have not been considered for the overall beach volume change analysis.

Figure 3.4Beach Profiles lines

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

(1) CSP Surveys (land part) 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 (Sea Part) using multi-beam echo sounder system to cover 10m CD; collected monthly (4 CSP Lines to be carried out up to a depth of 20 m in the month of January, May, August and October as per shoreline committee suggestion vide MoM of meeting dated 13th February 2019).These data sets are combined, processed and transferred to NIOT for analysis by the surveying agency.

Table 3.2 Landmark, places names and site condition around each CSP lines

CSP NOs.	LAND MARK	LOCATION	SITE CONDITION
CSP-01	CATHOLIC CRISMATIC PRAYER CENTER	EDAPPADU BEACH	Seawall
CSP-02			Beach
CSP-03			Seawall
CSP-04	ST.MARYS CHURCH	VALLAVILAY	Seawall
CSP-05			Seawall
CSP-06			Seawall
CSP-07	ST.NICOLAS CHURCH	NEERODY	Seawall
CSP-08			Seawall
CSP-09			Seawall
CSP-10	SREE BHADRAKALI TEMPLE	POZHIYOOR	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-36	NAGAR BHAGAVATHY TEMPLE	MULLUR	Beach
CSP-37			Beach
CSP-38	ADANI RECLAMATION AREA	ADANI PORT OFFICE VIZHINJAM	Seawall
CSP-39			Beach
CSP-40			Beach
CSP-41	VIZHINJAM LIGHT HOUSE	KOVALAM	Beach
CSP-42			Beach
CSP-43			Beach
CSP-44			Beach
CSP-45			Seawall
CSP-46			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			Eroding beach
CSP-52			Eroding beach
CSP-53	PUNTHURA FISH MARKET	PUNTHURA	Eroding beach
CSP-54			Seawall

CSP-55			Seawall
CSP-56			Seawall
CSP-57			Seawall
CSP-58	BEEMA PALLY	BEEMA PALLY	Seawall
CSP-59			Seawall
CSP-60			Seawall
CSP-61	CHERIYATHURA SPORTS GROUND	CHERIYATHURA	Seawall
CSP-62			Seawall
CSP-63	VALLIYATHURA BRIDGE	VALLIYATHURA	Seawall
CSP-64			Seawall
CSP-65			Seawall
CSP-66			Eroding beach
CSP-67			Seawall
CSP-68	SHANGUMUGHAM BEACH	SHANGUMUGHAM (SOUTH)	Seawall
CSP-69			Beach
CSP-70	ST.PETERS CHURCH	SHANGUMUGHAM (NORTH)	Beach
CSP-71			Beach
CSP-72	VETTUCAUD CHURCH	VETTUCAUD	Beach
CSP-73			Beach
CSP-74			Beach
CSP-75	VELI CHILDRENS PARK	KOCHUVELI	Beach
CSP-76			Beach
CSP-77			Eroding Beach
CSP-78	ST.THOMAS CHURCH	VALIYA VELI	Beach
CSP-79			Seawall
CSP-80	CHRISTIAN BROTHEREN CHURCH	THUMBA	Beach
CSP-81			Beach

The data received was analyzed by plotting each profile and using SANDS. The aim of this exercise was 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 future. The difference, if any, shall be investigated further to understand impact due to the port on the shoreline evolution. Profiles for different months were plotted location wise. A sample plot of the profile is shown in Figure 3.5.

A beach profile is defined as a set of beach levels taken at recorded distances in a straight line (Figure 3.5). It is accepted that beach profiles can only be of real use when surveys are taken over a period of time starting at exactly the same place and moving in exactly the same direction (the Origin and Orientation of the profile). SANDS software stores the beach profile surveys, to view them graphically and to analyse them to identify trends in beach levels at a location over time. The 'Beach Profile Graph' feature allows the user to graph and compares beach profiles from different/multiple locations.

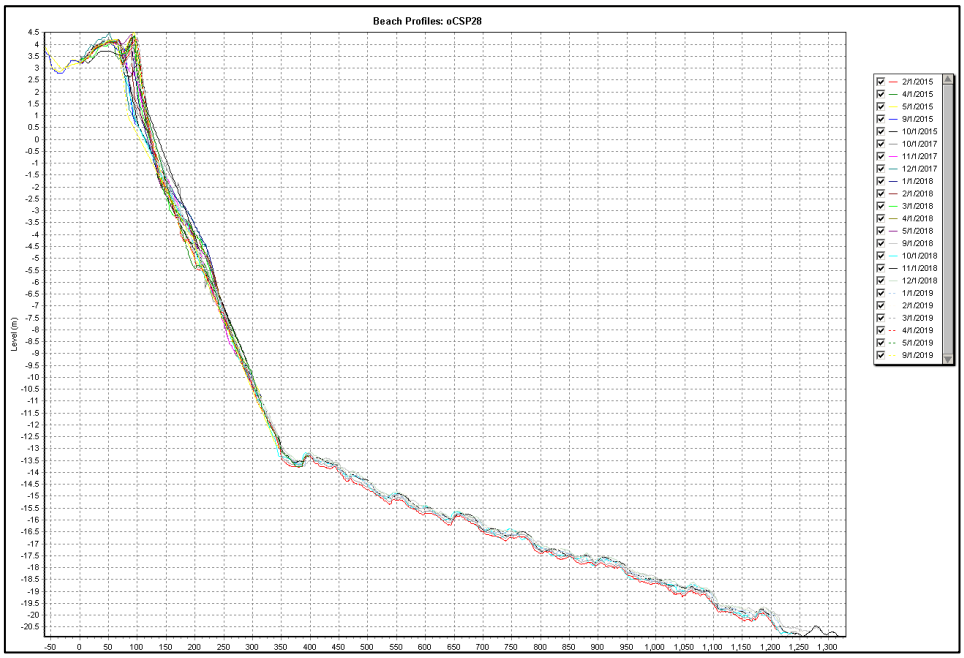


Figure 3.5 Sample beach profile graph of CSP 28(Pullavila) using SANDS software

It was observed during the analysis of cross shore profiles that some of the profiles appeared distorted, possibly due to some errors during the survey. These profiles are either discarded or manually corrected in respect of the earlier profiles. The profiles corresponding to the Vizhinjam Port area is completely discarded and mentioned as a development zone.

The CSP data after reprocessing qualitatively and quantitatively is directly imported to SANDS for shoreline change assessment. The following flow chart (Figure 3.6) explains the process and workflow in SANDS.

Figure 3.6 Work Flow in SANDS

3.3 Analyzing Beach Profiles in SANDS

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

3.3.1 Profile Analysis by Level

Profile analysis 'by Level' method analyses the changes in the chainage at which certain levels occur whilst the other analyses changes in level at certain chainages (Figure 3.7). In other words, this analysis looks at horizontal strips of the profile.

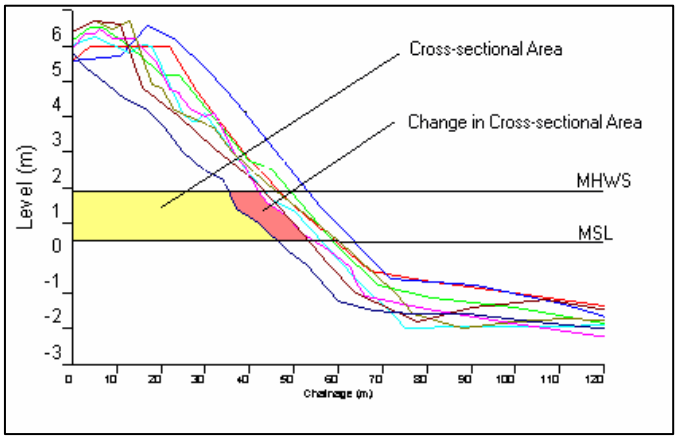


Figure 3.7 Profile Analysis by Level

3.3.2 Profile Analysis by Chainage

Profile analysis 'by Chainage' method analyses the changes in level at certain chainages whilst the other analyses changes in the chainage of certain levels. In other words, this analysis looks at vertical strips of the profile (Figure 3.8).

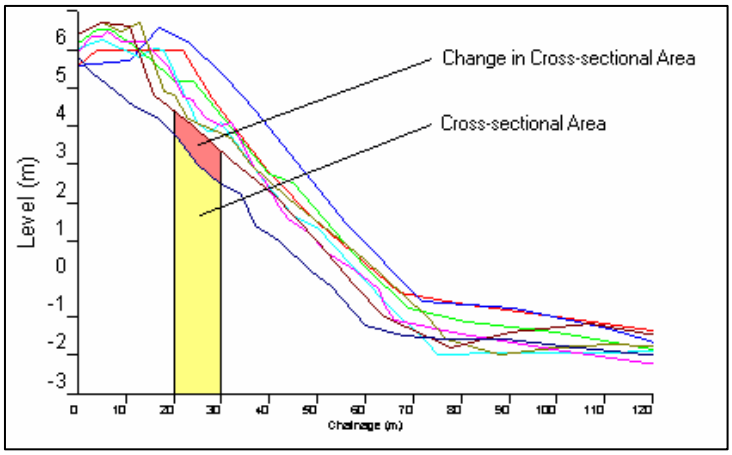


Figure 3.8 Profile Analysis by Chainage

Based on the above methods SANDS calculate the profile changes and then it calculates volumes of pre-defined areas. It also enables to group together all beach profile locations and analyze the volumes of these units. SANDS calculate the Profile Accretion / Erosion through a direct comparison between profiles over the period of comparison and allow the results to be displayed within a GIS-style plan-view format to give striking visual results.

4 RESULTS AND ANALYSIS

In the present study, the shoreline rate of change statistics from time series of multiple shoreline positions of 40 km coastal stretch of south Kerala coast (20 km either side of Vizhinjam Port) has been taken in to account for shoreline calculation using satellite images. The result from the shoreline change analysis carried out from October 2019 to September 2020 using 10m satellite images and 5m high resolution satellite images is presented in this report.

Hence, with the available satellite images of 10m resolution for the monthly shoreline change analysis, this classification may indicate high erosion and high accretion based on the scale followed for the same as higher resolution images. Based on the rate of change over the period, shoreline change has been categorized into 5 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 shoreline change analysis using high resolution satellite images for February 2018 and February 2019 have also been presented.

The observations from the beach profile analysis done using SANDS for the entire 40 km stretch has been presented as monthly, seasonal and half yearly changes in the beach volume for a period from October 2019 to September 2020. The volume changes have been assessed by comparing month to month profiles and the seasonal and the overall beach volume changes. We have removed the locations having sea walls from the analysis. The erosion and accretion are highlighted with red and green color fill in the charts for better understanding. The results shown in the charts are also presented in the tables.

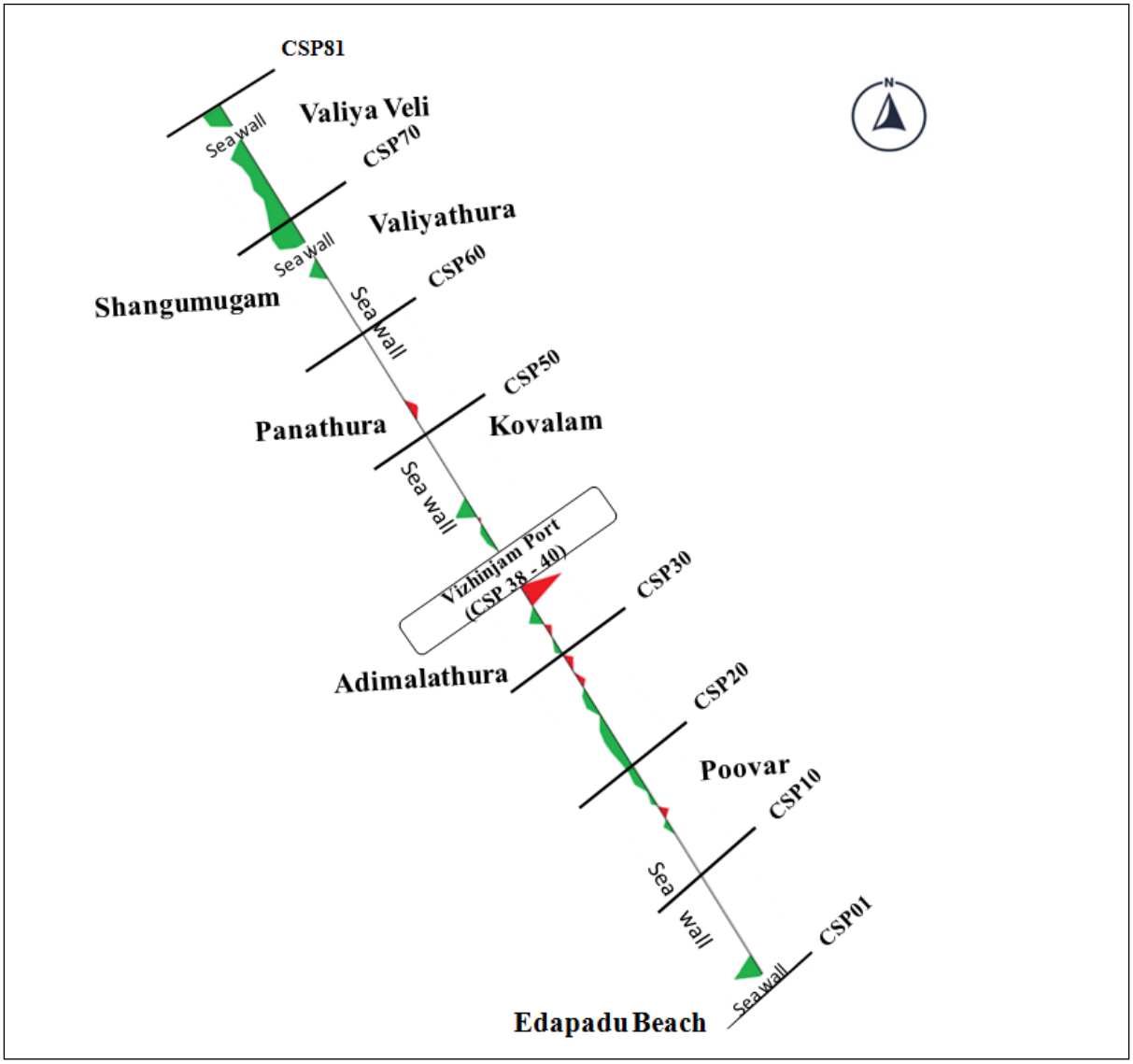
4.1 Results from Beach Profile Analysis

The beach profile data consist of both foreshore and offshore profiles. Monthly beach volume changes have been assessed by comparing month to month profiles. In the previous Annual reports October 2017-September 2018 and October 2018-September 2019, the beach volume (monthly, seasonal and yearly) changes from February 2015 to September 2020 has been analysed and reported. In continuation with the previous studies, this report includes the monthly, seasonal and overall changes from October 2019 to September 2020.

4.1.1 Monthly Beach Volume variations – October 2019 to September2020

In order to study the beach volume change in October 2019, the beach profile data of September 2019 has been considered for the analysis. The changes in every month (October 2019 to September 2020) and overall beach volume changes have been represented graphically in Figures 4.1 to 4.9 and in Table 4.1.

- During October 2019 the beach found to have accretion at most of the location except erosion at Poovar (CSP16), Pullavila (CSP28,30), Adimalathura (CSP33), Mullur (CSP36), Kovalam (CSP43), Punthura (CSP53).
- During the month of November 2019, the sediment deposition has taken place over most of the locations. Erosion noted at Pannathura (CSP51,52), Kovalam (CSP41,42,44), Mullur (CSP 36, 37) and Poovar (CSP17).
- In December 2019 beach was found to have erosion in most of the beaches other than Punthura (CSP53), Pannathura (CSP52), Poovar (CSP16,17), Karumkulam (CSP24) and Adimalathura (CSP34).
- During the month of January 2020, the sediment deposition has taken place over most of the locations. Erosion is noted at Thumba (CSP81), Kochuveli (CSP77), Shangumugham to Vettucaud (CSP70,71,72), Valliyathura (CSP66), Punthura (CSP53), Mullur (CSP37), Adimalathura (CSP33), Pullavila (CSP27,28), Karumkulam (CSP24), Poovar (CSP18, CSP15) and Edapadu (CSP02).
- In February 2020, beach was found to have accretion all along the entire coastal stretch.
- In March 2020, most of the locations show accretion except erosion at Karumkulam (CSP24, 26), Pullavila (CSP28), Kovalam (CSP44) and Pannathura (CSP52).
- During the month of April 2020 most of the stations are showing erosion and some parts of the beaches at Karumkulam (CSP22,23,26), Kovalam (CSP43-44) showing deposition.
- In May 2020, erosion has taken place over most of the locations. Accretion noted at Poovar (CSP19,20), Pullavila to Adimalathura (CSP30-33), Mullur (CSP36), Kovalam (CSP41), Pannathura (CSP51-52) and Valiyaveli (CSP78).
- During June 2020, accretion taken place at most of the stretches except at Shangumugham (CSP70-71), Valliyathura (CSP66), Kovalam (CSP43-44), Mullur (CSP37), Pullavila (CSP30) and Poovar (CSP15).



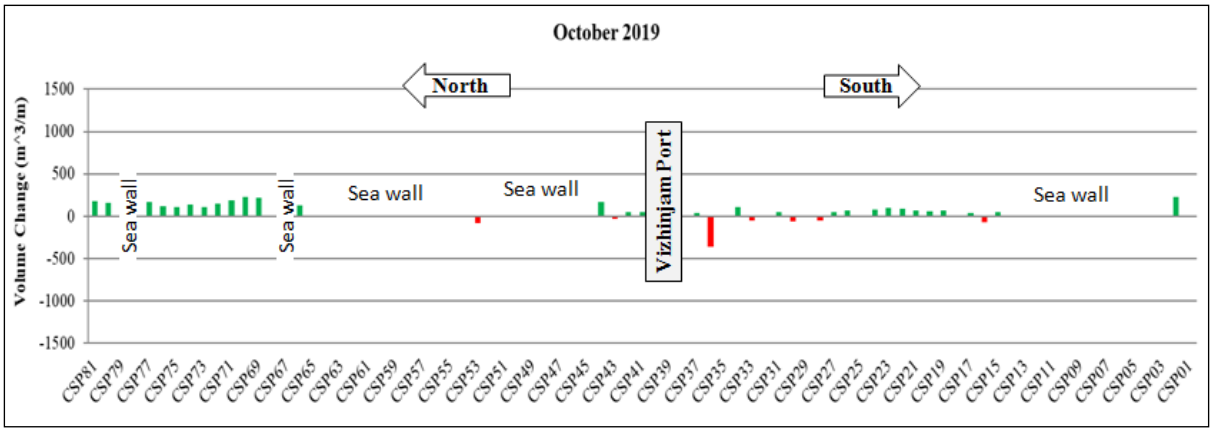


Figure 4.1 Monthly Beach Volume Changes in October 2019 in m^3/m

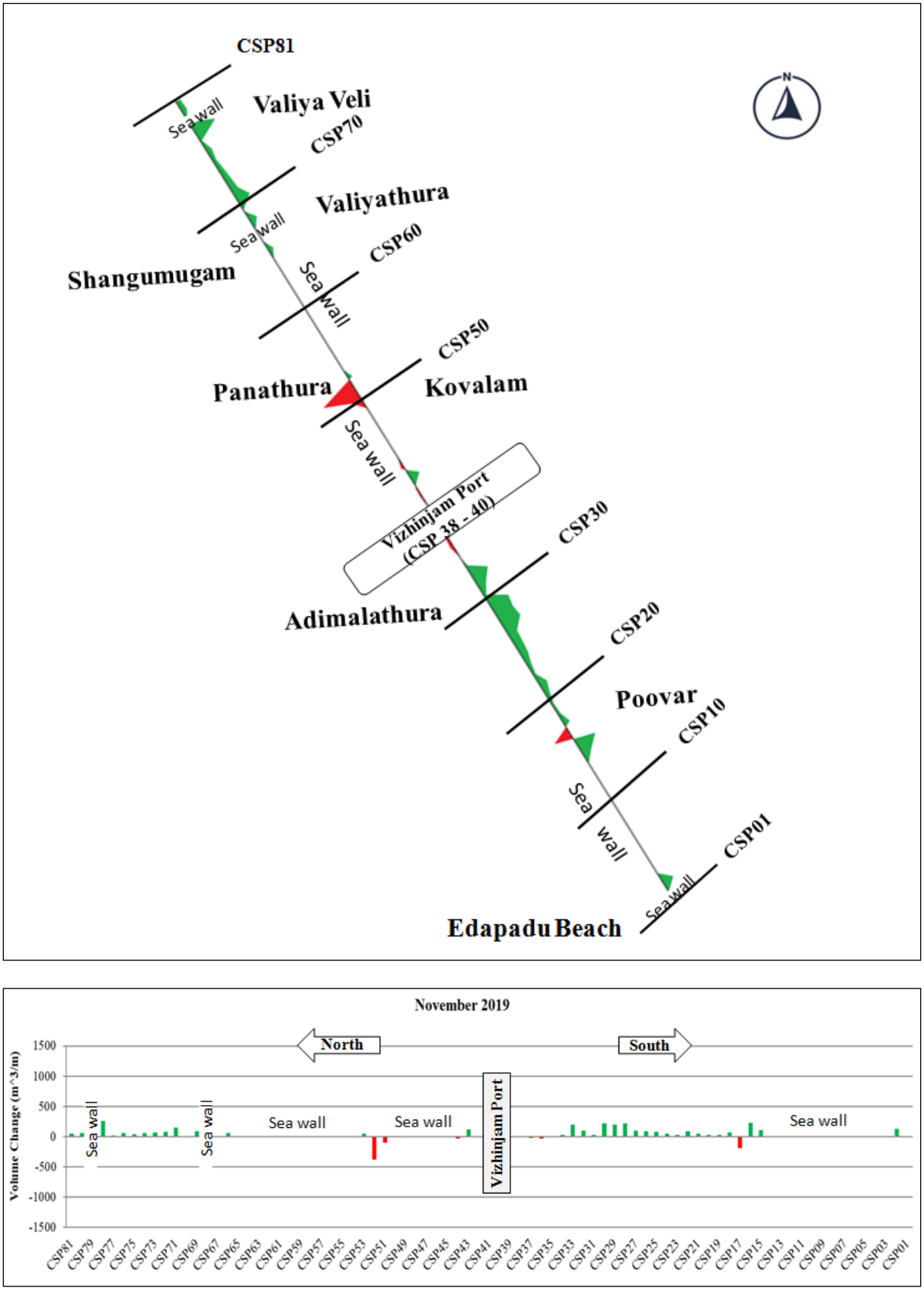


Figure 4.2 Monthly Beach Volume Changes in November 2019 in m^3/m

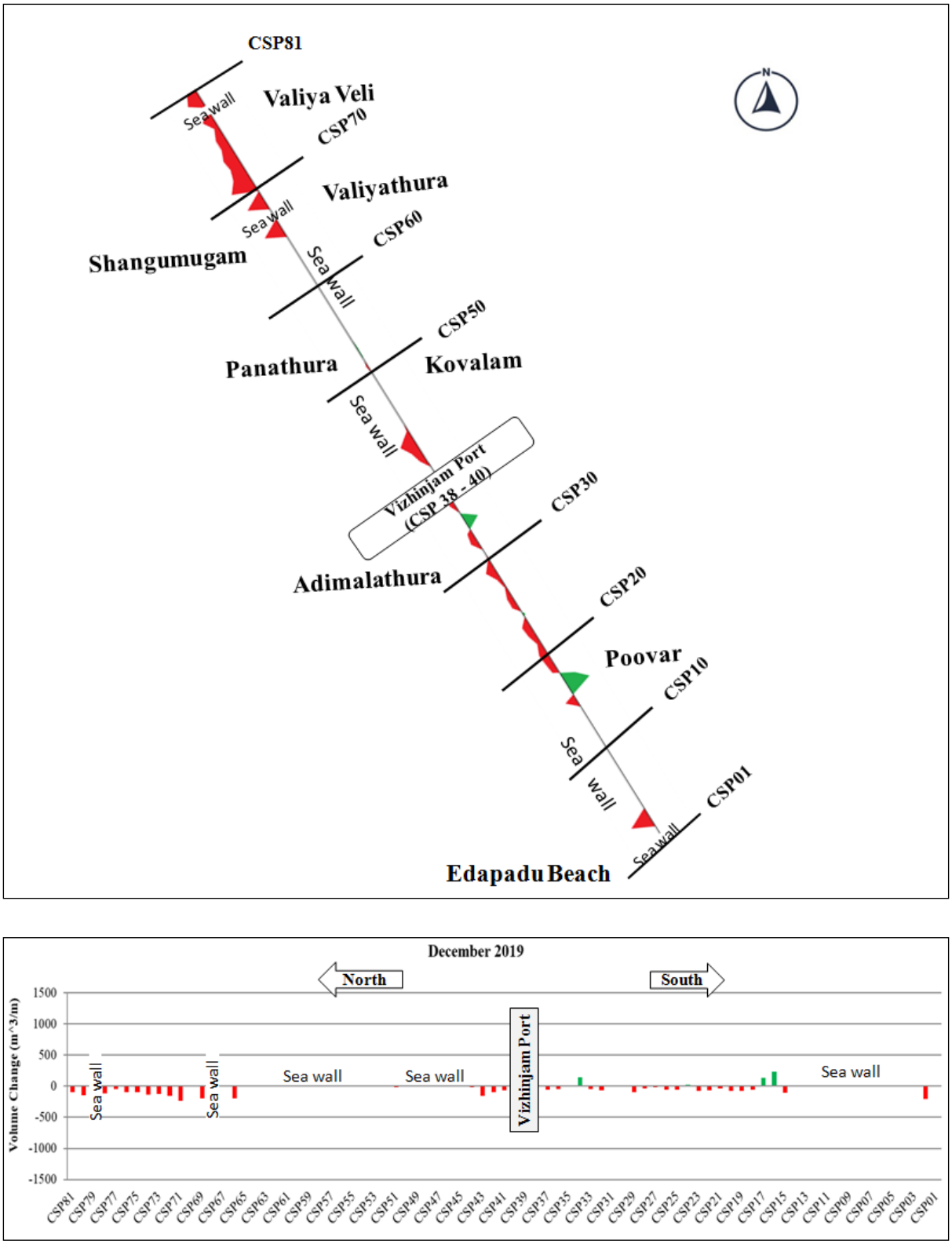


Figure 4.3 Monthly Beach Volume Changes in December 2019 in m^3/m

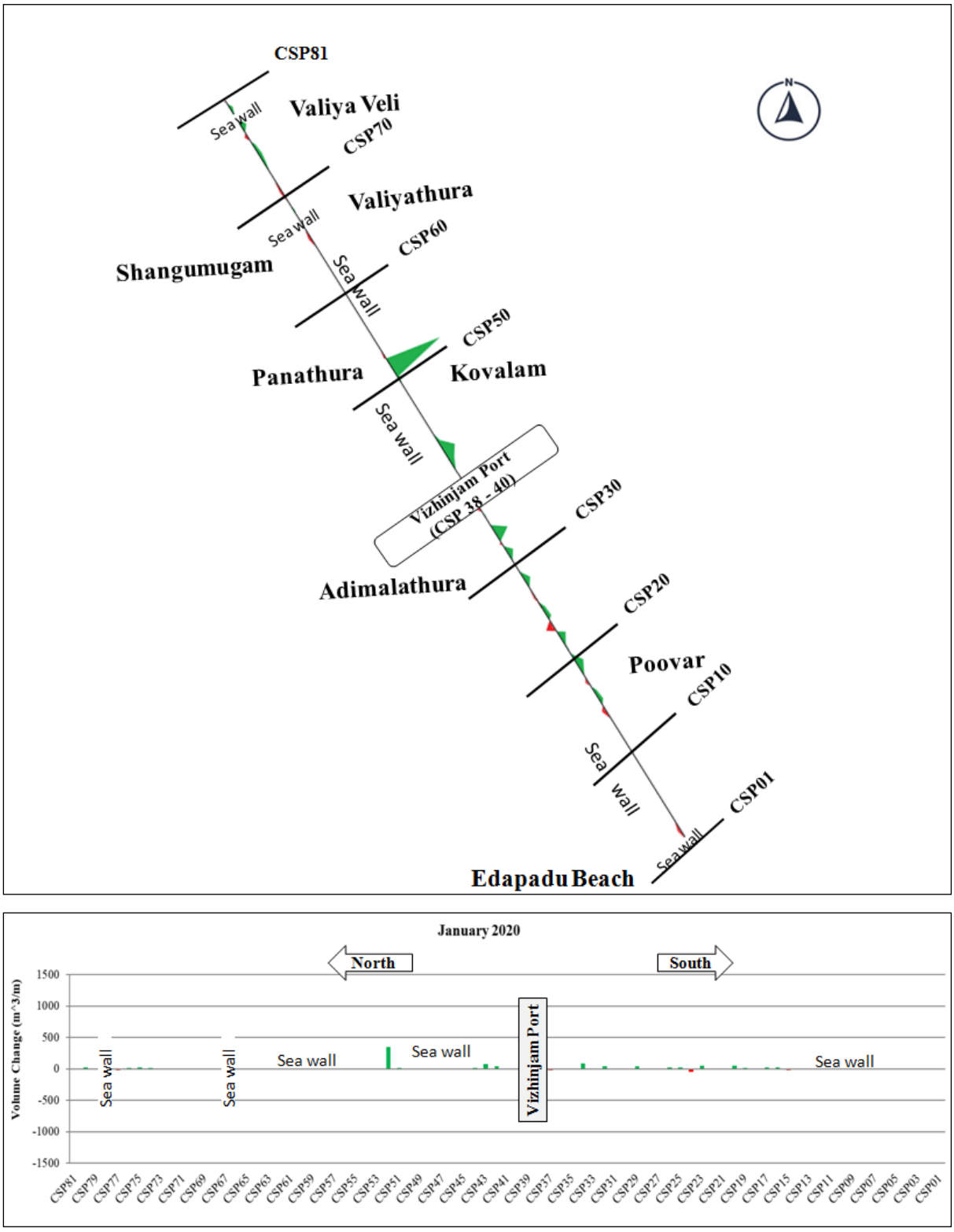


Figure 4.4 Monthly Beach Volume Changes in January 2020 in m^3/m

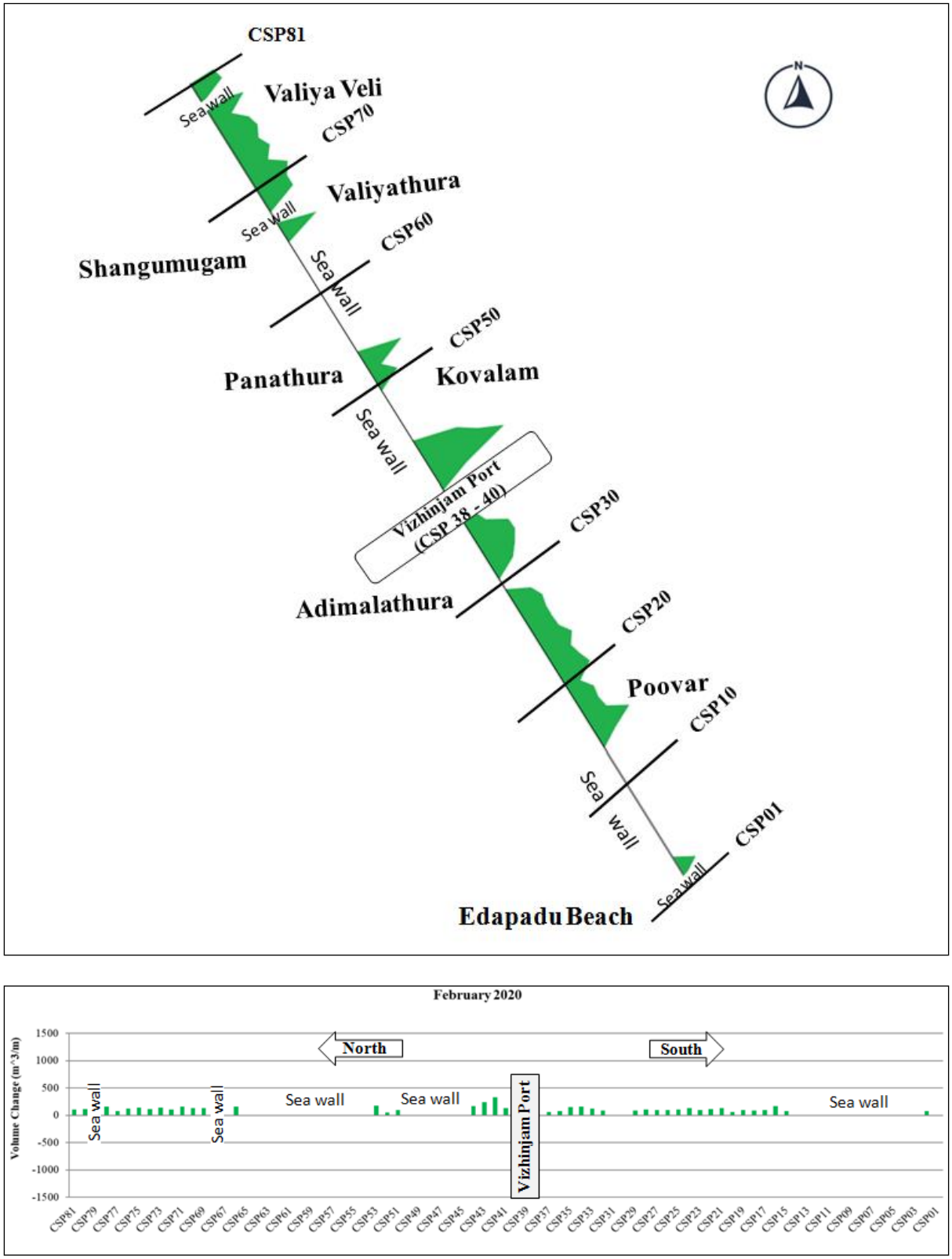
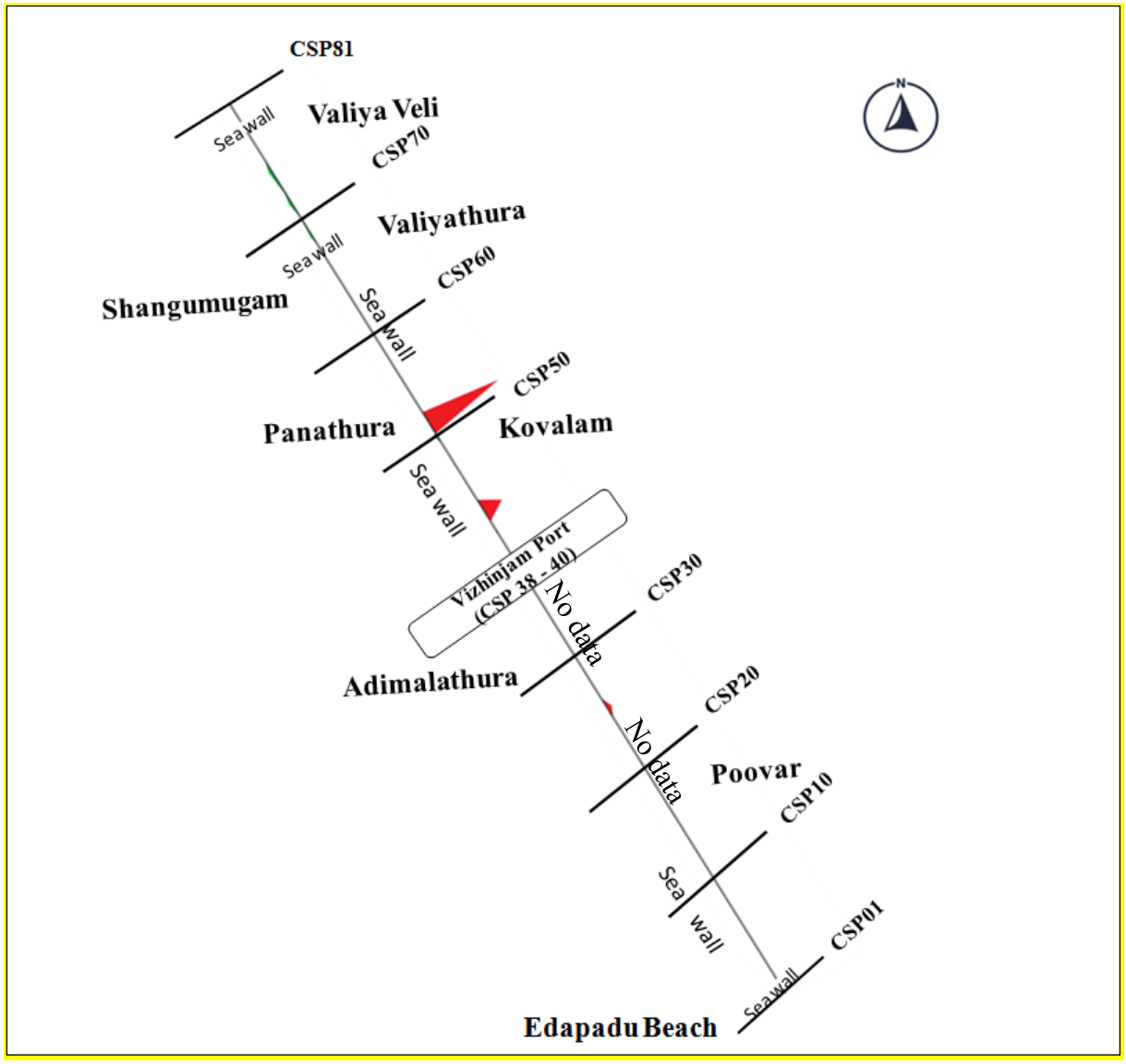


Figure 4.5 Monthly Beach Volume Changes in February 2020 in m^3/m



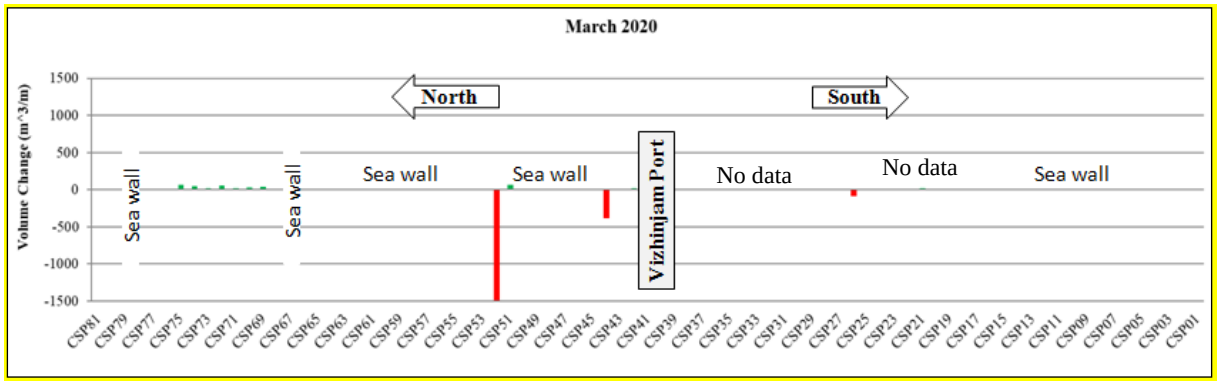


Figure 4.6 Monthly Beach Volume Changes in March 2020 in m^3/m

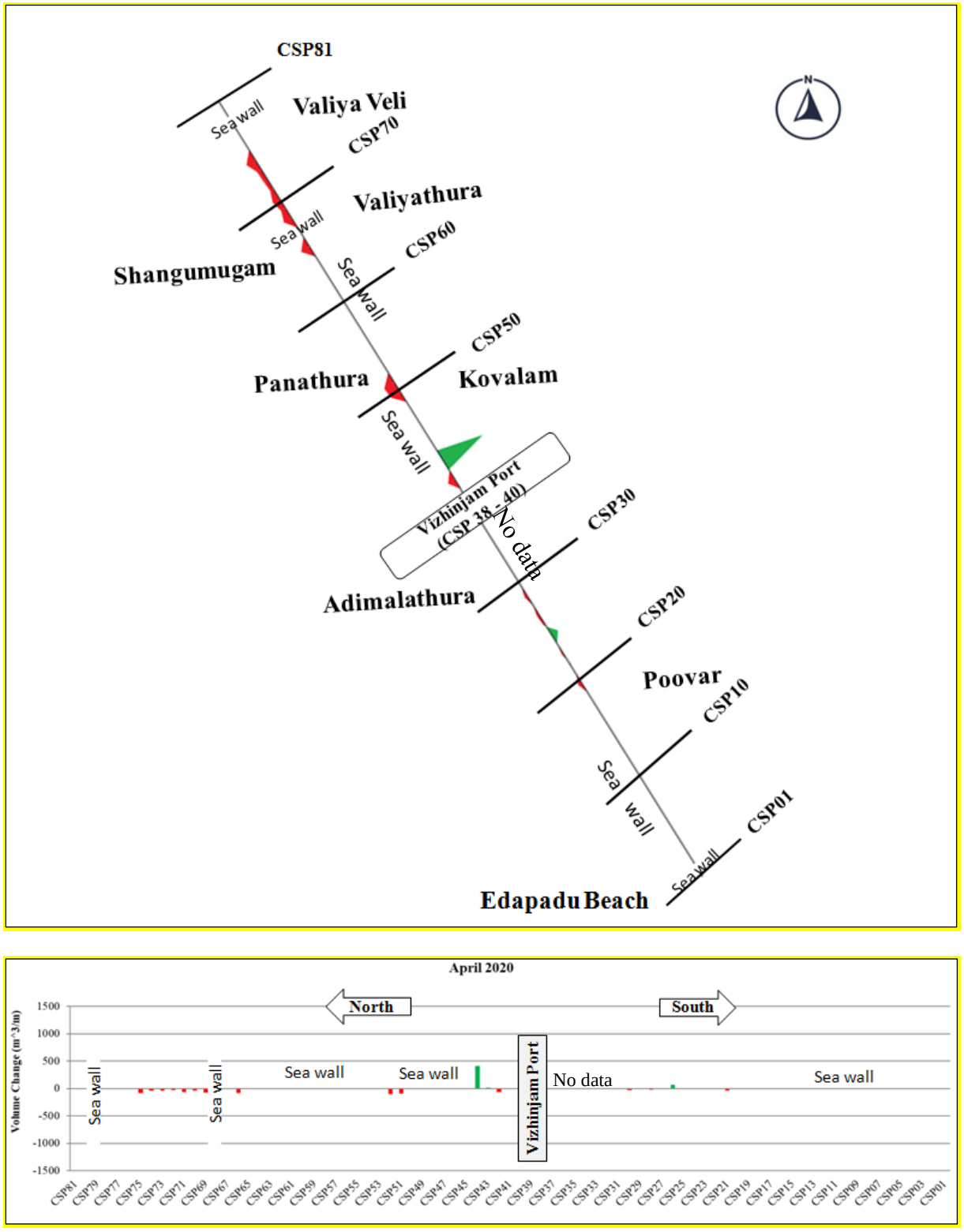


Figure 4.7 Monthly Beach Volume Changes in April 2020 in m^3/m

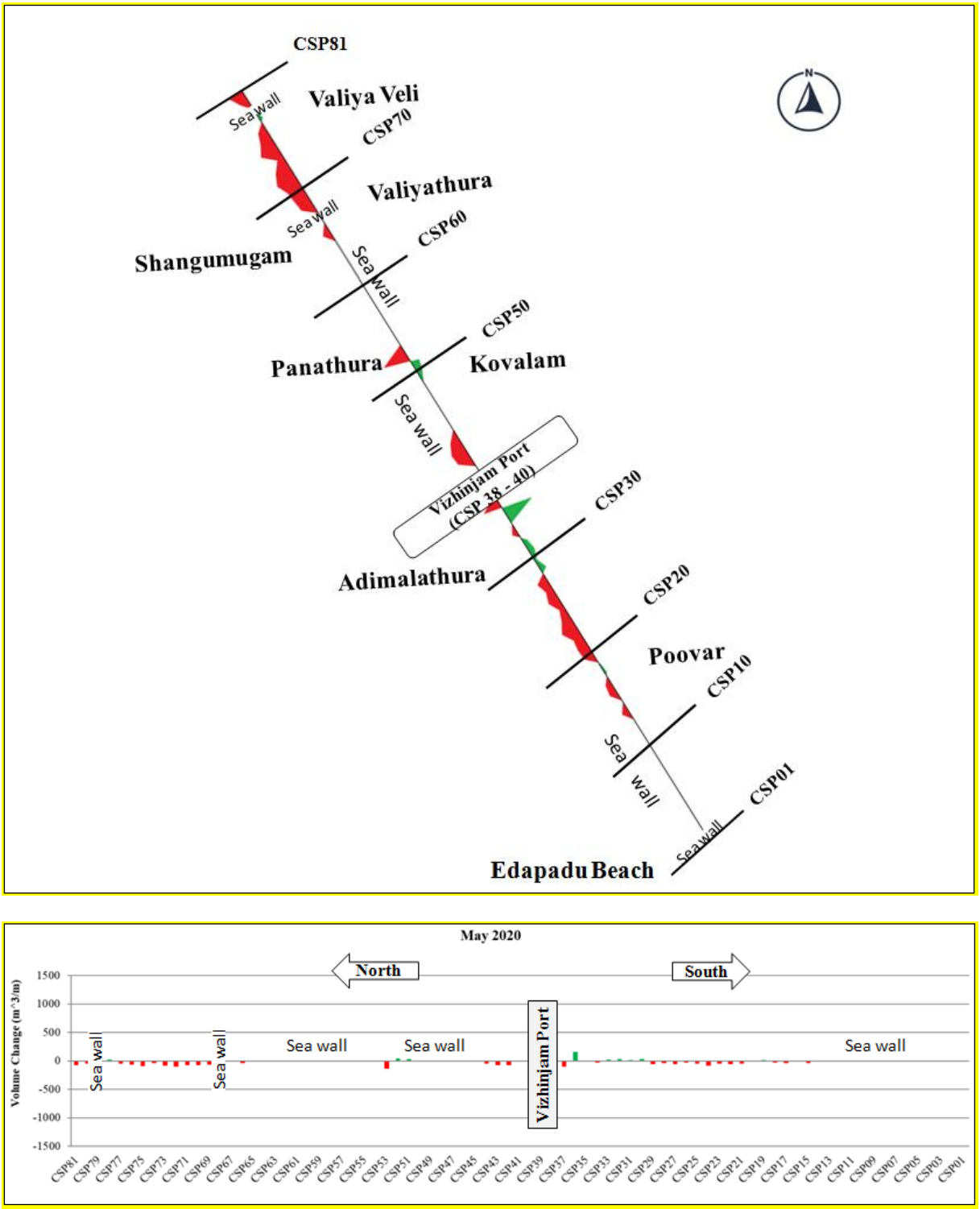


Figure 4.8 Monthly Beach Volume Changes in May 2020 in m^3/m

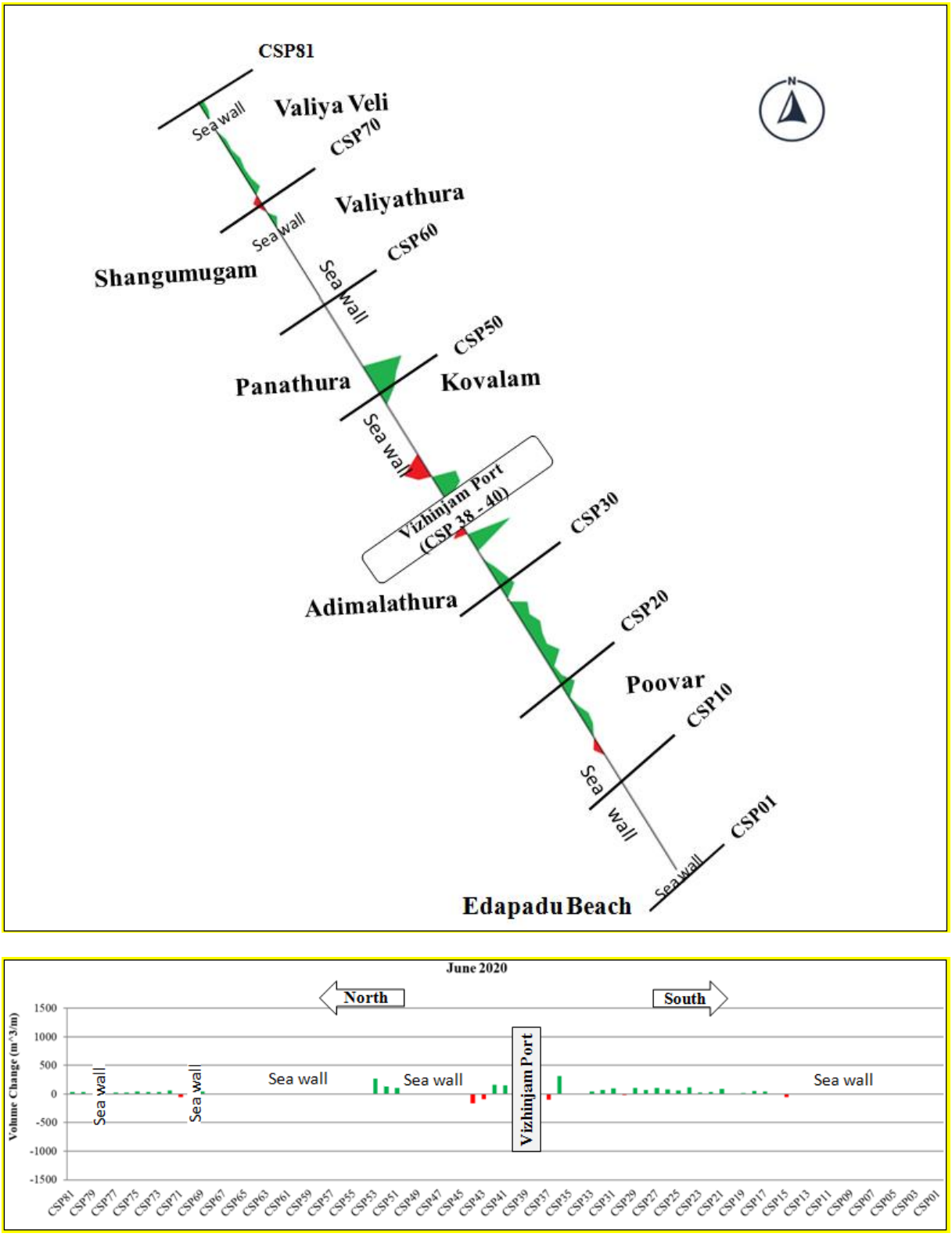


Figure 4.9 Monthly Beach Volume Changes in June 2020 in m^3/m

- Due to Covid-19 restrictions and high wave action along the Vizhinjam coast, offshore profiles for the month of July 2020 have not been collected. The cross shore profile data are not suitable for analysis as the depth to elevation difference and distance difference from the onshore and offshore points is high during the months of August 2020 and September 2020.
- The profile graphs showing the depth to elevation difference is more than 4m almost for the 81 profiles for August 2020 and September 2020 shown in Figure 4.10. The depth to elevation difference and the distance from the onshore and offshore points for the locations Karumkulam (CSP-26) and Vettucaud (CSP-74) shown in Figures 4.11 to 4.12.

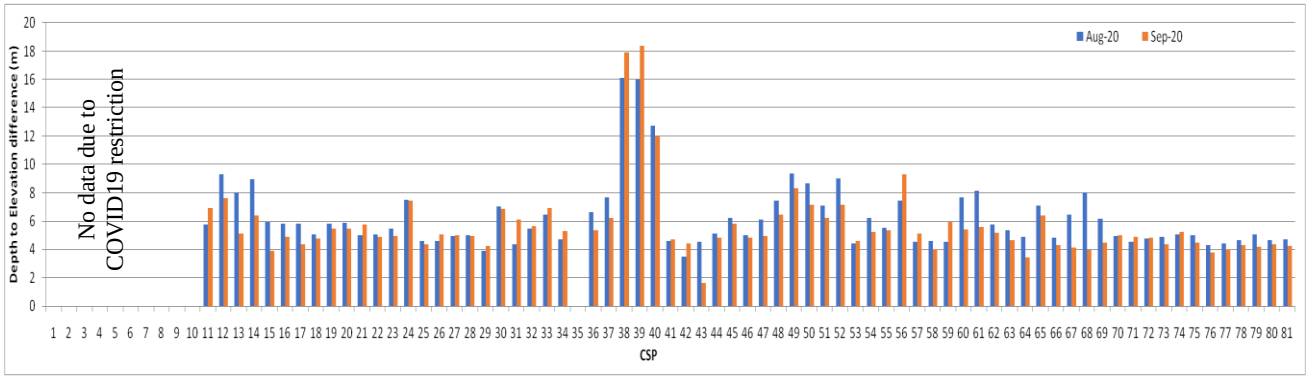


Figure 4.10 Depth to elevation difference for 81 profiles for the month of August 2020 and September 2020

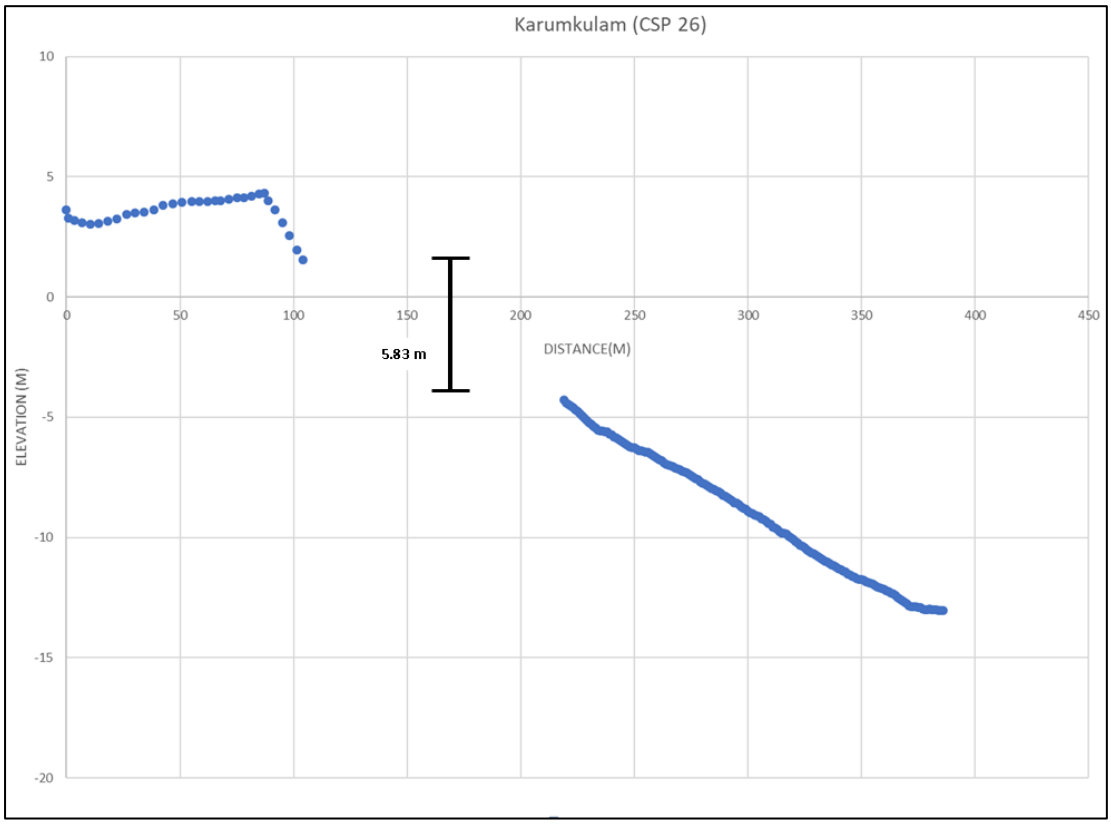


Figure 4.11 CSP Profile for Karumkulam (CSP-26)

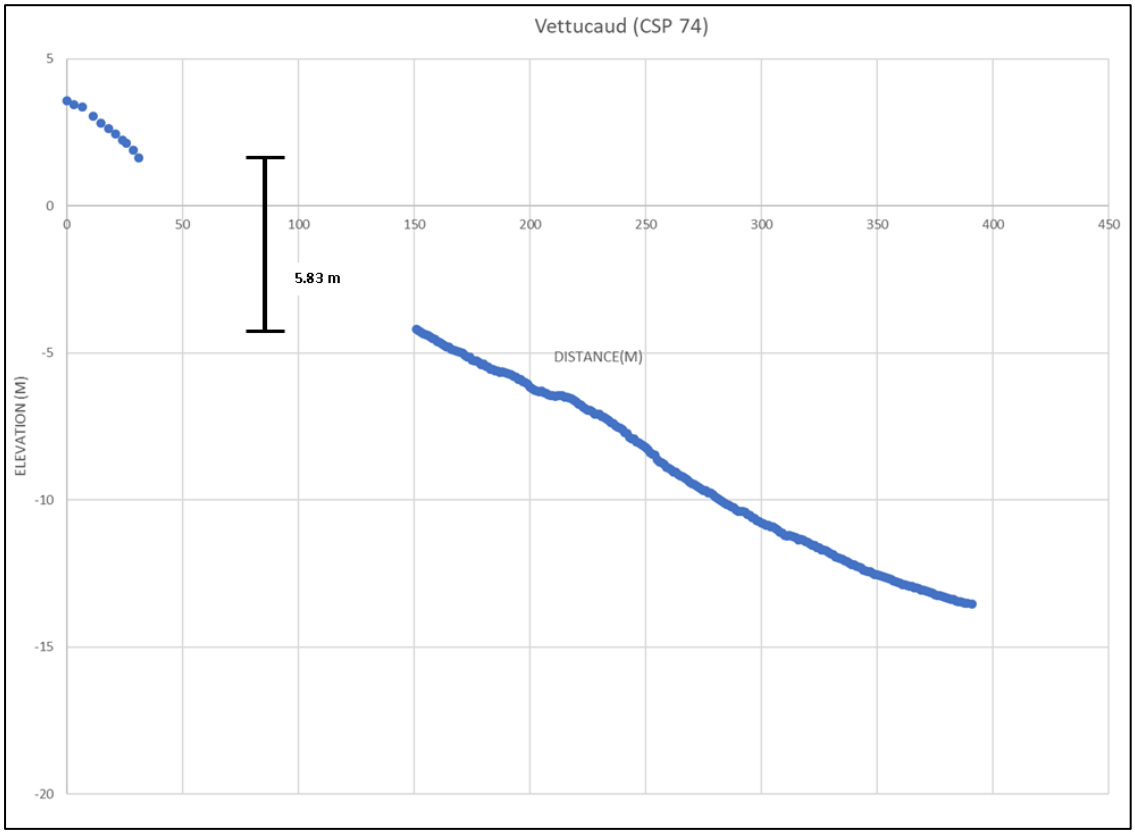


Figure 4.12 CSP Profile for Vettucaud (CSP-74)

Table 4.1 Monthly Beach Volume Changes during the months from October 2019 to June 2020 in m^3/m

	October 2019	November 2019	December 2019	January 2020	February 2020	March 2020	April 2020	May 2020	June 2020
CSP01	**Sea wall**					**No data due to COVID-19 restrictions**			
CSP02	226.71	129.04	-209.24	-15.54	76.78				
CSP03	**Sea wall**								
CSP04									
CSP05									
CSP06									
CSP07									
CSP08									
CSP09									
CSP10									
CSP11						**Sea wall**			
CSP12									
CSP13									
CSP14									
CSP15	52.52	106.60	-110.72	-21.72	76.76	**No data for March 2020**		-41.02	-52.20
CSP16	-71.06	229.87	231.54	28.20	169.31			**No data***	
CSP17	38.79	-193.05	129.38	20.57	92.04			-43.10	44.16
CSP18	12.48	72.74	-58.93	-14.55	83.47			-34.47	55.98
CSP19	68.70	33.27	-71.99	16.14	91.66			10.98	21.82
CSP20	57.37	25.65	-81.23	50.87	58.68			3.97	6.83
CSP21	70.77	52.78	-37.85	6.92	130.03	22.54	-35.31	-52.87	94.09
CSP22	89.15	91.31	-69.35	9.63	112.49	8.55	2.69	-59.14	38.44
CSP23	95.57	31.04	-78.92	48.94	100.09	14.84	5.88	-51.07	26.88
CSP24	78.11	50.43	24.06	-49.90	132.31	-6.97	-15.60	-85.34	119.59
CSP25	11.76	83.74	-56.67	28.43	101.18	12.70	-1.74	-52.34	65.44
CSP26	70.96	94.88	-54.29	23.39	98.05	-91.33	66.87	-30.04	78.29
CSP27	50.44	104.26	-14.64	-8.12	99.42	7.95	-14.25	-60.07	109.34
CSP28	-52.06	216.03	-38.91	-2.24	109.54	-3.87	-22.88	-40.26	72.53
CSP29	**No data**	199.76	-97.78	42.55	86.59	8.51	-1.92	-57.21	104.93
CSP30	-64.35	220.05	-9.20	1.78	**No data***	**No data***	-27.43	33.16	-15.79
CSP31	50.92	30.58	**No data***	**No data***	0.00	**No data***		11.80	98.64
CSP32	8.88	101.89	-69.43	44.35	89.71			31.94	73.29
CSP33	-50.98	195.47	-48.44	-13.23	126.68			22.80	44.95
CSP34	106.39	25.64	139.34	88.57	155.17			-31.46	8.83
CSP35	**No data***				153.07	**No data***			
CSP36	-356.50	-30.08	-48.19	10.34	77.38	**No data***		162.10	317.68
CSP37	42.57	-21.47	-53.56	-22.92	57.39			-99.58	-102.75
CSP38	**Port Area**								
CSP39									
CSP40									
CSP41	47.84	-14.32	-63.44	6.60	133.57	**No data***		2.30	151.78
CSP42	51.28	-10.43	-93.27	37.54	332.29	20.46	-66.35	-74.30	163.58
CSP43	-27.76	115.83	-154.79	81.30	236.45	13.34	11.39	-80.25	-91.12
CSP44	164.26	-29.00	-19.27	18.02	171.38	-384.38	409.17	-52.05	-159.89
CSP45	**Sea wall**								
CSP46									
CSP47									
CSP48									
CSP49	**No data***	**Sea wall**							
CSP50									
CSP51		-102.87	-19.92	16.59	99.29	62.58	-88.89	27.83	112.02
CSP52		-376.72	6.32	348.58	54.56	-1492.27	-98.83	43.99	174.18
CSP53	-77.29	52.18	9.05	-9.17	175.62	**No data***		-137.99	268.22
CSP54	**Sea wall**							**Sea wall**	
CSP55									
CSP56	**Sea wall**								
CSP57									
CSP58									
CSP59									
CSP60									
CSP61									
CSP62									
CSP63									
CSP64									
CSP65									
CSP66	131.78	60.88	-193.85	-14.54	155.69	0.30	-81.28	-43.12	-2.54

CSP67	**Sea wall**								
CSP68									
CSP69	217.42	87.10	-193.16	9.17	131.78	41.29	-72.83	-66.92	47.71
CSP70	225.80	**No data***		-1.72	131.60	25.65	-41.08	-73.38	-11.76
CSP71	185.68	150.83	-241.01	-11.84	162.94	17.26	-64.23	-79.93	-49.93
CSP72	143.55	78.87	-157.24	-3.61	101.82	59.16	-30.30	-106.50	58.48
CSP73	109.20	69.53	-124.23	1.55	137.87	22.23	-36.24	-80.82	36.38
CSP74	138.70	57.04	-139.16	14.44	114.99	44.88	-39.17	-35.70	31.83
CSP75	108.51	42.11	-95.43	23.22	138.64	67.01	-85.11	-98.54	45.50
CSP76	119.63	62.79	-95.84	16.66	126.17	**No data***		-65.92	24.60
CSP77	166.17	20.80	-48.34	-17.73	77.50			-45.17	30.61
CSP78	6.94	257.02	-112.90	36.78	160.59			20.63	7.10
CSP79	**Sea wall**				**No data***			**Sea wall**	
CSP80	162.01	62.20	-149.94	21.65	117.79			-46.18	34.78
CSP81	173.16	54.47	-95.95	-14.03	106.96			-78.05	38.65

* indicates No data or data not used due to the depth to elevation difference and the difference in the distance between the onshore and offshore point is high.

4.1.2 Seasonal Beach Volume variations from October 2019 to September 2020

Seasonal variation has been analyzed as post monsoon (October 2019 to November 2019), fair weather period (December 2019 to March 2020) and pre-monsoon period (April 2020 to May 2020), Monsoon (June 2020 to September 2020) for the period October 2019 to September 2020.The results have been presented to depict the total changes that occur in a particular season by analyzing profiles between each month in a season.

4.1.2.1 *Results for Beach Volume Change in Post Monsoon 2019 (October 2019-November 2019)*

Beach volume change during post monsoon shows accretion trend at most of the locations on the 40km stretch beach. Erosion noted at Poovar (CSP17), Mullur (CSP 36) and Punthura (CSP53) during this period as shown in Figure 4.13.

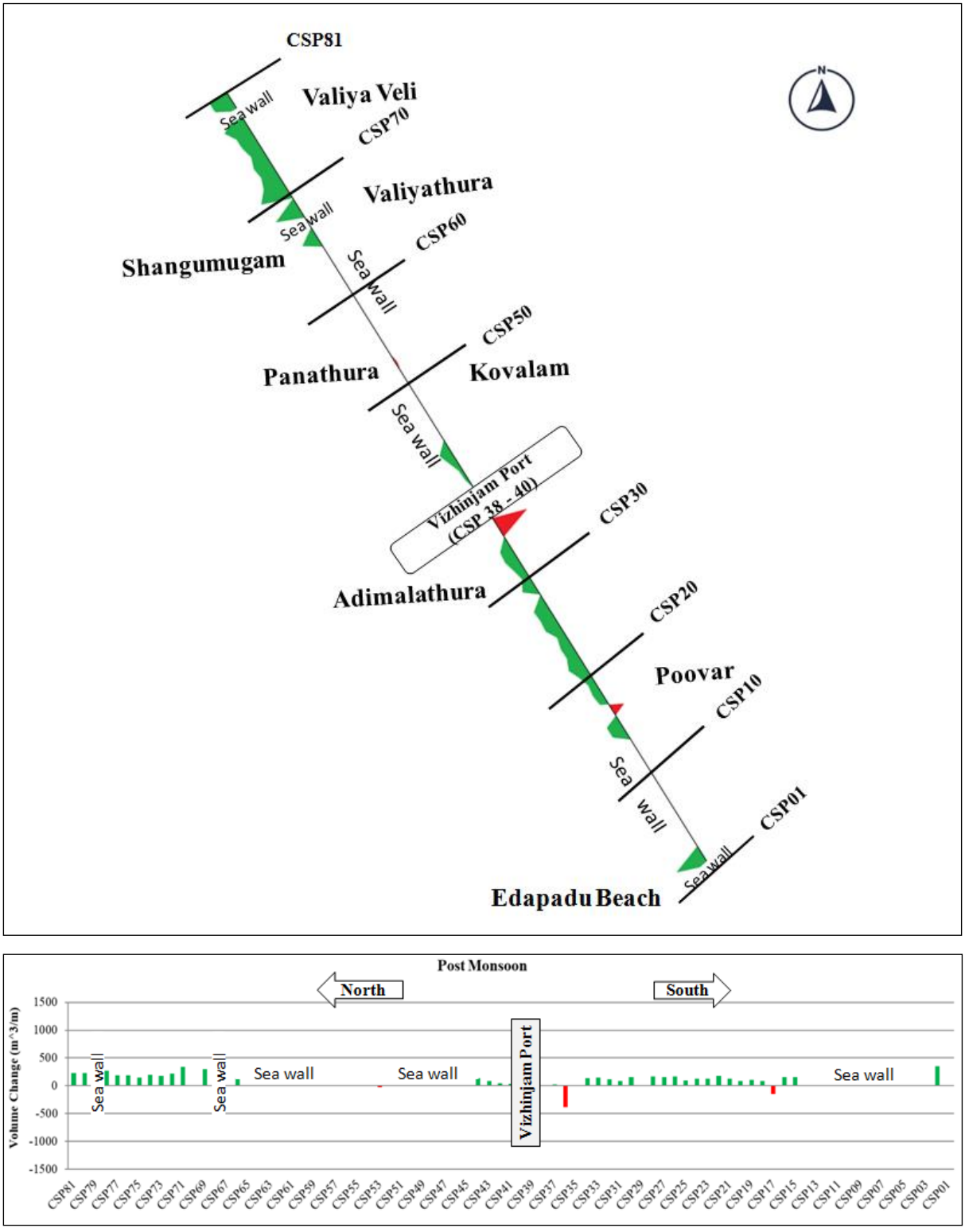
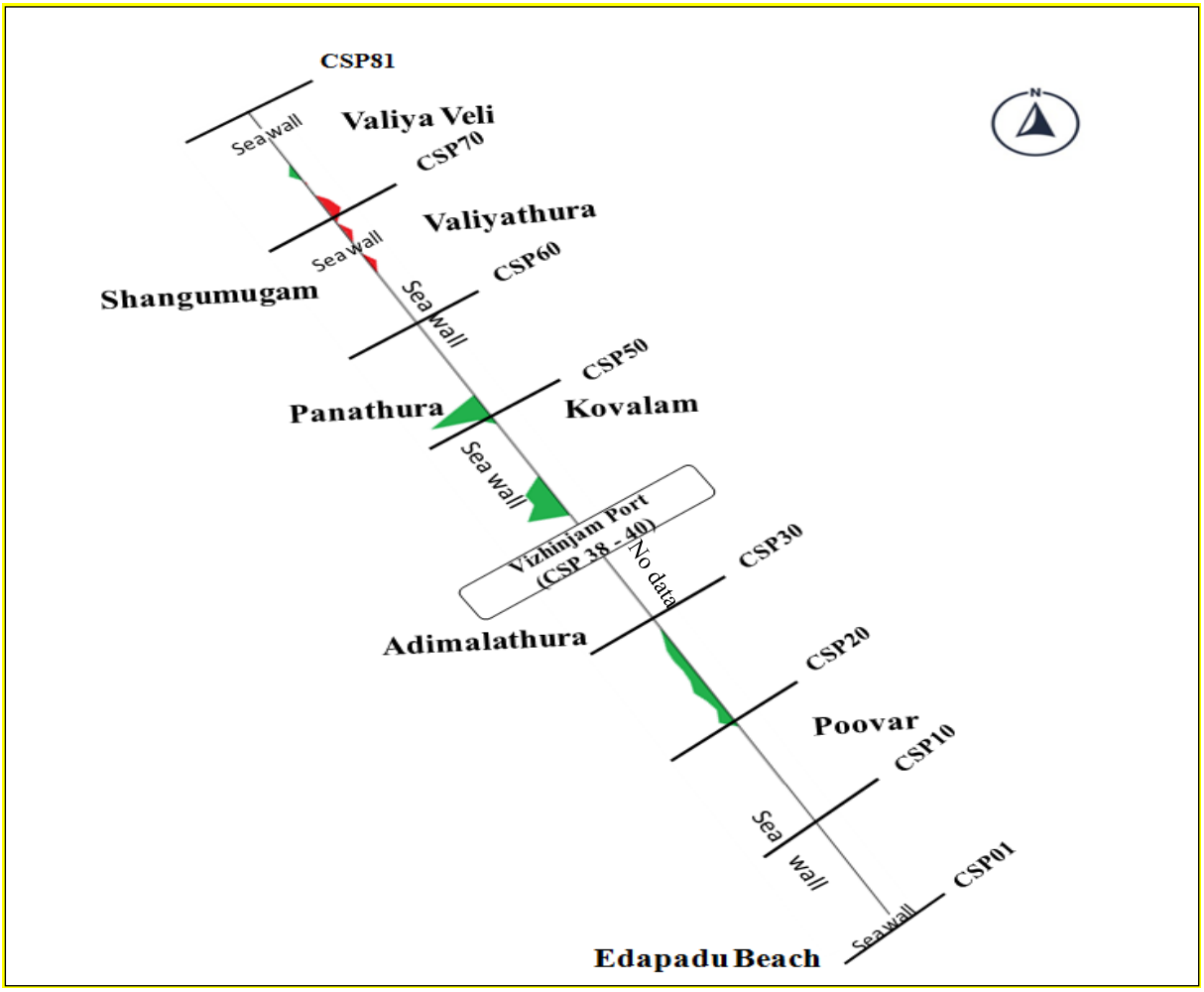


Figure 4.13 Seasonal Beach Volume Changes during Post Monsoon in m^3/m

4.1.2.2 *Results for Beach Volume Change in Fair Weather Period 2020 (December 2019-March 2020)*

During the fair weather period (Figure 4.14) the beach exhibits accretion for most of the locations. Erosions are noticed at Valliyathura to Shangumugham (CSP66-69),

Shangumugham (CSP71), Pannathura (CSP52), Kovalam (CSP44) and Karumkulam (CSP26). The beach on the southern part of the Port, between Poovar to Karumkulam shows accretion trend for both post monsoon and fair weather period.



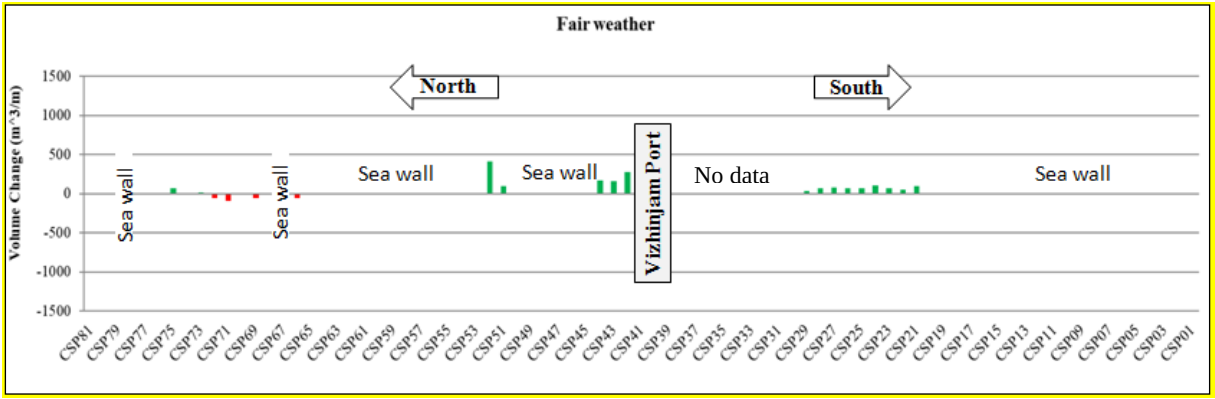


Figure 4.14 Seasonal Beach Volume Changes during Fair weather period in m^3/m

4.1.2.3 *Results for Beach Volume Change in Pre-Monsoon Period 2020 (April 2020-May 2020)*

Most of the locations underwent net erosion for the period of April 2020 to May 2020 (Figure 4.15). Significant erosion noticed at northern side of the port. Karumkulam (CSP26), and Kovalam (44) shows accretion.

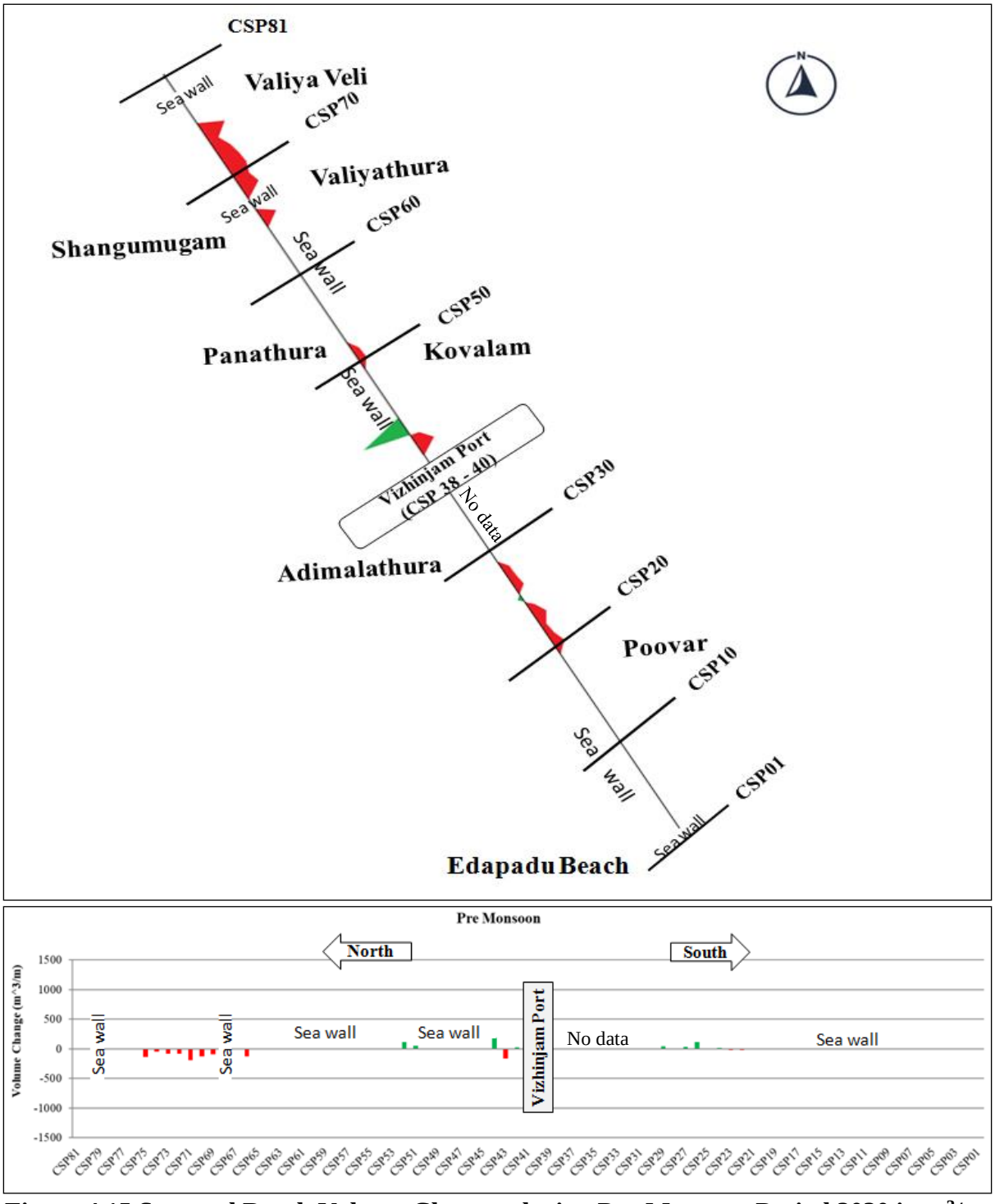


Figure 4.15 Seasonal Beach Volume Changes during Pre-Monsoon Period 2020 in m^3/m

4.1.2.4 *Results for Beach Volume Change in Monsoon Period 2020 (June 2020 -September 2020)*

During the monsoon period (Figure 4.16) the beach exhibits erosion for most of the locations and depositions are noticed at Mullur (CSP37), Kovalam (CSP42,43), Pannathura to Punthura (CSP51-53), Shangumugham (CSP71) and Kochuveli (CSP75).

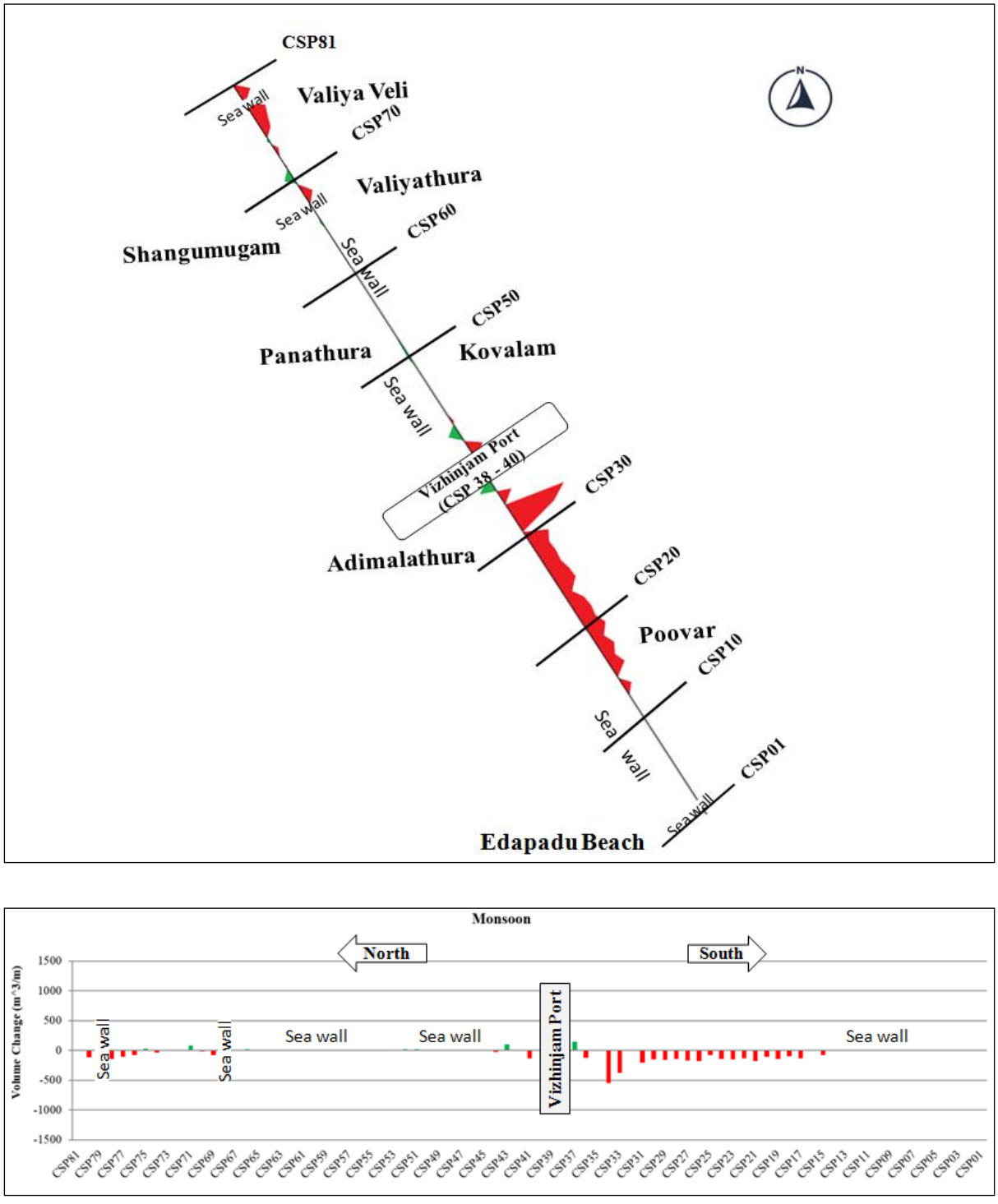


Figure 4.16 Seasonal Beach Volume Changes during Monsoon Period 2020 in m^3/m

4.1.3 Overall beach volume variation during October 2019 to September 2020

The overall beach volume change shows accretion all along the beach for this period.

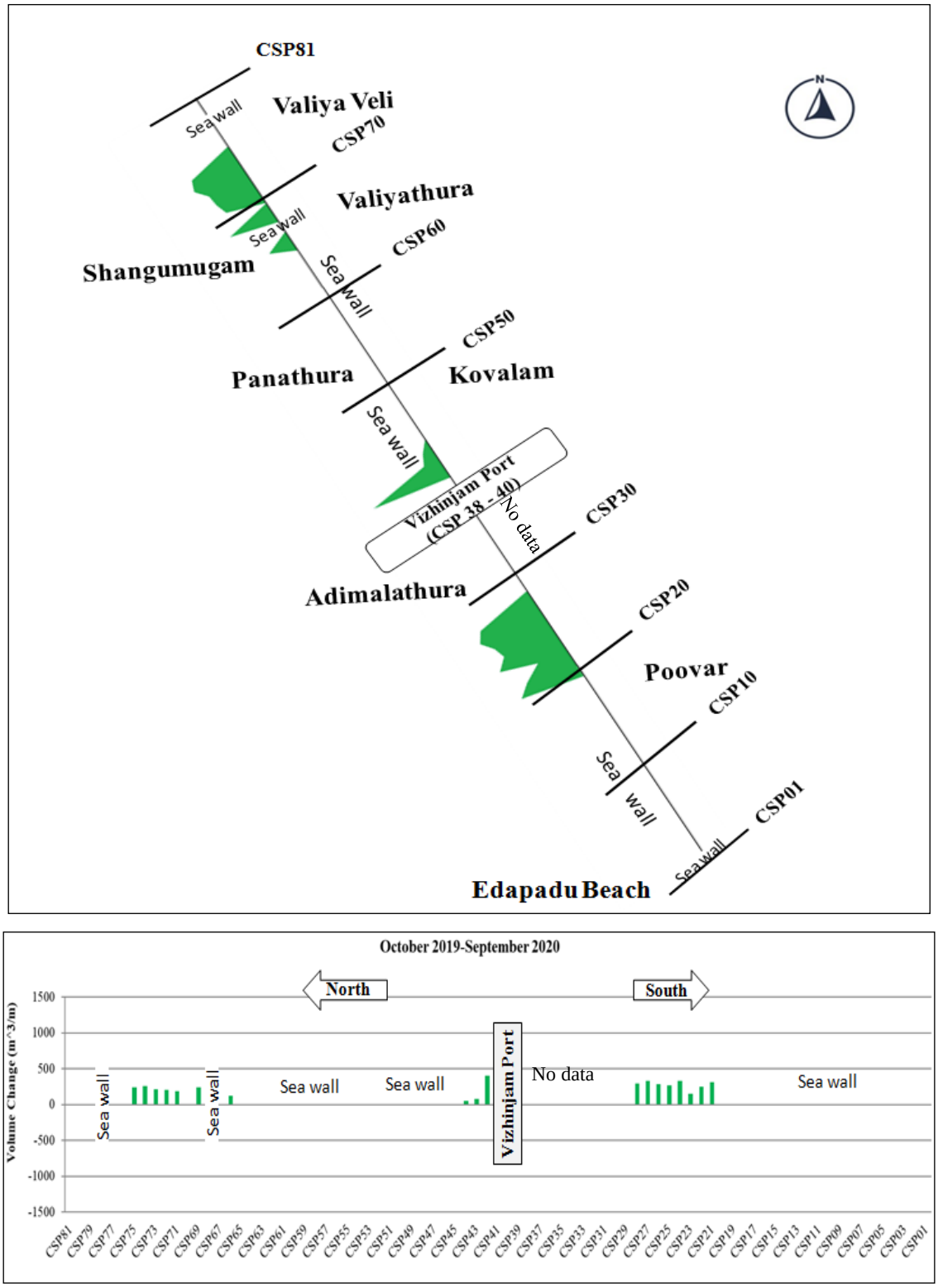


Figure 4.17 Overall Beach Volume Changes - October 2019 to September 2020 in m^3/m

Table 4.2 Seasonal and Overall Beach Volume Changes in m^3/m

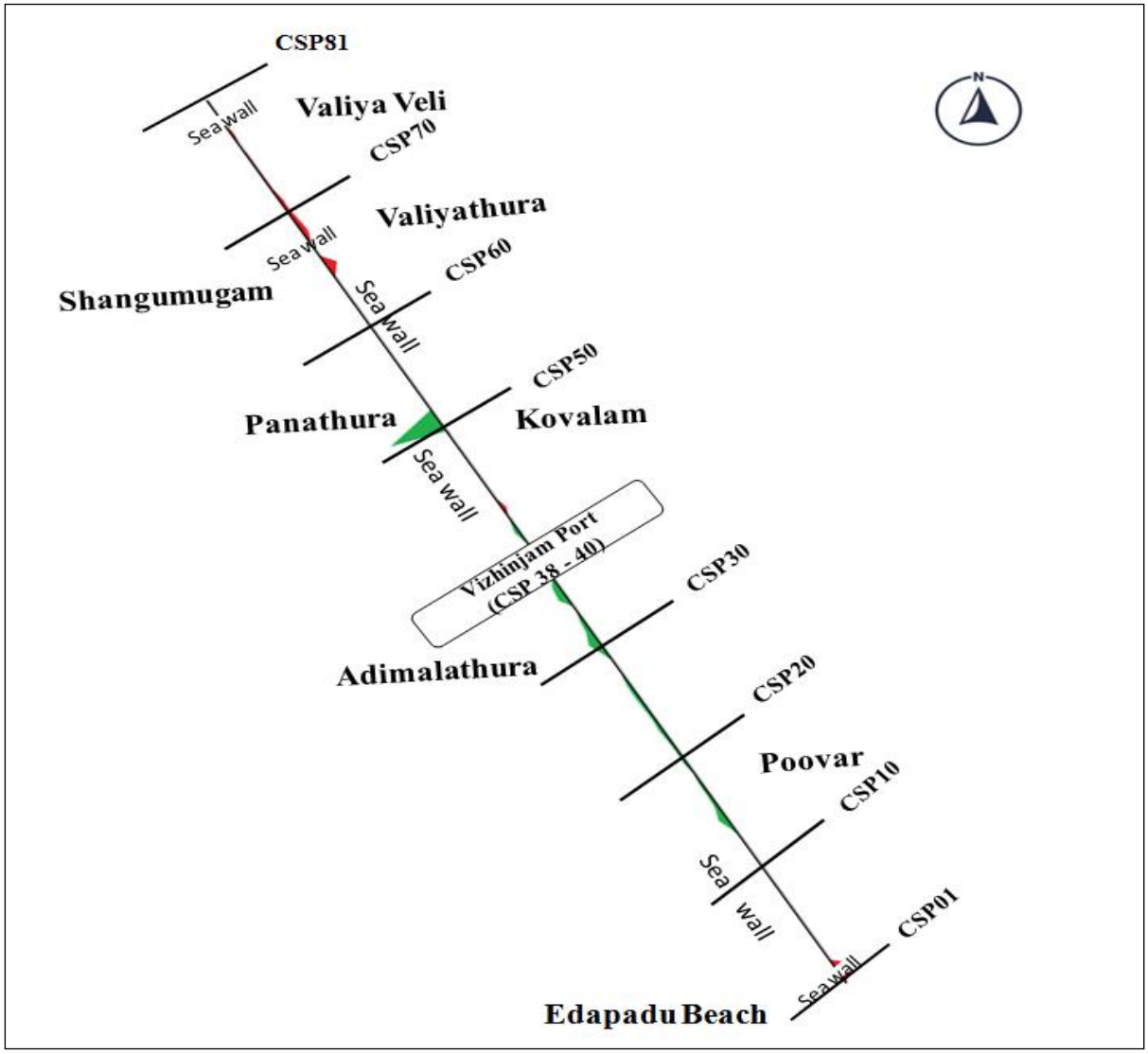
Location	Post Monsoon (October 2019 to November2019)	Fair weather (December 2019 to March 2020)	Pre-Monsoon (April 2020 to May 2020)	Monsoon (June2020-September 2020)	Overall (October 2019 to September 2019)
CSP01	**Sea wall**	No data due to COVID-19 restrictions			
CSP02	355.74				
CSP03	**Sea wall**				
CSP04					
CSP05					
CSP06					
CSP07					
CSP08					
CSP09					
CSP10					
CSP11		**No data/ Data not used***		**Sea wall**	**No data / Data not used***
CSP12					
CSP13					
CSP14					
CSP15	159.12			-80.771	
CSP16	158.81			**No data**	
CSP17	-154.26			-133.192	
CSP18	85.22			-94.7626	
CSP19	101.97			-146.089	
CSP20	83.02			-102.434	
CSP21	123.55	121.64	-88.18	-179.298	313.0438
CSP22	180.46	61.32	-56.45	-136.877	246.6236
CSP23	126.61	84.95	-45.18	-152.027	151.1342
CSP24	128.54	99.50	-100.94	-139.944	327.7466
CSP25	95.50	85.65	-54.09	-79.4032	268.981
CSP26	165.84	-24.18	36.83	-175.249	286.4938
CSP27	154.70	84.60	-74.33	-169.325	331.0743
CSP28	163.97	64.52	-63.14	-143.749	293.9844
CSP29	**No data***	39.87	-59.13	-156.064	313.0438
CSP30	155.71		5.73	-147.456	**No data/ Data not used***
CSP31	81.50	**No data/ Data not used***		-200.987	
CSP32	110.77			**No data**	
CSP33	144.50			-378.267	
CSP34	132.04			-544.142	
CSP35	**No data***			**No data**	
CSP36	-386.58			-123.705	
CSP37	21.10			147.0058	
CSP38	**Port Area**				
CSP39					
CSP40					
CSP41	33.52	**No data***		-130.706	**No data***
CSP42	40.85	297.02	-140.66	3.609144	397.828
CSP43	88.07	176.30	-68.86	102.9198	76.9234
CSP44	135.26	-214.24	357.12	-20.8239	48.09038
CSP45	**Sea wall**				
CSP46					
CSP47					
CSP48					
CSP49	**No data***	**Sea wall**			**No data/ Data not used***
CSP50					
CSP51		158.53	-61.06	20.40562	
CSP52		-1082.81	-54.84	17.31063	
CSP53	-25.11	**No data/ Data not used***		11.04655	
CSP54	**Sea wall**			-67.8162	
CSP55				-195.413	
CSP56	**Sea wall**				
CSP57					
CSP58	**Sea wall**				**No data***

CSP59	**Sea wall**				
CSP60					
CSP61					
CSP62					
CSP63					
CSP64					
CSP65					
CSP66	192.66	-52.41	-124.40	23.13934	126.3994
CSP67	**Sea wall**				
CSP68					
CSP69	304.51	-10.92	-139.75	-82.1229	240.1075
CSP70	**No data/ Data not used***		-114.46	-13.5925	**No data***
CSP71	336.51	-72.64	-144.15	87.33922	186.347
CSP72	222.42	0.13	-136.80	-5.79423	205.4277
CSP73	178.72	37.42	-117.07	4.959408	211.7716
CSP74	195.74	35.15	-74.87	-32.4925	259.8597
CSP75	150.62	133.45	-183.65	28.07147	238.1122
CSP76	182.42	**No data/ Data not used***		-76.4635	**No data/ Data not used***
CSP77	186.97			-107.329	
CSP78	263.96			-142.638	
CSP79	**Sea wall**			**Sea wall**	
CSP80	224.20			-111.642	
CSP81	227.62			-11.2102	

* indicates No data or data not used due to the depth to elevation difference and the difference in the distance between the onshore and offshore point is high.

4.1.4 Overall Beach volume variation during February 2015 and February 2020

This analysis has been carried out to identify and compare the beach volume variation before the commencement of port dredging process with the current scenario. The beach volume changes for February 2015 and February 2020 (Figure 4.18) shows accretion at Pannathura to Punthura (CSP52-53), Kovalam (CSP41-43), Mullur (CSP36,37), Adimalathura (CSP31-34) and Poovar to Pullavila (CSP15-29). Erosion noticed at Edapadu beach (CSP02), Azhimala (CSP35), Kovalam (CSP44), Pannathura (CSP51), Valliyathura (CSP66), Shangumugham to Valliyathura (CSP69-77) and Thumba (CSP80-81).



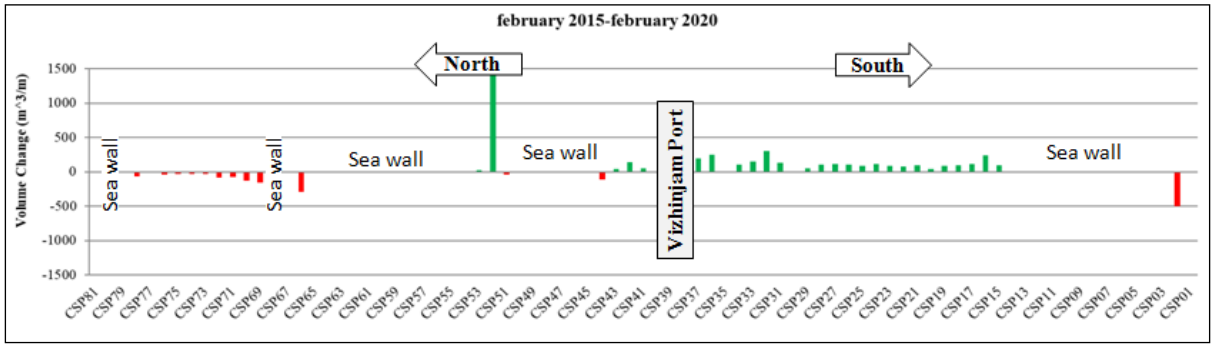


Figure 4.18 Beach Volume Changes - February 2015 and February 2020 in m^3/m

4.2 Results for Shoreline Change Analysis from Satellite images

In the previous submitted Annual report for the period October 2017 to September 2018, the result from the shoreline change analysis using high resolution satellite images carried out for 2000-2018 and annual variation for the year 2015-2016, 2016-2017, 2017-2018 has been presented. As a part of NGT direction, the shoreline change analysis has been carried out for the years 2000-2010, 2010-2018, 2000-2018 using high resolution LISS 4 (5m) and PAN (2.5m) images to study the changes before and after 2010. Further, the shoreline change analysis has been carried out for the years 2000-2005, 2005-2010, 2010-2015, 2015-2018 to study the immediate changes prior and after port commencement activity (December 2015). Similarly, in Annual report for the period October 2018-September 2019, monthly, seasonal, annual and inter annual shoreline changes and beach volume changes has been assessed and reported.

The spots of erosion listed from the above analysis using high resolution satellite images are Valliyathura (CSP63 to CSP67), Punthura (CSP53 to CSP57), Poovar to Edapadu (CSP01 to CSP09). Hence, in continuation with the earlier Annual report October 2017- September 2018 and Annual report October 2018 to September 2019, this annual report compiles the monthly, seasonal and overall shoreline change over the period from October 2019 to September 2020 using available high resolution satellite images.

4.2.1 Monthly Shoreline Change Analysis from October 2019 to September 2020

The monthly shoreline change analysis from October 2019 to September 2020carried out using available high resolution satellite images has been presented in the Figure 4.19 to 4.30 respectively.

- In October 2019, most of the transects indicates accretion, few transects of Kovalam and Mullur indicates erosion and stable coast at Thumba, Cheriyathura, Pannathura and Edapadu beach.
- The shoreline change analysis map of November 2019 shows accretion at Cheriyathura, Pannathura, Kovalam, Mullur to Poovar and Edapadu beach while erosion noted from Valliyathura to few transects of Punthura.
- The shoreline change analysis map of December 2019 shows that the accretion from Thumba to northern transects of Valliyathura, Adimalathura to Karumkulam while erosion

is noted at few transects of Valliyathura and Cheriyathura, Punthura to Pannathura, Mullur, and Poovar to Edapadu beach.

- Most of the transects indicate accretion, few transects of Thumba, Shangumugham and Pannathura indicates erosion, stable coast is seen at Karumkulam to Vallavilay for the month of January 2020.
- The shoreline change analysis map of February 2020 shows accretion at Vettucaud, and Karumkulam while erosion noted Kochuveli, Shangumugham, Valliyathura, Punthura, Adimalathura and Edapadu beach.
- The shoreline change analysis map of March 2020 shows stable coast except erosion at few transects of Cheriyathura, Punthura, Pullavila and accretion at Kochuveli, Shangumugham and Edapadu beach.
- Most of the transects indicates erosion at Kochuveli, Pannathura, Mullur to Poovar, Vallavilay and Edapadu beach while accretion at few transects of Vettucaud and Shangumugham, stable coast at few transects of Karumkulam, Poovar for the month of April 2020.
- The shoreline change analysis map of May 2020 shows accretion at Thumba, Vettucaud, Punthura, Kovalam, Mullur, Karumkulam, and Poovar while erosion noted at Shangumugham, Valliyathura, Pullavila, Vallavilay and Edapadu beach.
- The shoreline change analysis map of June 2020 shows that that the accretion from Vettucaud, Shangumugham, Valliyathura and Pannathura while erosion is noted at few transects of Thumba, Punthura and Poovar while stable at Cheriyathura, Mullur to Karumkulam beach.
- The monthly shoreline changes analysis (July 2020) shown in Figure 4.28, the erosion is noted along most of the coast except accretion at few transects of Shangumugham and Vallavilay for July 2020.
- The shoreline change analysis map of August 2020 (Figure 4.29) shows that the erosion is noted along most of the coast except the spots of accretion at few transects at Shangumugham, Pannathura, Karumkulam, and Poovar.
- The shoreline change analysis map of September 2020 (Figure 4.30) shows that the accretion is noted along Thumba, Vettucaud, Punthura, Pannathura, Adimalathura, Vallavilay, Edapadu beach except erosion at Valliyathura, Cheriyathura, southern transects of Shangumugham, Pannathura, Mullur and Karumkulam.

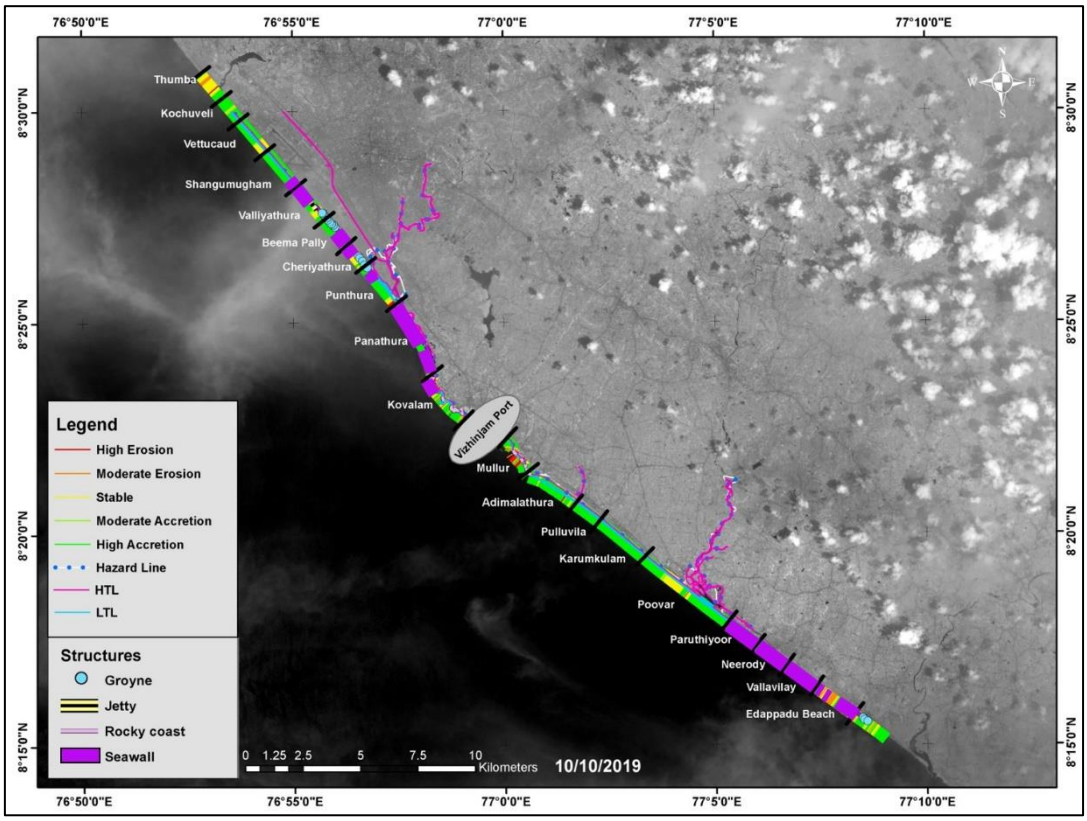


Figure 4.19 Shoreline Change Map -October 2019

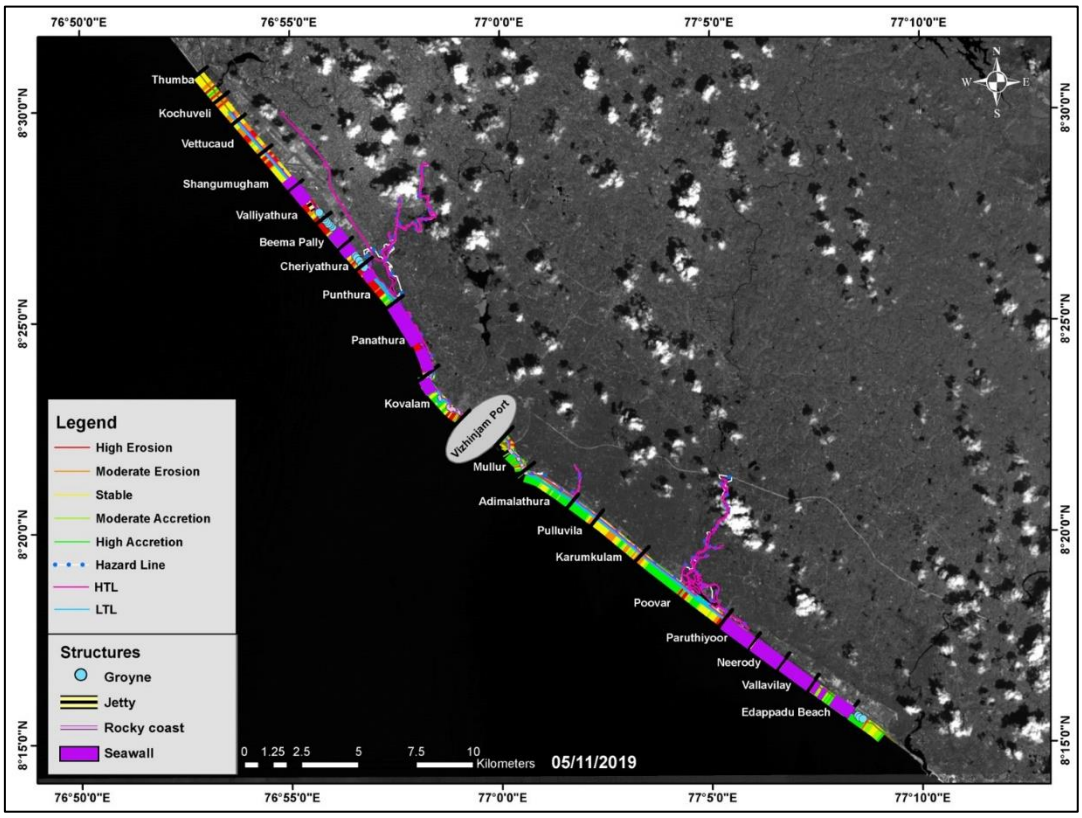


Figure 4.20 Shoreline Change Map - November 2019

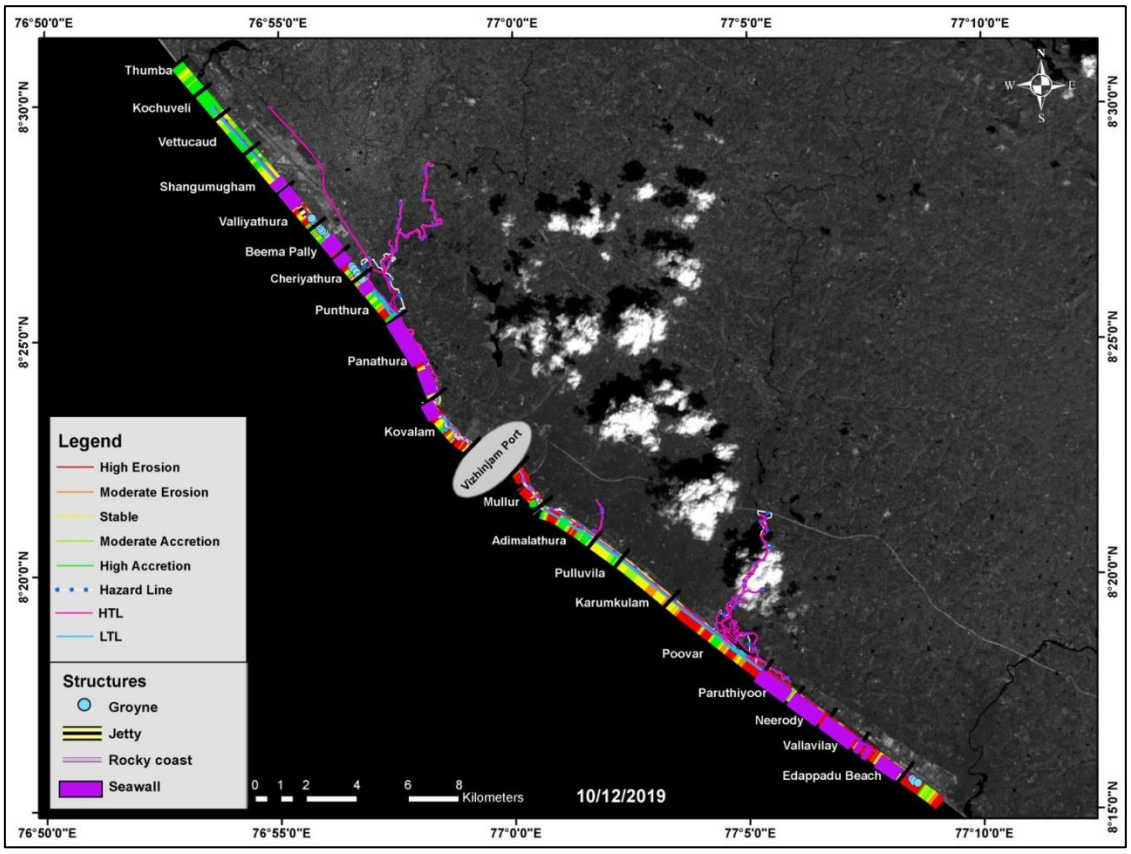


Figure 4.21 Shoreline Change Map - December 2019

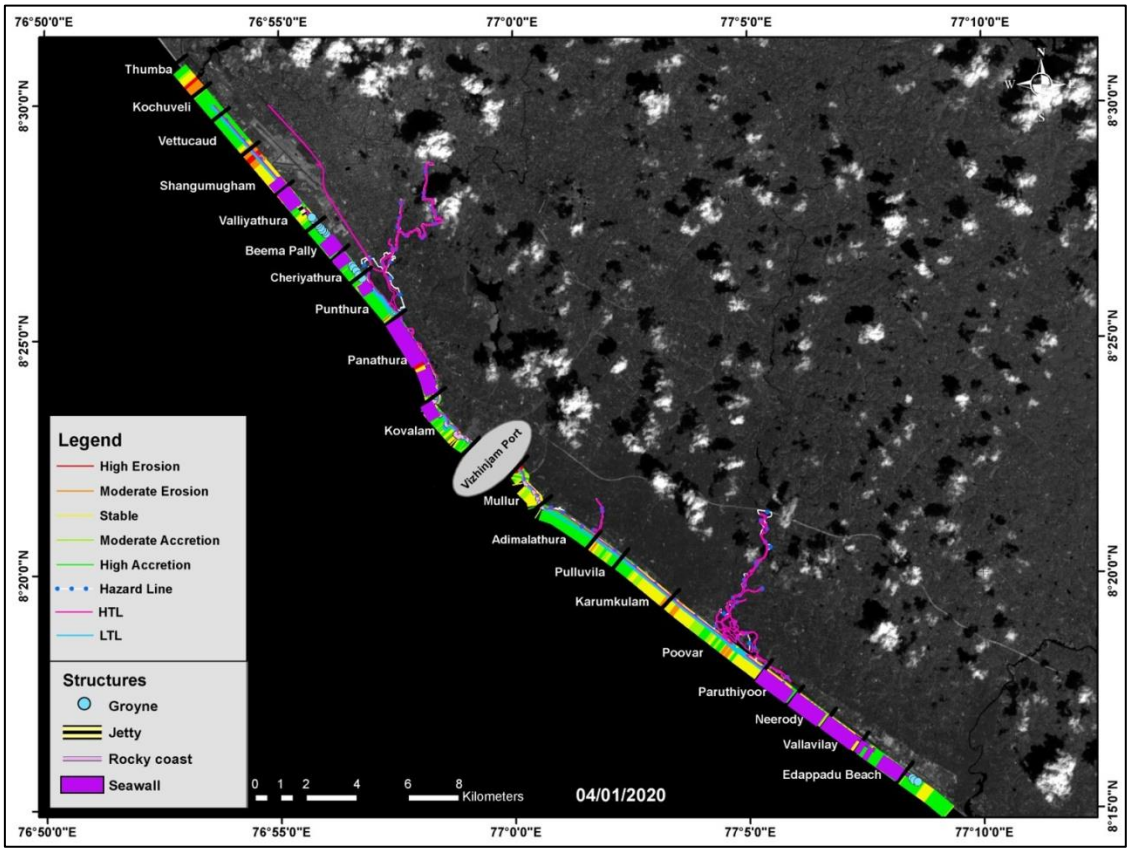


Figure 4.22 Shoreline Change Map -January 2020

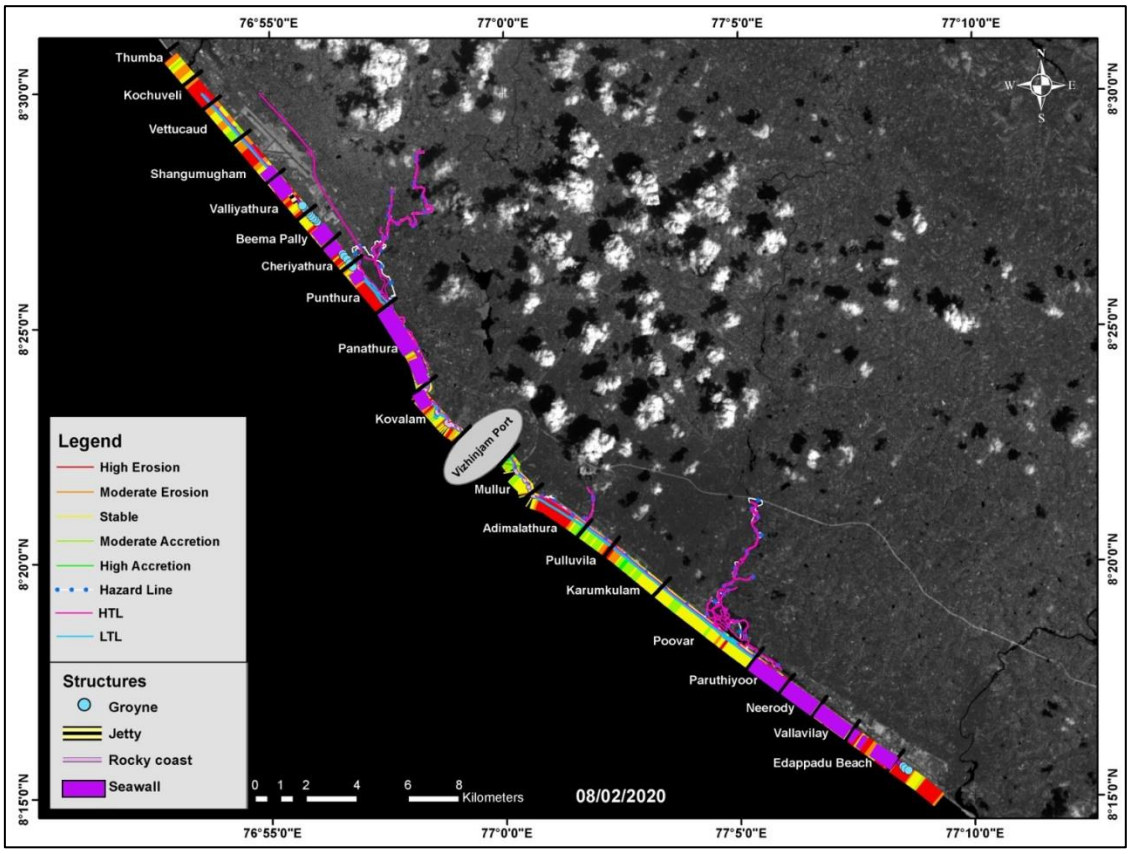


Figure 4.23 Shoreline Change Map - February 2020

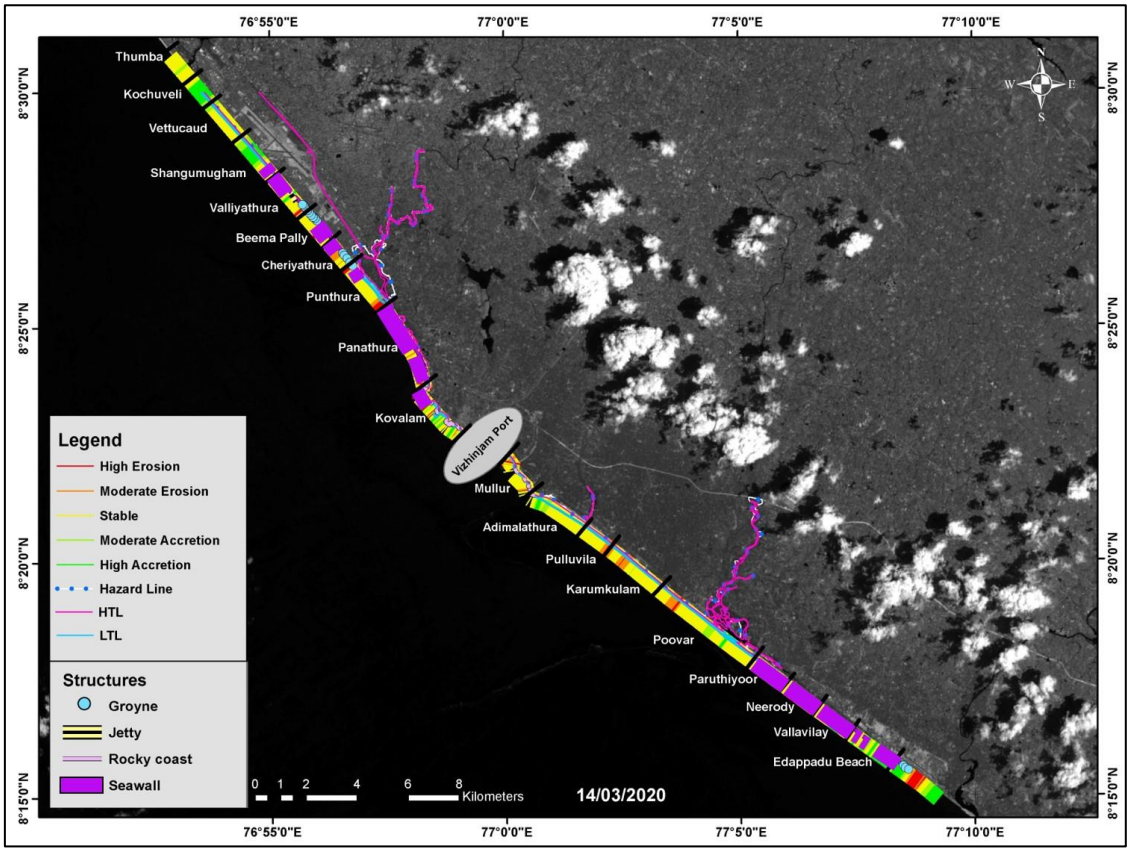


Figure 4.24 Shoreline Change Map -March 2020

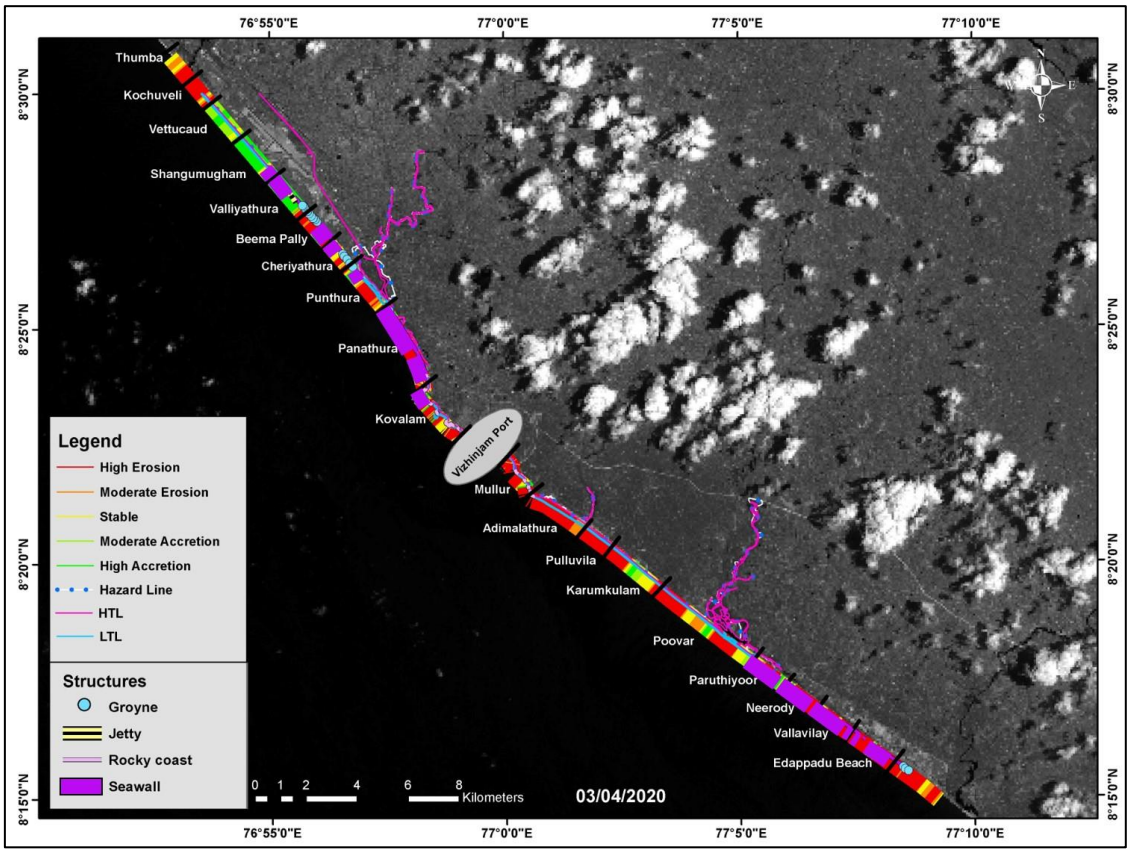


Figure 4.25 Shoreline Change Map -April 2020

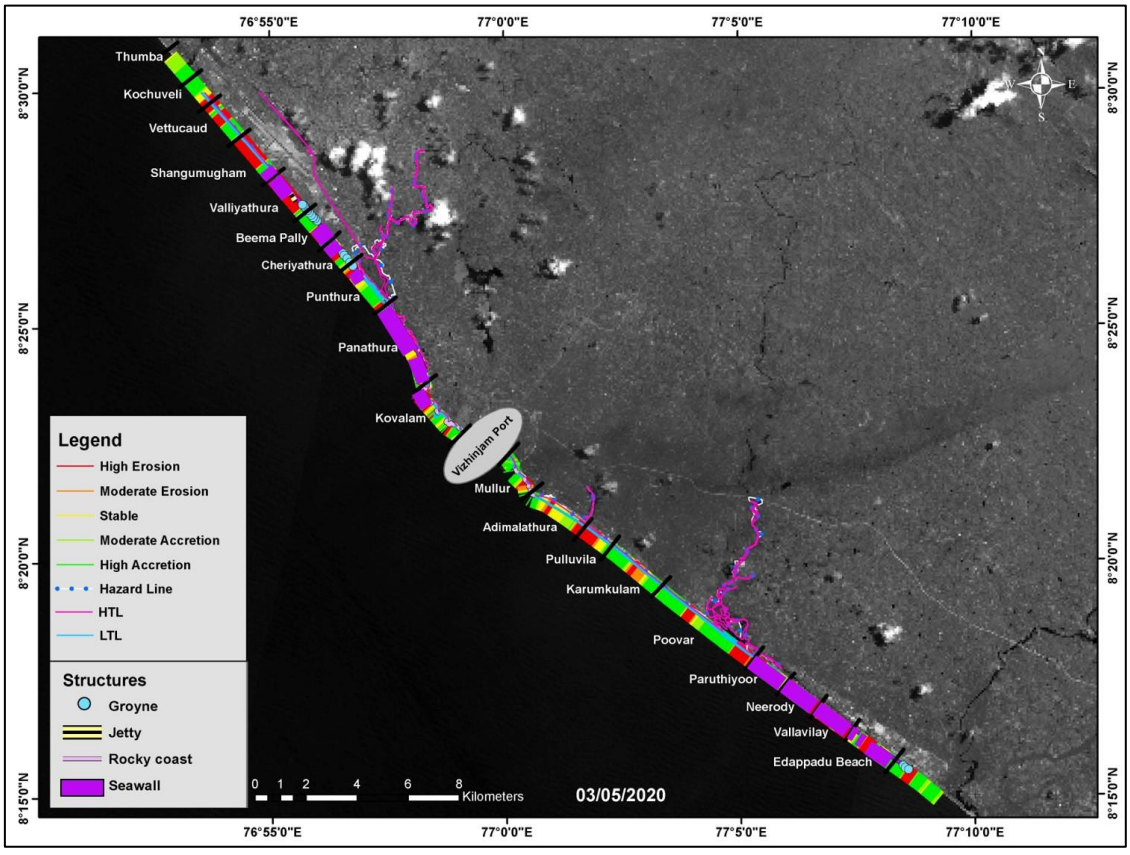


Figure 4.26 Shoreline Change Map - May 2020

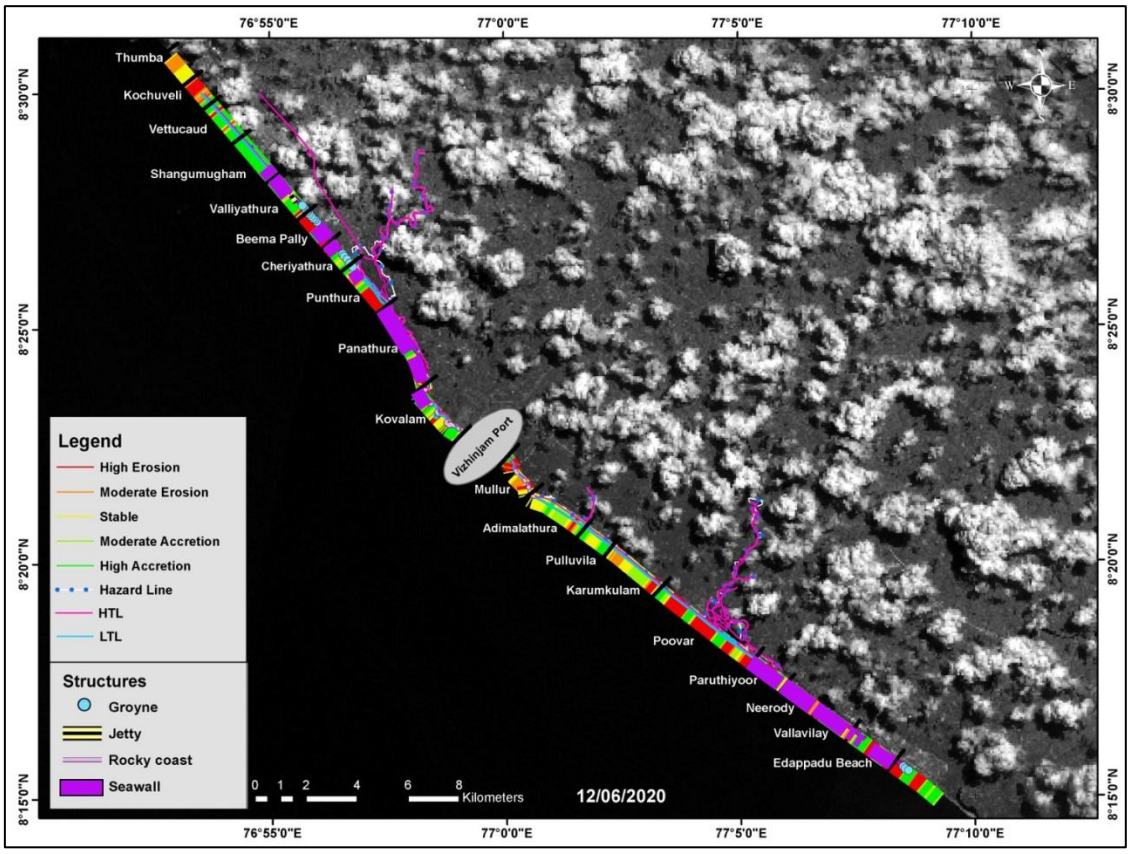


Figure 4.27 Shoreline Change Map - June 2020

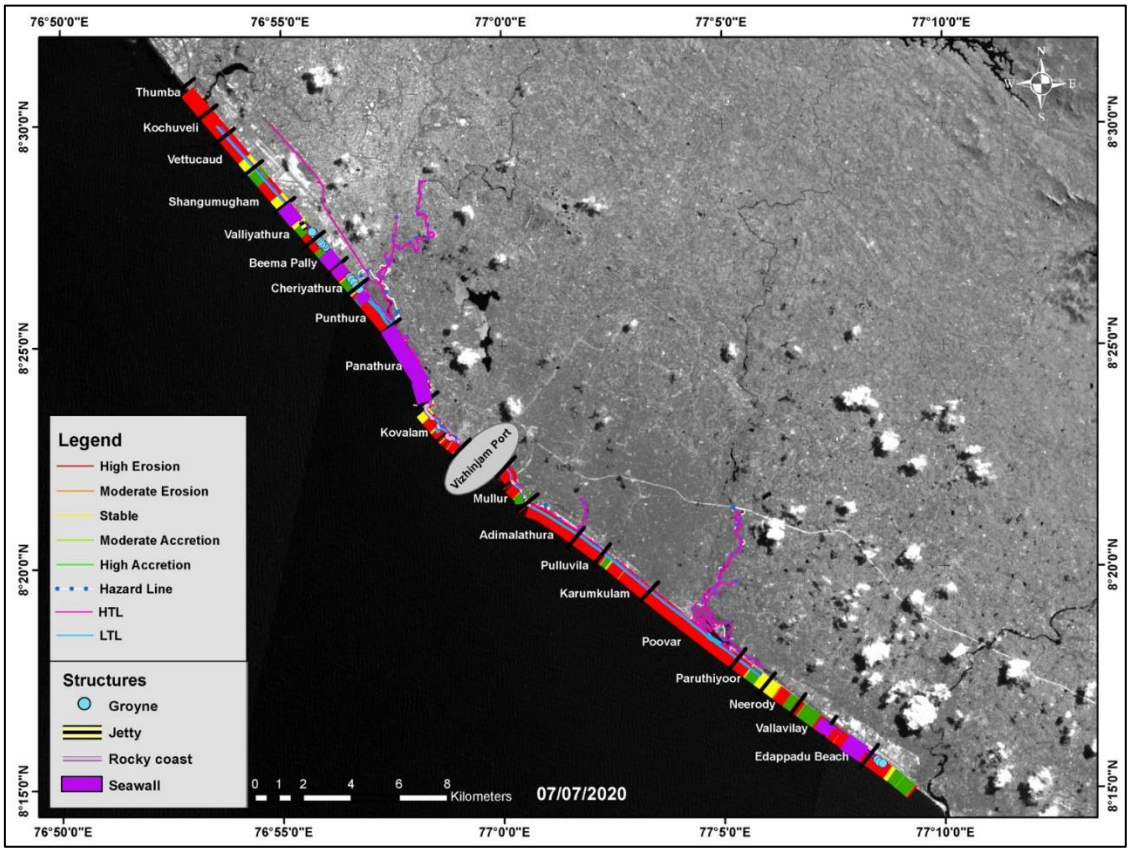


Figure 4.28 Shoreline Change Map –July 2020

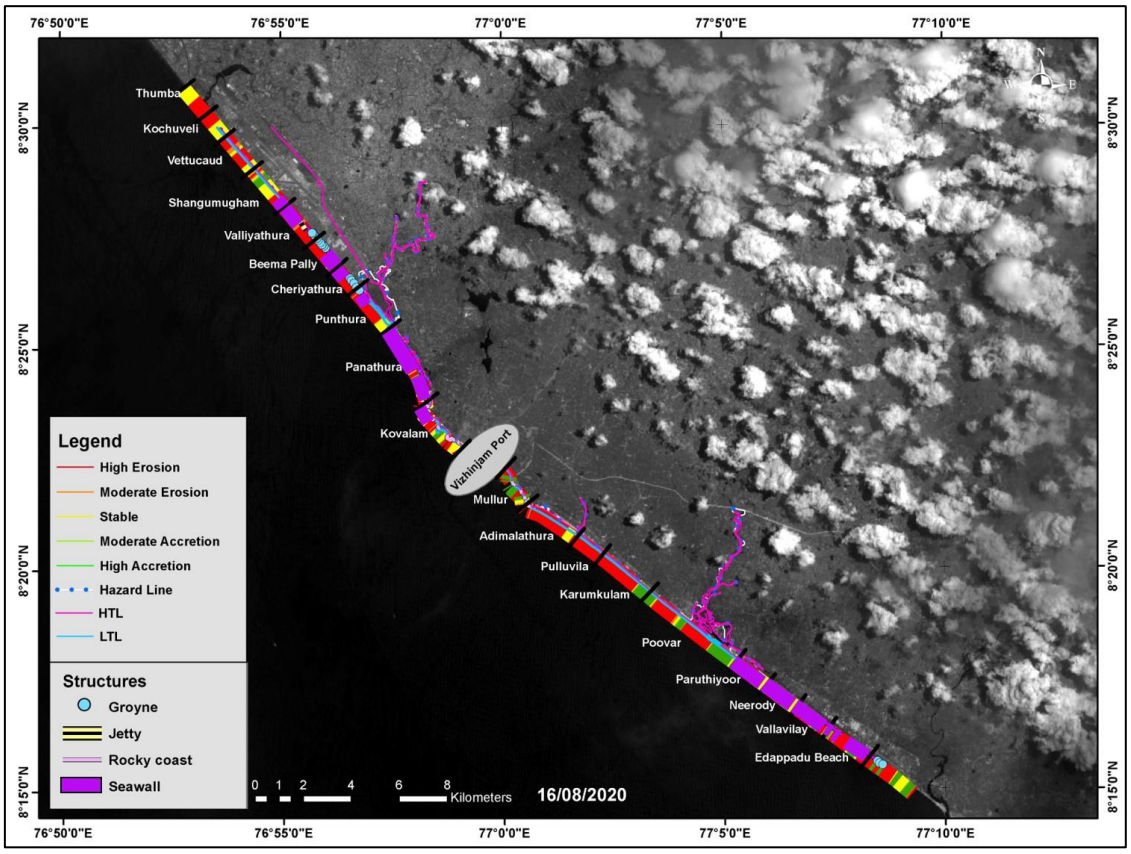


Figure 4.29 Shoreline Change Map - August 2020

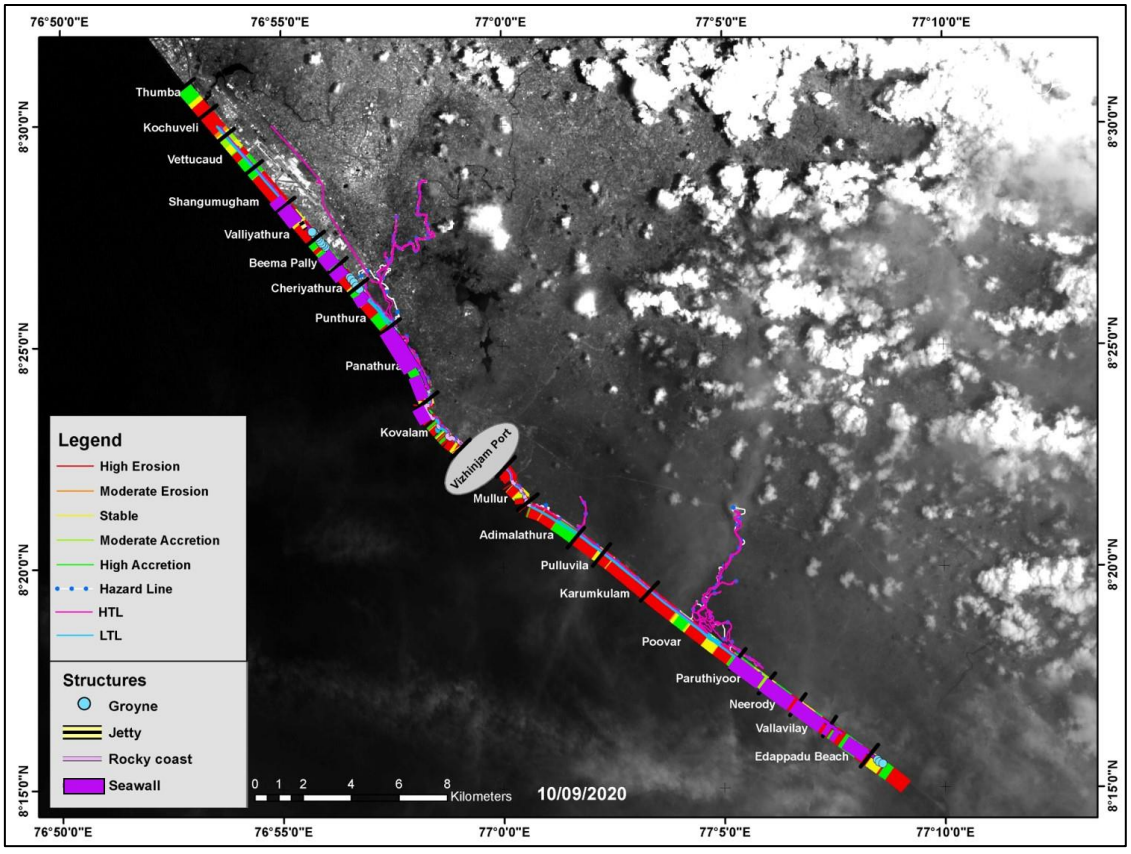


Figure 4.30 Shoreline Change Map - September 2020

4.2.2 Seasonal Shoreline Change from October 2019 to September 2020

As suggested by the shoreline and expert committee meeting held during 12th and 13th February 2019, the seasonal pattern has been followed in this report as Post monsoon (October-November 2018) Fair weather period (December 2018-March 2019), Pre-monsoon (April-May 2019) and Monsoon (June – September 2019).

4.2.2.1 *Results for Shoreline Change in Post Monsoon 2019 (October-November 2019)*

The seasonal shoreline change analysis for the post monsoon period 2019 is shown in Figure 4.31. The post monsoon period (October 2019 to November 2019) indicates accretion at Cheriyathura, Pannathura, Kovalam, Mullur to Poovar and Edapadu beach while erosion noted from Valliyathura to few transects of Punthura.

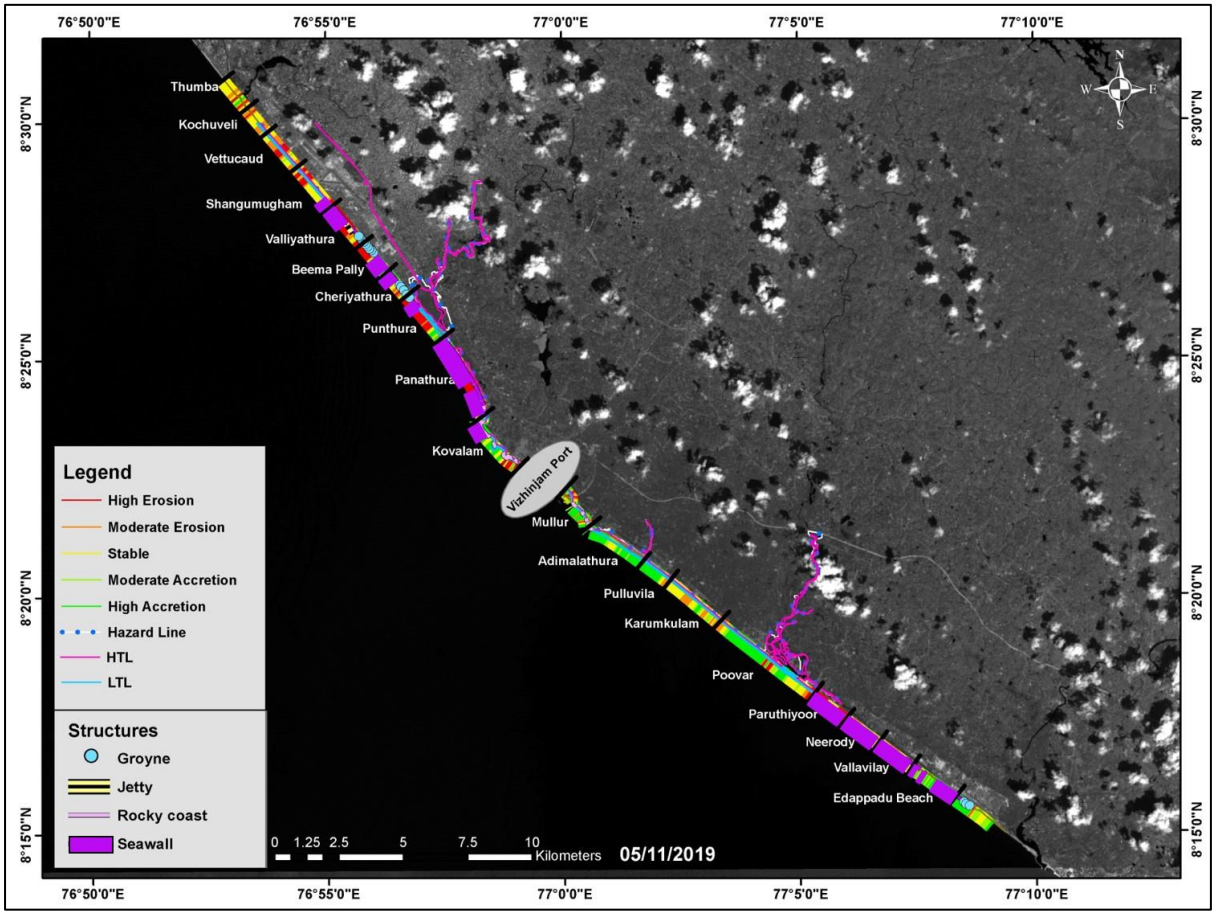


Figure 4.31 Shoreline Change Map –Post Monsoon 2019

4.2.2.2 *Results for Shoreline Change in Fair Weather Period 2020 (December 2019-March 2020)*

The seasonal shoreline change analysis for the fair weather period 2019 is shown in Figure 4.32. The fair weather period (December 2018 to March 2019) indicates at most of the stretches while erosion is noticed at few transects of Thumba, Shangumugham, Valliyathura, Cheriyathura, Pannathura, Karumkulam and Poovar.

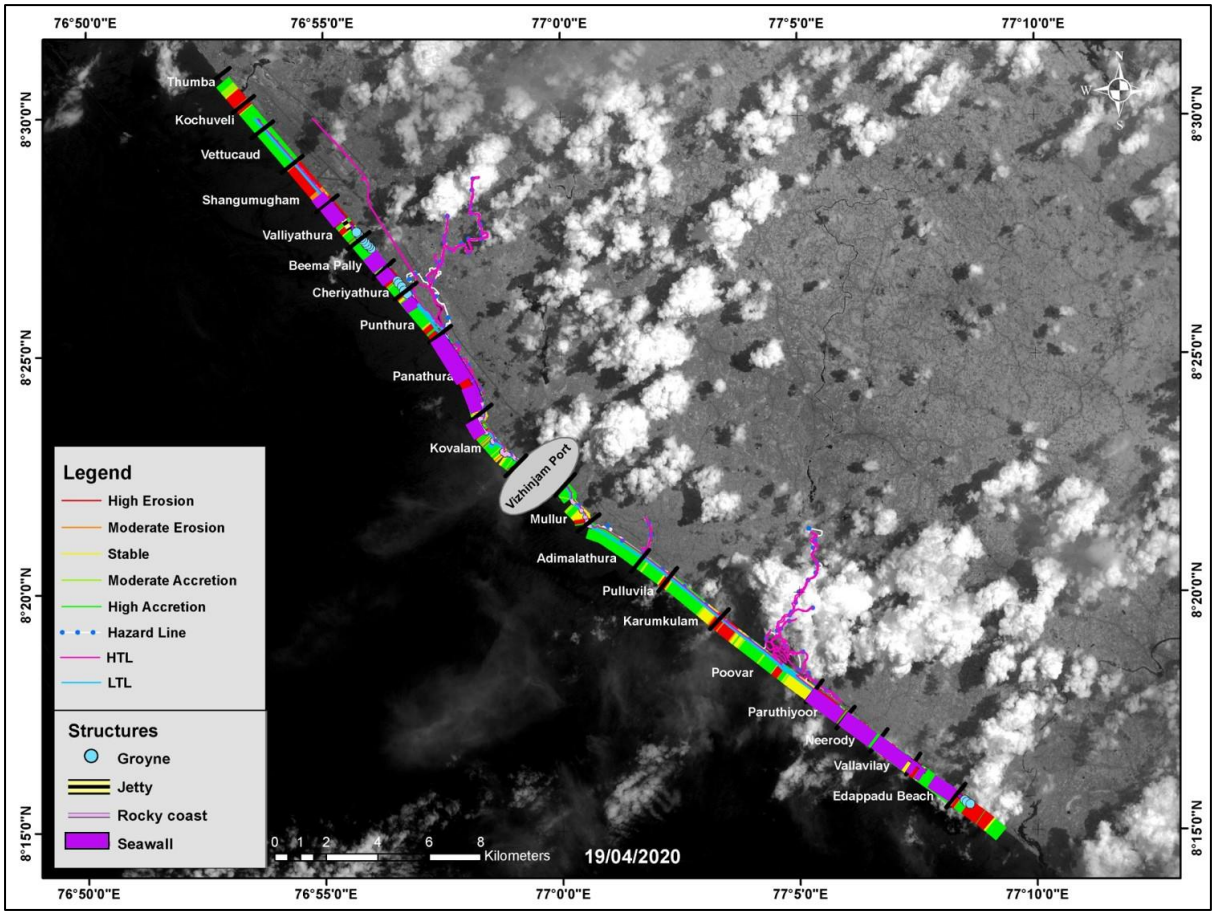


Figure 4.32 Shoreline Change Map –Fair Weather Period2019

4.2.2.3 *Results for Shoreline Change in Pre-Monsoon Period 2020 (April 2020-May 2020)*

The seasonal shoreline change analysis for the pre-monsoon period 2020 is shown in Figure 4.33. The pre-monsoon period (April 2020 to May 2020) indicates accretion at Thumba, Vettucaud, Punthura, Kovalam, Mullur, Karumkulam, and Poovar while erosion noted at Shangumugham, Valliyathura, Pullavila, Vallavilay and Edapadu beach.

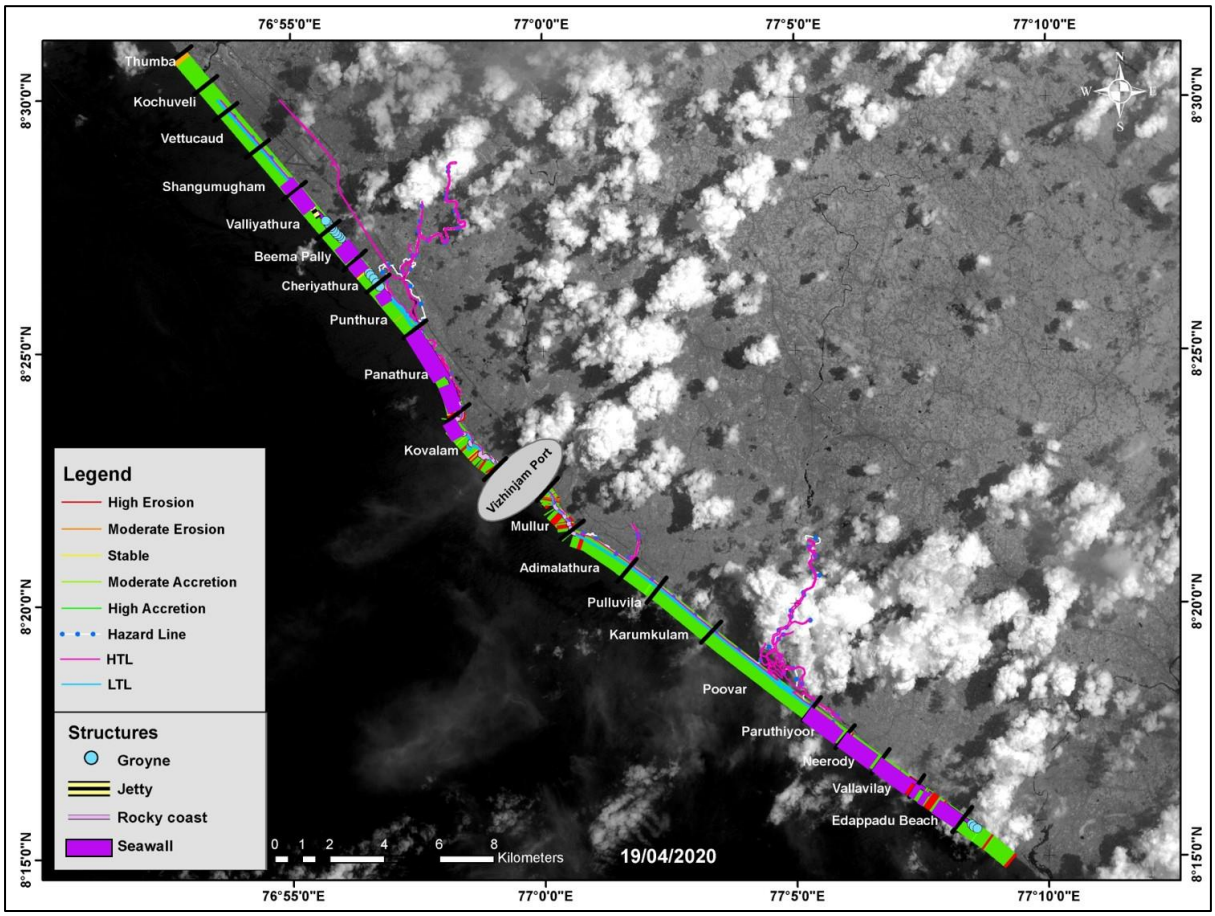


Figure 4.33 Shoreline Change Map –Pre-Monsoon Period 2019

4.2.2.4 *Results for Shoreline Change in Monsoon Period 2020 (June 2020-September 2020)*

The seasonal shoreline change analysis for the monsoon period 2019 is shown in Figure 4.34. The monsoon period (June 2019 to September 2019) erosion along the coast except accretion few transects at Shangumugham, Mullur and Vallavilay.

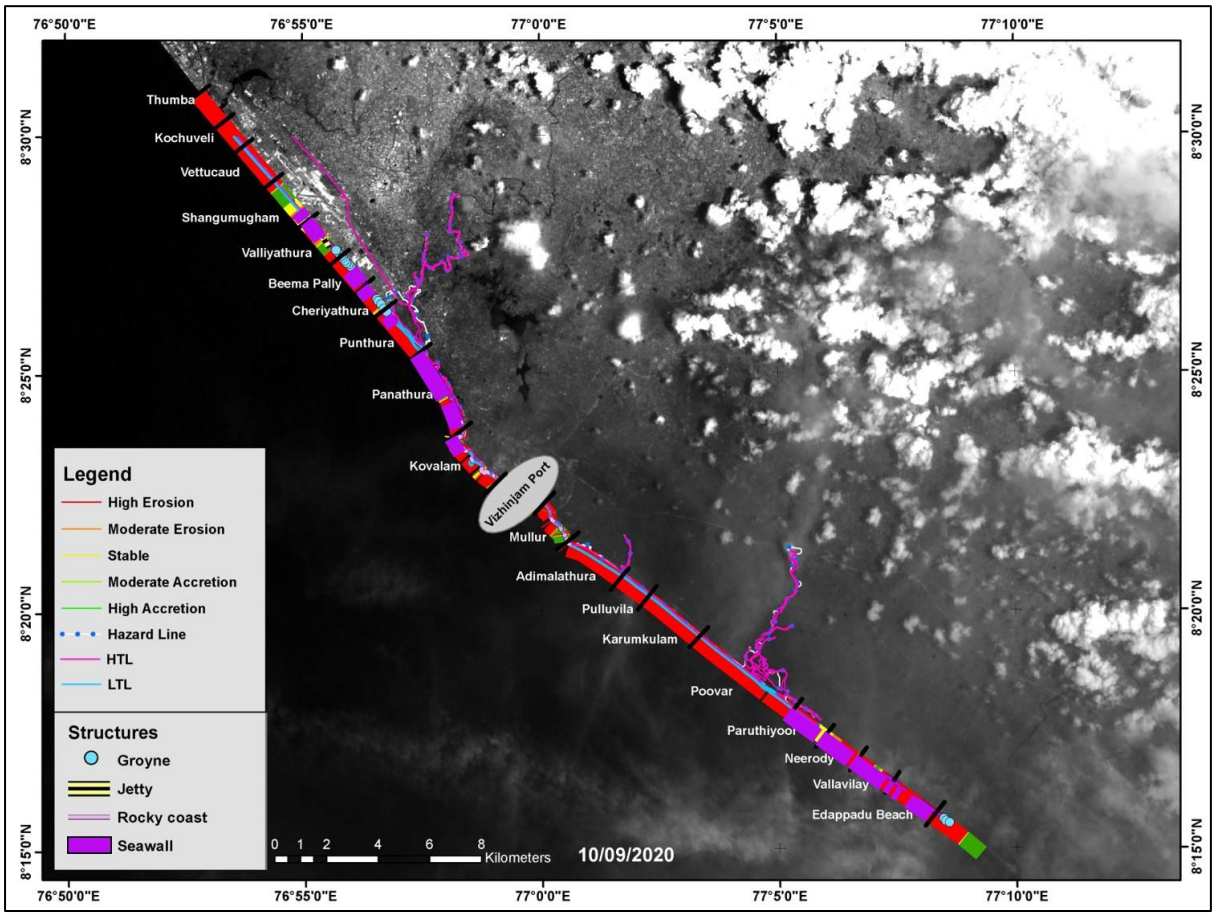


Figure 4.34 Shoreline Change Map –Monsoon Period 2020

4.2.3 Overall Shoreline Change from October 2019 to September 2020

Using high resolution satellite images (5m and 10m spatial resolution), the result has been processed for the period October 2019 to September 2020. Figure 4.35 shows the shoreline change map from October 2019 to September 2020. High erosion is noticed at Thumba to Valliyathura, Punthura, and Karumkulam to Edapadu beach and accretion at Cheriyathura, Pannathura, Kovalam, Mullur to Pullavila and south of Edapadu beach.

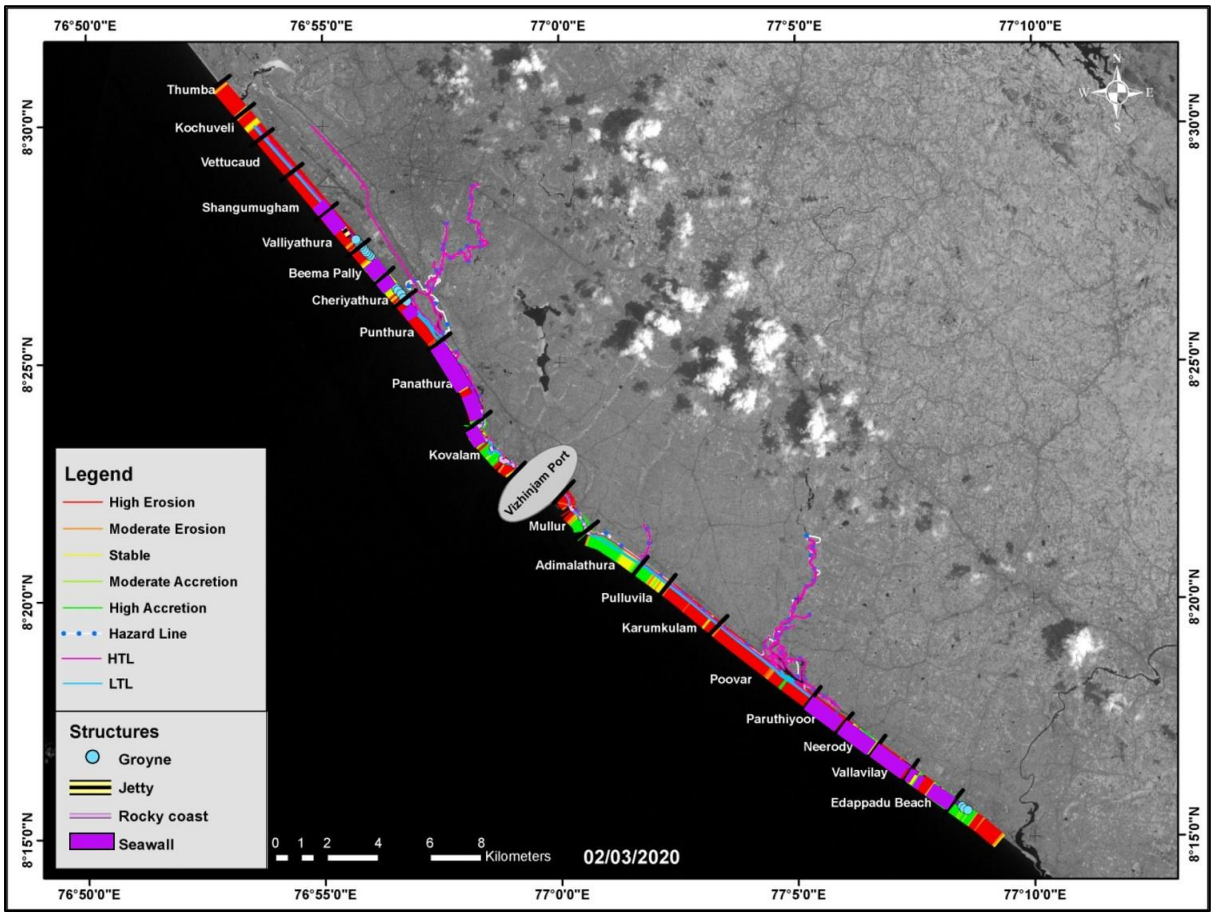


Figure 4.35 Overall Shoreline Change Map October 2019 to September 2020

4.2.4 Seasonal Shoreline Change comparison between 2018-2019 and 2019-2020

October 2018 and October 2019 (Post Monsoon period)

Using Resourcesat 2A-LISS4 and Sentinel 2A/2B-MSI satellite images (5m and 10m spatial resolution), the shoreline change has been compared between the October 2018 and October 2019 shorelines. Figure 4.36 shows the shoreline change map for October 2018 and October 2019. Accretion is noticed at Vettucaud, Valliyathura, Punthura, Pannathura, and Mullur to Vallavilay while erosion is noticed at Kochuveli, Shangumugham beach and Edapadu beach for the period October 2018 and October 2019.

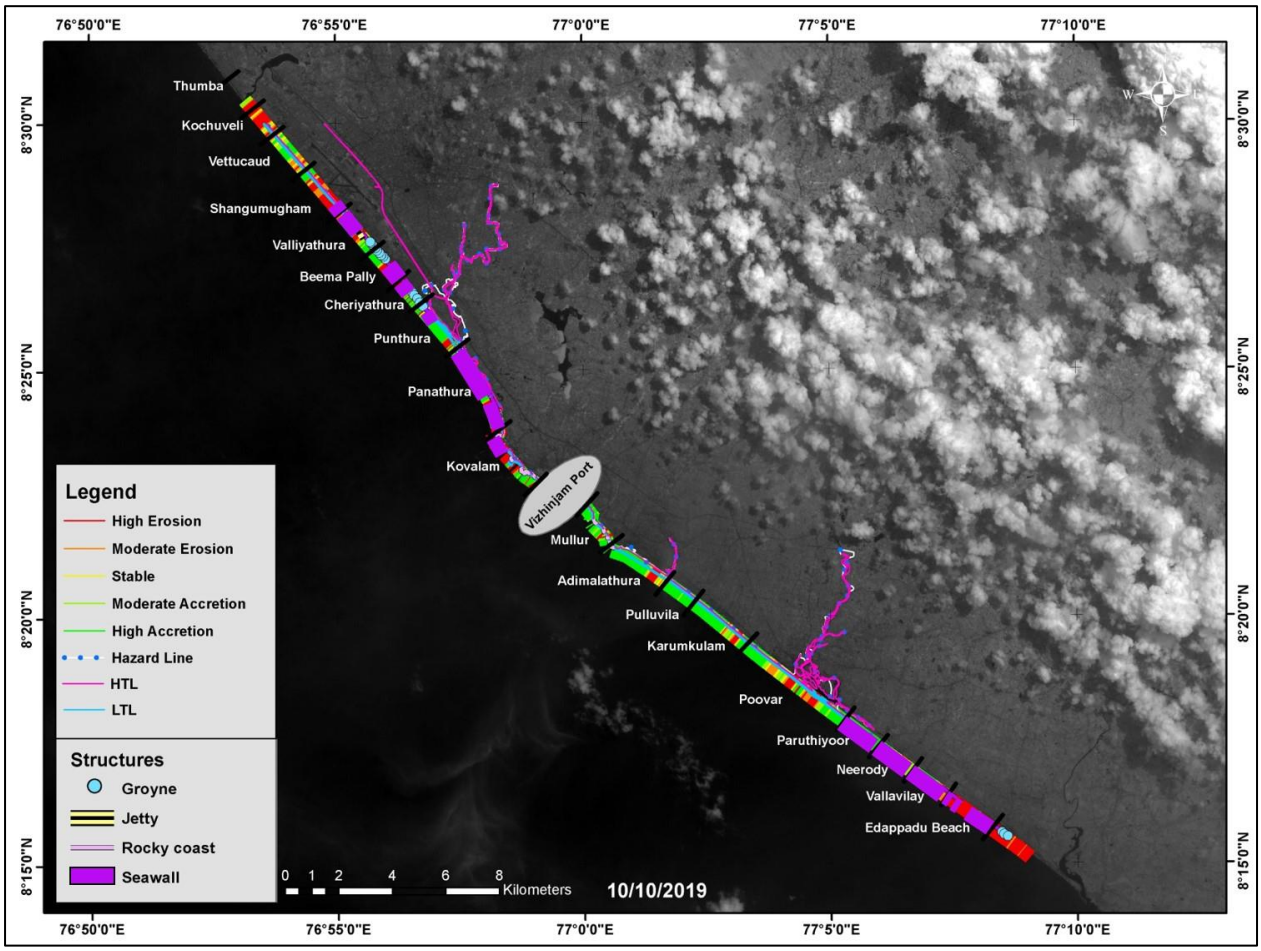


Figure 4.36 Shoreline Change Map October 2018 and October 2019

January 2019 and January 2020 (Fair weather period)

The shoreline change has been compared between the January 2019 and January 2020 shorelines using Sentinel 2A/2B-MSI satellite images (10m spatial resolution). Figure 4.37 shows the shoreline change map for January 2019 and January 2020. Accretion is noticed at Vettucaud, Shangumugham beach, Pannathura, Kovalam, Mullur and Edapadu beach while erosion is noticed at Valliyathura, Punthura, Adimalathura and Pullavila for the comparison of shorelines between January 2019 and January 2020.

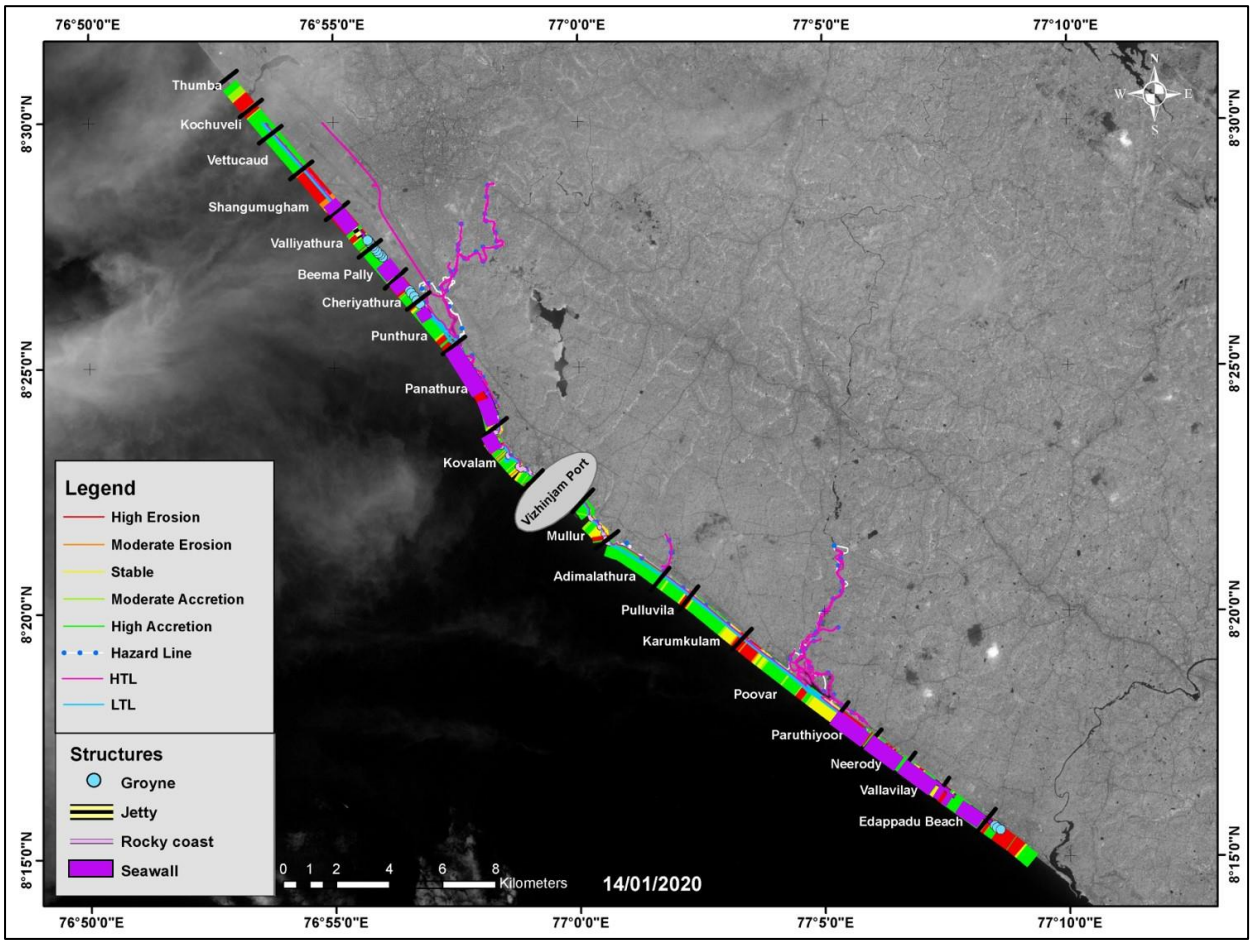


Figure 4.37 Shoreline Change Map January 2019 and January 2020

April 2019 and April 2020 (Pre-Monsoon period)

The shoreline change has been compared between the April 2019 and April 2020 shorelines using Sentinel 2A/2B-MSI satellite images (10m spatial resolution) and LISS4 satellite images (5m spatial resolution). Figure 4.38 shows the shoreline change map for April 2019 and April 2020. Accretion is noticed at Vettucaud, Shangumugham beach, Pannathura, Kovalam while erosion is noticed at Kochuveli, few transects of Valliyathura, Cheriyathura, Punthura, Adimalathura, Mullur to Poovar and Edapadu beach for the comparison of shorelines April 2019 and April 2020.

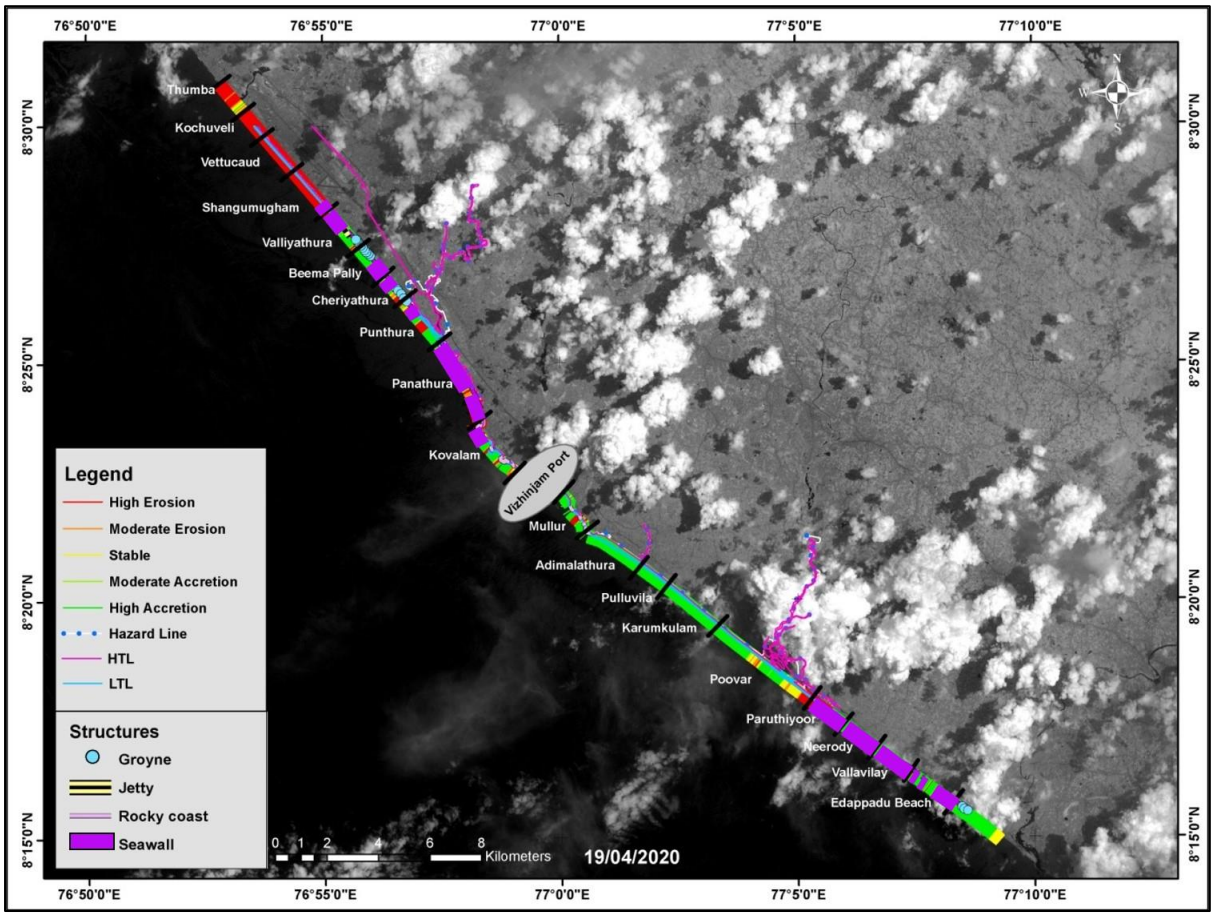


Figure 4.38 Shoreline Change Map April 2019 and April 2020

September 2019 and September 2020 (Monsoon period)

The result has been processed for the period September 2019 to September 2020. Figure 4.39 shows the shoreline change map from September 2019 to September 2020. High erosion is noticed at Thumba to Shangumugham, Valliyathura, Punthura, Adimalathura, and Pullavila, Poovar and Edapadu beach and accretion at Cheriyathura, Pannathura, Kovalam, Mullur, Karumkulam, Vallavilay and Adimalathura.

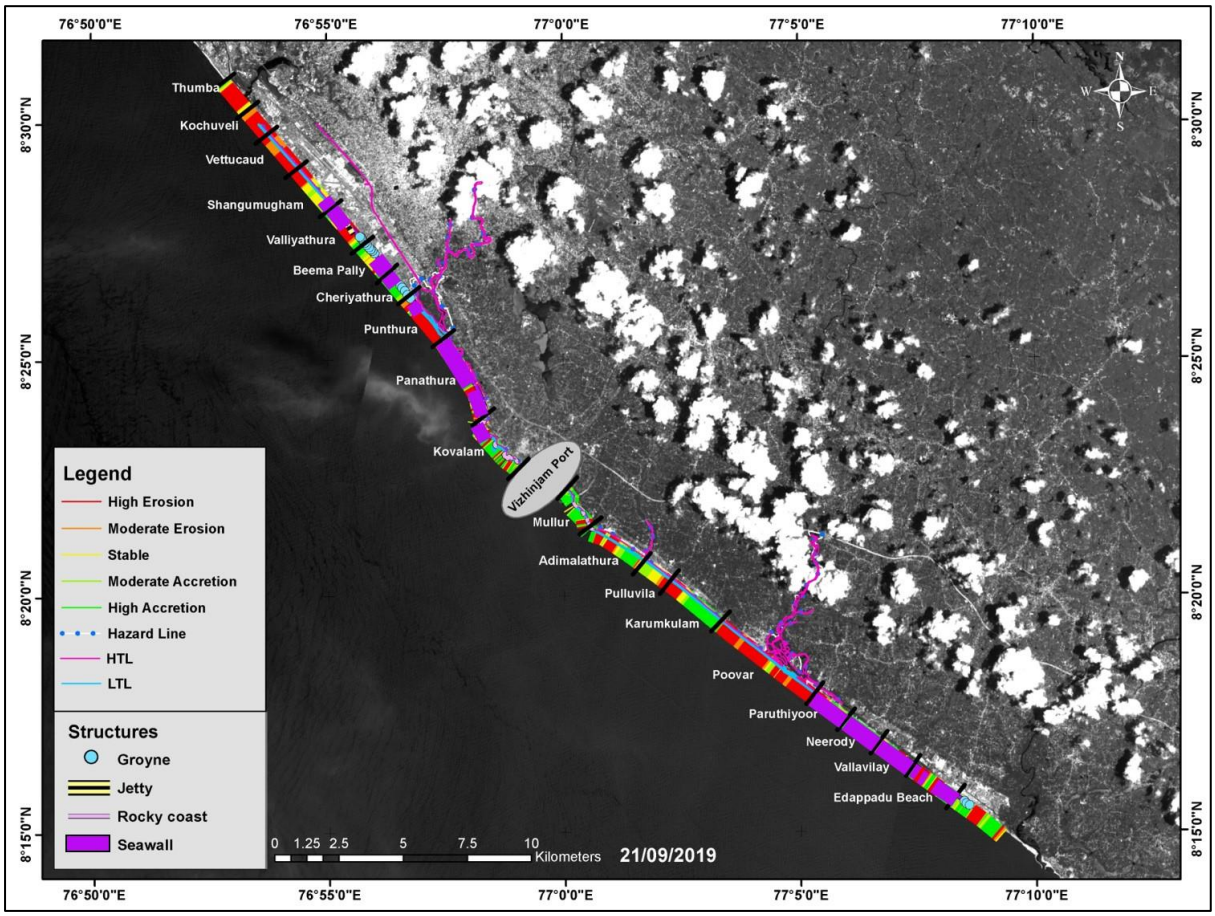


Figure 4.39 Shoreline Change Map September 2019 and September 2020

4.2.5 Shoreline Change comparison between January 2015 and January 2020

The comparison of January 2015 shoreline with January 2020 using high resolution satellite images has been presented in the Figure 4.40. The comparison shows erosion at Valliyathura, Punthura and Edapadu beach while Kovalam, Mullur, Adimalathura to Poovar shows accretion and stable at Thumba to north of Shangumugham and south of Edapadu beach.

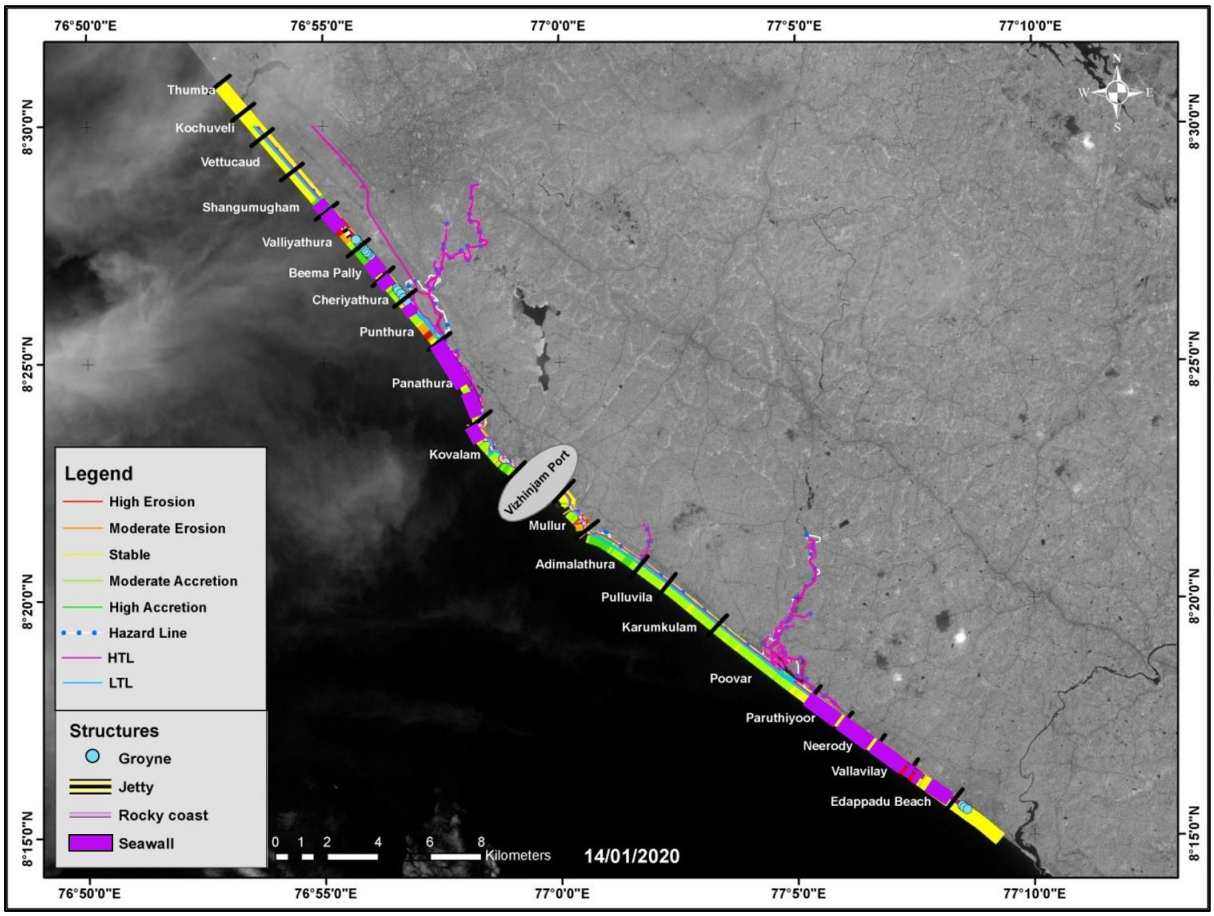


Figure 4.40 Shoreline Change Map- January 2015 to January 2020

4.3 Validation and Comparison of results

For the validation of the results from the shoreline derived from the satellite images of different spatial resolution (PAN (2.5m), LISS 4 (5m) and MSI (10m)) has been compared shown in Figure 4.41. The transect numbers indicate the 30m interval along the 40km stretch from Thumba to Edapadu beach (1350 number of transects).The comparison shows that the error in extraction of shoreline from 10m Sentinel images is 4.65m while the error from 5m satellite image is 2.75m when compared with the shoreline derived from 2.5m satellite images. The error in extracting the shoreline from satellite images reduces with respect to the spatial resolution of the satellite images.

It can be noted that the result from the two analysis (high resolution satellite image and beach profile data) shows concurrence.The difference in the shoreline distance along the transects south of Vizhinjam port is due to the fact that the beach profile data has been collected at different time and date whereas the satellite image captures the entire coast at a single time and date.

The field shoreline data collected by NIOT during September 2018 using DGPS has been compared with shoreline derived from Beach profile (collected by Surveying agency)and satellite imagery is shown in Figure 4.40. With the higher resolution satellite images, the field shoreline exactly matches with the shoreline derived from the satellite images whereas shoreline derived from the beach profile matches at every 500m.

As suggested in the shoreline committee dated 5th September 2019, the LTL, HTL and Hazard line has been demarcated on the shoreline maps provided in this report. Also, the graph shown in Figure 4.42 compares the shoreline derived from 5m and 10m satellite images, beach profile data, LTL, Hazard line with the field collected shoreline data specific to the stretch from Shangumugham to Punthura.

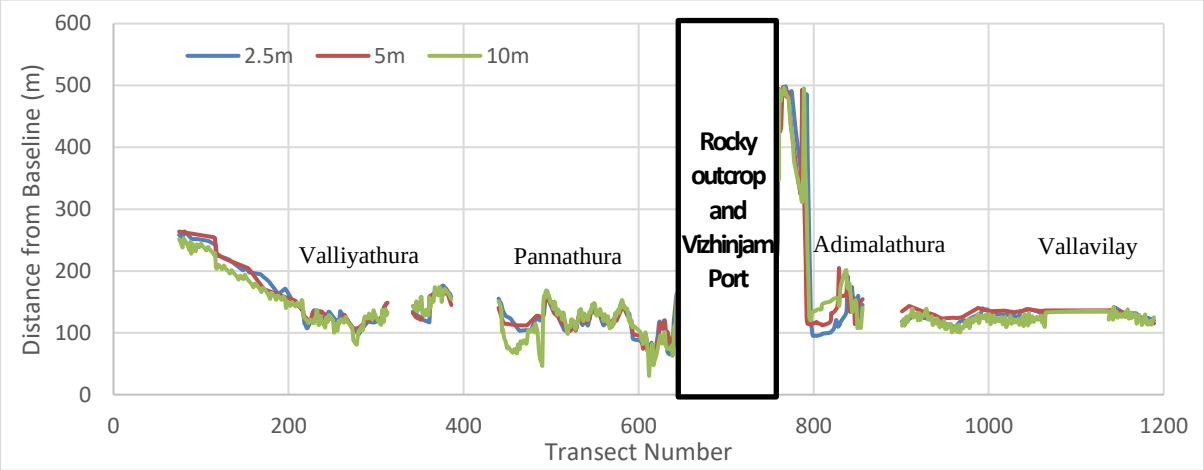


Figure 4.41 Comparison of Shoreline data from satellite images of different spatial resolution and beach profile data with field shoreline

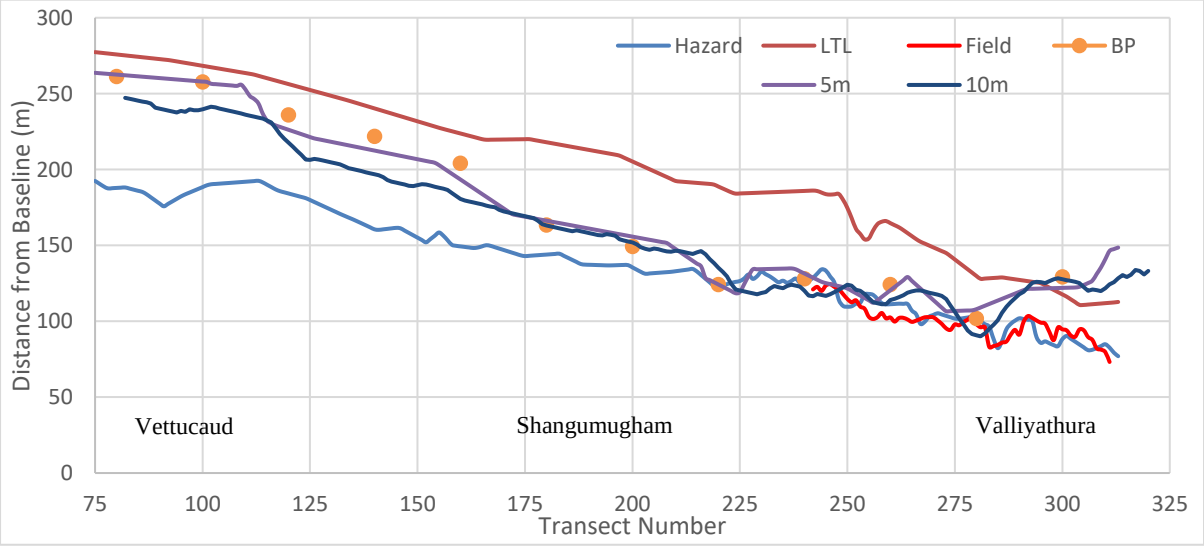


Figure 4.42 Comparison of Shoreline data from satellite images of different spatial resolution, beach profile data, LTL, Hazard line with field shoreline from Vettucaud to Valliyathura

The comparison of the erosion spots from the previous annual report October 2017-September 2018 for the shoreline change analysis for the years 2000-2005, 2005-2010, 2010-2015, and 2015-2018 has been compared with the results of 2018-2019 shown in Table 4.3. It can be noted that the spots of erosion such as Valliyathura, Shangumugham and Punthura remains same before the commencement of the port (December 2015). However, the spots such as Thumba to Vettucaud to the north of Valliyathura show erosion during the period October 2019- September 2020.

Snail Kumar et al, 2018 have discussed the increase in the significant wave height on western shelf seas (~1.2m) than the eastern shelf seas (~1.0m) in the last decade due to stronger influence of summer monsoon in the Arabian sea compared to Bay of Bengal which plays an important role in the beach sediment transport.

Table 4.3 Comparison of Erosion spots since 2000 using high resolution satellite images

	2000-2005	2005-2010	2010-2015	2015-2018	2015-2019	2015-2020	2018-2019	2019-2020
Erosion spots	No data to the north of Shangumugham					-	Kochuveli	Thumba to Vettucaud
	Shangumugham	Valliyathura	Shangumugham	Valliyathura	Valliyathura	Valliyathura	Shangumugham	Shangumugham
	Valliyathura		Valliyathura				Valliyathura	Valliyathura
	Punthura		Punthura	Punthura	Punthura	Punthura	Punthura	Punthura
	Pullavila		Pannathura	-	Pullavila to Edapadu	Edapadu	Pullavila to Edapadu	Karumkulam to Edapadu
			Poovar					

5 VETTING OF REPORTS/ DATA

Periodical (monthly, seasonal and half yearly) reports on field data quality check and data on water quality, sediments, shoreline monitoring, etc. are scrutinized by NIOT. The Oceanographic and bathymetric data received from AVPPL for the year 2019-2020 are listed in tables 5.1. Sediment samples were collected at the cross-shore profile locations seasonally. Water quality (turbidity, TSS and salinity being carried out at 4 locations, two each north and south of Vizhinjam port). Vetting of Reports on data analysis and model studies for Vizhinjam Port using data collected by AVPPL (March 2018 to February 2019) by LnTIEL during November 2019, Swath Calibration report (MFB BETHEL) for January 2019 and February 2019, water quality, oceanographic and bathymetric data collection (by Shankar & Co from June 2019) for assessment of Shoreline changes has been completed till September 2020.

Table 5.1 Data Status October 2019 to September 2020

Sl no.	Parameters	Post monmsoon (October 2019 -January 2020)				Pre monsoon (Feb 2020-May 2020)				SW Monsoon (June 2020- September 2020)			
1	Wave (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Tide (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	Met (1 location)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	ADCP (4 locations) at 20 m water depth	×				✓				✓			
5	Bathymetry	✓				-				✓			
6	Beach Profile (81 locations at 500 m distance)	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓
	Turbidity	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7	River bathymetry (7 locations)									✓			
8	Water sample (TSS, Salinity and temp)	✓				✓	-		✓	✓			
9	Grain size(81 locations at 500 m distance)	✓				✓				-			
10	LEO (81 locations at 500 m distance)	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓

5.1 Methodology adopted for verifying various monitored data

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

The beach profile data quality check has been carried out based on the quantity of the data received against the temporary bench mark and beach profile comparison with the earlier data sets. The data set has been discarded from the analysis based on the following criteria:

1. No simultaneous offshore profile data with onshore profile observed less than +1 m contour.
2. More than 50% spatial profile deviation from the previous month data with respective to x and y coordinates
3. Data set which has less than 4 data points
4. The cross sectional profiles survey has been carried out using RTK method. The NIOT team members visited site during RTK survey and checked the base station and rover setup during survey. The consistency of position and level before starting the survey and after finishing survey has been checked during survey.

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 arising due to some reasons are carefully examined and removed before the analysis. Further to normalize the gaps in a single profile bilinear interpolation has been carried out to fill the data gaps and uniform 1 meter interval profile data has been generated. Shoreline and Near shore Data System (SANDS) that was used in the analysis has its own Data Quality procedure which will not allow the system to proceed and analyze the data but ends up with error. All profiles are manually checked before entering the data in to SANDS.

The calibration of multi-beam echo sounder commonly referred as patch test. It is required to identify the offsets which would be applied to the data in order to compensate any misalignment in various sensors used. The offsets from vessel reference point, DGPS antenna and transducer was measured and entered into the acquisition software with in-situ measurement of sound velocity profiler. NIOT has instructed to AVPPL for carrying out the crossline survey as per the IHO standards for multi-beam survey. The NIOT team has checked patch test and other offsets for bathymetry survey.

TSS data provided was analyzed was verified using the protocol prescribed by the American Public Health Association (APHA) 21st Edition 2540 D and also validated using available data. Turbidity was measured using turbidity meter as per APHA protocol. The instrument was calibrated using formazin / factory calibrated standard.

The ADCP current data analyzed using standard oceanographic methods and analysis techniques by the software being used by the surveying agency. These includes standard visualization techniques, pre and post calibration at lab, time-series and 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 was tabulated against time. Data gaps, Spikes or improbable data was verified and removed. As the present used directional wave rider buoy is working based on the GPS principle, hence 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, duplicate set of few samples are collected and analysed at NIOT Geotechnical laboratory for cross verification of results submitted.

6 CONCLUSION

NIOT has carried out shoreline analysis using available high resolution satellite images and analysis of beach profile data for October 2019 to September 2020. Apart from that NIOT has also vetted / reviewed project proposals, field measured data and reports on various oceanographic data related to port development and modeling report by LNTIEL.

The zones of High erosion and accretion have been derived from the available high resolution satellite images for the study period. 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.

Beach profile analysis for the entire 40km stretch has been carried out to estimate the monthly, seasonal and annual changes in the beach volume. The shorelines derived from the satellite images of different spatial resolution and beach profile has been compared with the shoreline collected from field. Further the analysis using available high resolution satellite images has been extended with the monthly, seasonal and annual shoreline change analysis from October 2019 to September 2020. The zones of high erosion and accretion derived from the satellite images have been compared with the results from the beach volume change.

The comparison of the erosion spots from the shoreline change analysis (Annual Report 2017-2018) for the years 2000-2005, 2005-2010, 2010-2015, 2015-2018, 2018-19 has been compared with the results of 2019-2020 and 2015-2020. It can be noted that the spots of erosion such as Valliyathura, Shangumugham and Punthura remains same before and after the commencement of the port (December 2015). However, the spots such as Thumba to Vettucaud to the north of Valliyathura show erosion during the period October 2019- September 2020.

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