सी एस आई आर - राष्ट्रीय समुद्र विज्ञान संस्थान
(वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद)
दोना पावला, गोवा 403 004 भारत
CSIR - National Institute of Oceanography
(Council of Scientific & Industrial Research)
DONA PAULA, GOA - 403 004, India

Dr.R.Mani Murali
Senior Principal Scientist

01/07/2024

Sub: Submitting the project report

Dear Mr. Rajput,

Greetings from CSIR-NIO, Goa. I am pleased to submit 3 copies of the project report entitled "Impact Assessment Study on Mudflats & Mangroves in the Area Due to the Expansion Project of Phase III at Adani Petronet (Dahej) Port Limited" with this letter. I will also send the invoice of 15% of the project cost for the payment very soon. It is requested to acknowledge the receipt of the reports and do the further needful action for the payment after you receive the invoice. I sincerely thank you for awarding this project to CSIR-NIO, Goa.

With regards

R. M 01/07/24
(R.Mani Murali)

आर. मणि मुरली / R. Mani Murali
वरिष्ठ प्रधान वैज्ञानिक / Senior Principal Scientist
सी. एस. आई. आर. - राष्ट्रीय समुद्र विज्ञान संस्थान
CSIR - National Institute of Oceanography
दोना पावला, गोवा / Dona Paula, Goa 403004
भारत / India

To

Mr. Chiragsing Rajput,
Environment Department | Adani Ports & Special Economic Zone Ltd.
Adani Corporate House, 3rd Floor, North Wing, Shantigram,
Ahmedabad - 382421, Gujarat, India.
Mob +91 9687678443 | Ext. 59523 | chiragsing.rajput@adani.com

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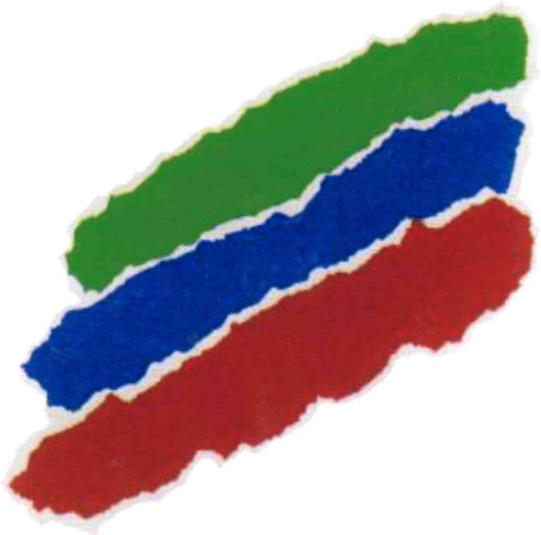
NIO/SP-24/2024
(SSP 3591)

Impact Assessment Study on Mudflats & Mangroves in the area due to the expansion project of phase III at Adani Petronet (Dahej) Port Limited

Sponsored by

M/s. Adani Petronet (Dahej) Port Limited,
Dahej, Dist. Bharuch (Gujarat)
India



June 2024

Final Report

सीएसआईआर – राष्ट्रीय समुद्र विज्ञान संस्थान
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NIO/SP- 24/2024

(SSP 3591)

Impact Assessment Study on Mudflats & Mangroves in the area due to the expansion project of phase III" at Adani Petronet (Dahej) Port Limited

Sponsored by:

M/s. Adani Petronet (Dahej) Port Limited,
Dahej, Dist. Bharuch (Gujarat)
India

June 2024

FINAL REPORT

सीएसआईआर – राष्ट्रीय समुद्र विज्ञान संस्थान
CSIR-NATIONAL INSTITUTE OF OCEANOGRAPHY
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Dr.Darwin Ramteke **Scientist**	**Associate Project Leader**
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Mr. SK Ariful Hossain **SRF**	**Member**

1 INTRODUCTION

M/s. Adani Petronet (Dahej) Port Limited, Gujarat (India) contacted the National Institute of Oceanography (NIO), Goa for the techno-commercial quote for the Impact assessment study on mudflats and mangroves in the area due to the expansion project of phase III" at Adani Petronet Dahej Port Ltd, Dahej, Gujarat. This project was forwarded to CSIR-NIO, Goa, based on the directions of the honourable NGT dated 23rd November 2023, based on Appeal No. 74 of 2016. CSIR-NIO, as a premier research Institute of Oceanography in the Indian Ocean region, has carried out many projects of this kind in the past for various agencies. CSIR-NIO has the best talents in the world in various aspects of oceanography measurements, and also basic and applied research of Oceanography fields. CSIR-NIO took up this project with the specific scope of work mentioned in this report in a later section.

2 STUDY AREA

The M/s. Adani Petronet (Dahej) Port Limited is a deep-water, solid cargo port in the Gulf of Khambhat, Dahej, Gujarat, India. This port is a joint venture between Adani Ports and Special Economic Zone Limited (APSEZ) and Petronet LNG Limited, the two prominent players in India's infrastructure and energy industries. The Dahej port, strategically located on Gujarat's coastline, is an important gateway for both internal and international trade. It facilitates the import and export of a variety of commodities, like Coal, Fertilizers, Minerals, Project Cargo, etc. The expansion of Phase III at the Dahej Adani Petronet Port is a crucial milestone in the port's development, aimed at increasing capacity and capabilities to meet rising demand and assist India's economic growth.

This study presents a comprehensive analysis of the environmental impact assessment due to the expansion of Phase III at the M/s. Adani Petronet (Dahej) Port Limited (Fig. 1). The extension of Phase III is geographically located between 21° 40' N and 21° 42' N latitudes and 72° 31' E and 72° 32' E longitudes. The region extends across 23 hectares of approved reclaimed land (Annexure 1), out of which 16 hectares of the area have already been reclaimed, and the reclamation work of 7 hectares of the area is yet to be started. However, the Phase III region is enriched with mudflats and coastal vegetation. The expansion of Phase

III at the M/s. Adani Petronet (Dahej) Port Limited may have some environmental impacts. Land reclamation and dredging activities required to build additional infrastructure may disrupt coastal habitats. Increased shipping traffic and vessel operations may lead to noise pollution, marine life disruption, and the spread of exotic species. Furthermore, increased industrial activity may lead to air and water pollution, posing threats to local communities and ecosystems. Port operations may also produce more waste, necessitating adequate waste management measures to avoid pollution. However, by carefully planning, implementing effective mitigation measures, and adhering to environmental standards, the port can reduce its environmental impact and foster sustainable development practices.

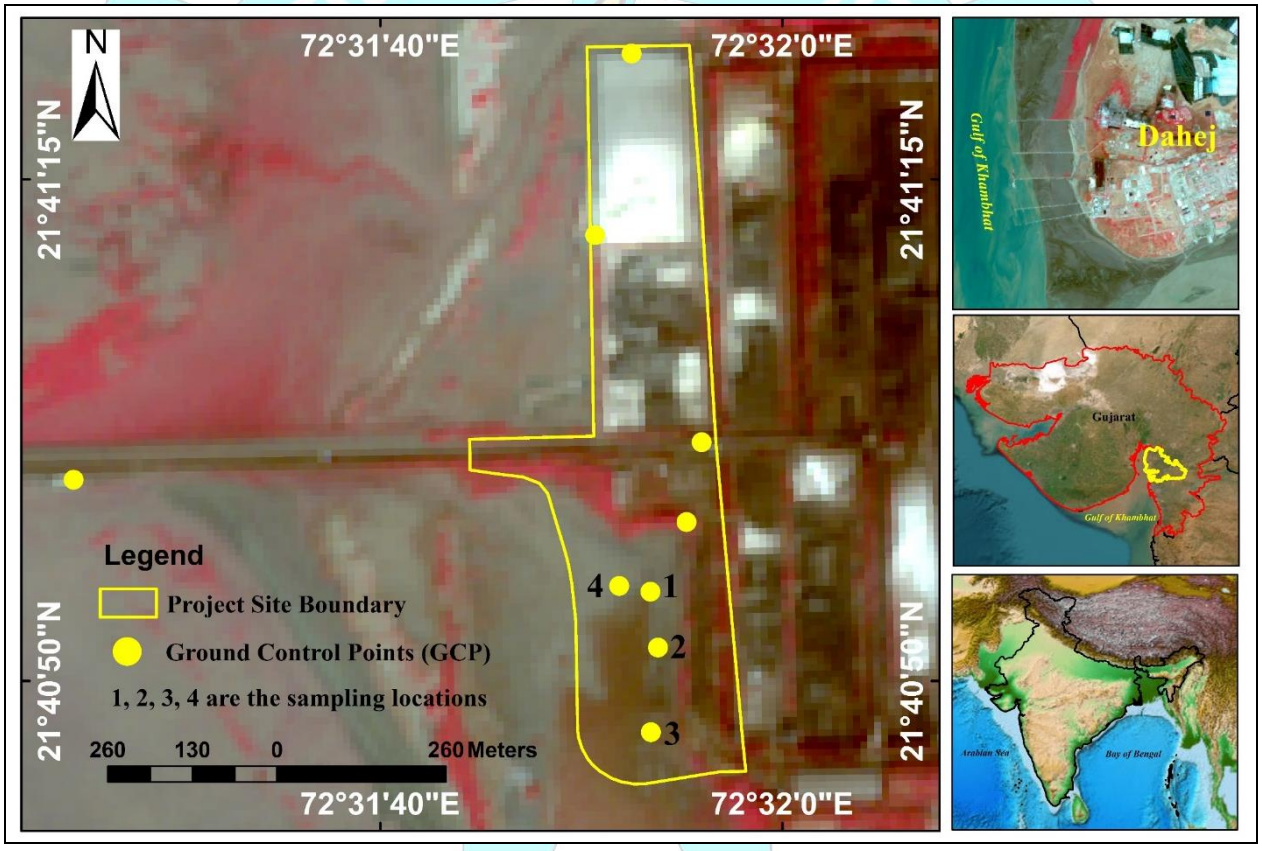


Fig. 1 *Location map of the M/s. Adani Petronet (Dahej) Port Limited, Dahej, Gujarat.*

3 PROPOSED SCOPE OF WORK

a) To carry out an impact assessment study to assess whether any significant impact is being caused to the ecology of the local area, especially mudflat and mangrove, by the project proponent due to the proposed expansion project (Phase-III) at Adani Petronet (Dahej) Port Limited.

b) To provide recommendations and remedial measures/management plan, if any adverse impact is found due to proposed expansion activities.

4 METHODOLOGY

Geospatial technologies such as remote sensing, Geographic Information Systems (GIS), and digital image processing systems are proven techniques to map and monitor ecologically sensitive regions such as mudflats, mangroves, coral, dunes and beaches. The Satellite Remote Sensing data due to its repetitive, multi-spectral and synoptic nature provides a unique view to recognize various features on land.

In this study, the satellite images and other available archived satellite data for the study area (Fig 1) have been used to map the presence of mudflats and mangroves in the study area. The sensitivity of the study area before the reclamation and the proposed expansion project on the study area is being analysed. The impact of the proposed expansion in the study area and the quantitative analysis of the reclaimed area were studied in detail along with the field validation. Cloud-free archived satellite images with the same spatial resolution and at similar season data (Table 1) have been finalised for mapping the whole study area. Details of the finalized satellite images (Table 2) are described. Utmost care was taken to understand and map the extent of mudflats and mangroves in the study area. Advanced digital image processing and analysis techniques have been used. The digital data of the study area was radiometrically and spectrally enhanced by linear contrast stretching and visual interpretation techniques. They were geometrically rectified and geo-referenced to the world space coordinate system by taking ground control points(GCP). The enhanced geo-referenced images were used for mapping in the utmost careful way.

Field observations were carried out on 29th Jan 2024 to understand the sensitivity of the ecological units of the study area before the remote sensing analysis. Around 16 hectares of the study area have been already reclaimed and the archived images would be the only way to estimate the presence of ecologically sensitive regions before the reclamation. Based on this study, suitable remedial measures or recommendations as per the Indian/world practices have been provided.

4.1 Satellite data acquisition and processing

Sentinel-2 is part of the European Union's Copernicus program. It comprises two satellites, Sentinel-2A and Sentinel-2B, which revolve around the Earth in a sun-synchronous polar orbit. The satellites are capable of acquiring high-resolution optical images of the Earth's surface across the visible, near-infrared, and shortwave infrared spectral bands. The Sentinel-2 satellites typically have a revisit period of approximately 5 days at the equator, enabling regular and reliable monitoring of changes on the Earth's surface. The Sentinel 2 Multispectral Instruments (MSI) covering the study area for the years 2015, 2016, 2018, 2020, 2022, and 2024 were procured from the Copernicus Open Access Hub at the same time. The timeframe of the analysis window (2015–2024) is 9 years long. Table 1 summarizes the details of the satellite images used in the present study.

Digital image processing software was used to stack, subset, and mosaic the visible and shortwave infrared bands of these images. The SNAP Sen2cor processor then radiometrically corrected all images, converting the digital number (DN) value into spectral radiance in the first step and the spectral radiance into spectral reflectance in the second. Afterwards, we performed image enhancement techniques, such as histogram equalization, on all images to improve the contrast. In this study, the Sentinel 2 MSI images of 2015 were considered as the base year for the whole analysis. The details of the methodological framework are illustrated in **Fig. 2.**

Table 1 Satellite Datasets details

Satellite Image	Scene No.	Date of Acquisition	Spatial Resolution	Source
Sentinel 2 Level 1C	T43QBE	30th November 2015	10 m	ESA Copernicus
Sentinel 2 Level 1C	T43QBE	24th November 2016	10 m	ESA Copernicus
Sentinel 2 Level 1C	T43QBE	24th November 2018	10 m	ESA Copernicus
Sentinel 2 Level 1C	T43QBE	23rd November 2020	10 m	ESA Copernicus
Sentinel 2 Level 1C	T43QBE	28th November 2022	10 m	ESA Copernicus
Sentinel 2 Level 1C	T43QBE	22nd March 2024	10 m	ESA Copernicus

Table 2 Details of Sentinel 2 satellite spectral bands.

Band	Resolution	Central Wavelength	Description
B1	60 m	443 nm	Ultra Blue (Coastal and Aerosol)
B2	10 m	490 nm	Blue
B3	10 m	560 nm	Green
B4	10 m	665 nm	Red
B5	20 m	705 nm	Visible and Near Infrared (VNIR)
B6	20 m	740 nm	Visible and Near Infrared (VNIR)
B7	20 m	783 nm	Visible and Near Infrared (VNIR)
B8	10 m	842 nm	Visible and Near Infrared (VNIR)
B8a	20 m	865 nm	Visible and Near Infrared (VNIR)
B9	60 m	940 nm	Short Wave Infrared (SWIR)
B10	60 m	1375 nm	Short Wave Infrared (SWIR)
B11	20 m	1610 nm	Short Wave Infrared (SWIR)
B12	20 m	2190 nm	Short Wave Infrared (SWIR)

4.2 Normalised Difference Vegetation Index

NDVI (Normalized Difference Vegetation Index) is a 1970s remote sensing technique. In 1973, a scientist named Rouse proposed the concept of employing light reflectance in visible and near-infrared (NIR) wavelengths to determine the abundance and health of plants. He employed two filters: one to detect red light and another to detect near-infrared light. He estimated NDVI by subtracting the NIR band's reflectance from the red band's reflectance and dividing the result by the sum of the NIR and red bands' reflectances (Equation 1).

$$NDVI = \frac{NIR_{\rho\lambda} - Red_{\rho\lambda}}{NIR_{\rho\lambda} + Red_{\rho\lambda}} \quad 1$$

Where $NIR_{\rho\lambda}$ and $Red_{\rho\lambda}$ denote the spectral reflectance of the NIR and Red bands, respectively. The normal range for NDVI values is from -1.0 to 1.0, with negative values showing clouds and water and positive values close to zero showing bare soil. Higher positive values of NDVI range from 0.1 to 0.5 for sparse vegetation to 0.6 and above for dense green vegetation (**Fig. 4**).

4.3 Normalised Difference Water Index

McFeeters (1996) developed the NDWI, which used the green and NIR bands to delineate water surface features in all images. The NDWI is the most robust and accurate technique for delineating the land and water transition zones. Equation 2 represents the normalized difference water index (NDWI).

$$NDWI = \frac{Green_{\rho\lambda} - NIR_{\rho\lambda}}{Green_{\rho\lambda} + NIR_{\rho\lambda}} \quad 2$$

Where $Green_{\rho\lambda}$ and $NIR_{\rho\lambda}$ denote the spectral reflectance of the green and NIR bands, respectively. The NDWI value ranges between -1 and +1, where the positive value represents the water pixel and the negative value represents the land pixel (**Fig. 5**).

4.4 Land Use Land Cover (LULC) mapping using Supervised Classification

In the present study, standard false color composite (FCC) images, the normalized difference vegetation index (NDVI), and the normalized difference water index (NDWI) were utilized to identify the land use and land cover features. We created the False Color Composite (FCC) image using four bands: NIR bands in red, red bands in green, and green bands in blue (**Fig. 3**). This image is useful for manual feature identification using a visual interpretation approach. Land use and land cover maps for the 2015, 2016, 2018, 2020, 2022, and 2024 time periods were generated by the supervised classification method and maximum likelihood techniques. The supervised classification was performed on all the images using the maximum likelihood algorithm. Maximum likelihood classification is a statistical technique employed to categorize pixels in satellite data into distinct land cover classes based on their spectral attributes. The methodology operates under the assumption that the spectral values associated with each class in the image adhere to a normal (Gaussian) distribution. It then calculates the probability of assigning a pixel to a particular class. We assign the pixel to

the class with the highest probability. We have classified four distinct land use classes to illustrate the dynamics in land use and land cover across the study area.

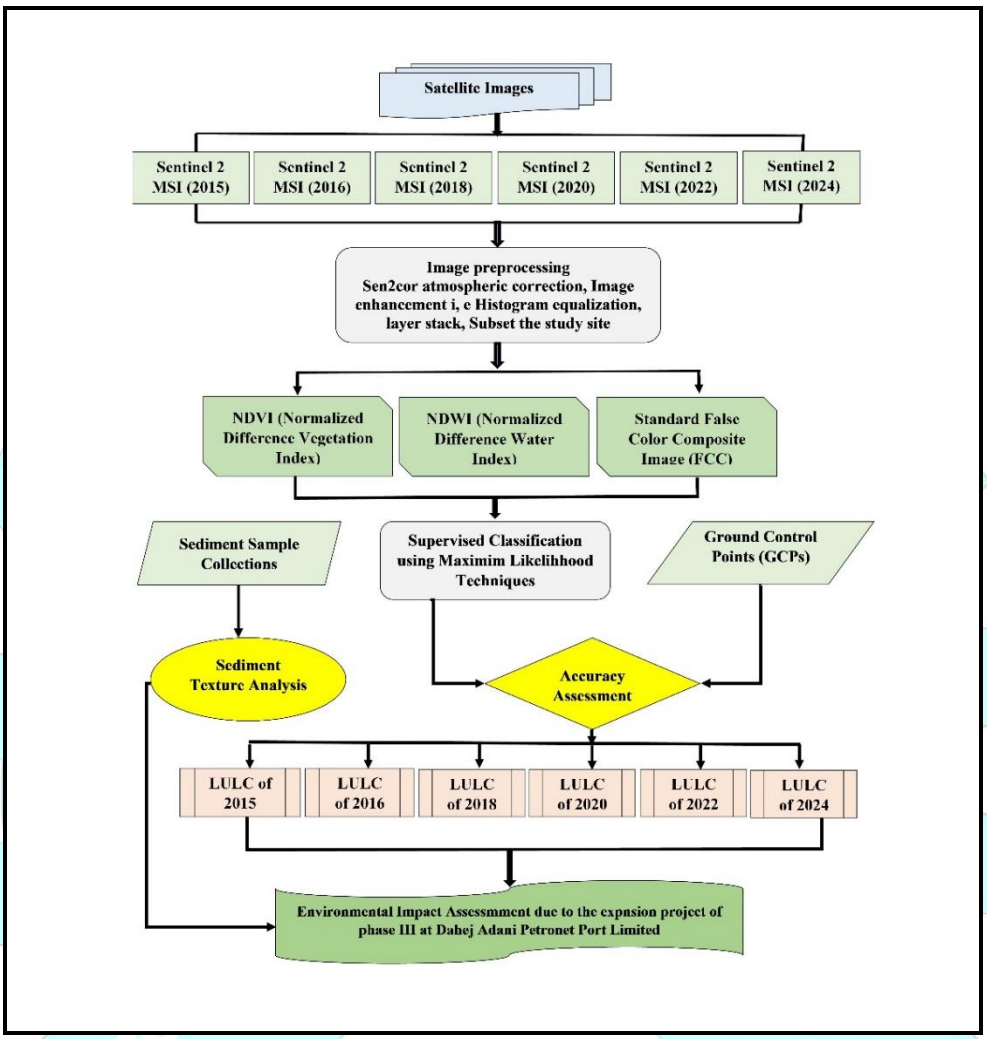


Fig. 2 *Schematic representation of Environmental Impact Assessment Study.*

4.5 Accuracy assessment of LULC Map

A random sample technique was used to validate the LULC classification based on the collected GCPs and Google Earth images. The accuracy of the LULC map produced was evaluated using accuracy assessment and Kappa statistics. Here, the LULC classes show overall accuracy values of 97.56%, 96.67%, 93.55%, 96.15%, 100%, and 96.3%, and kappa coefficient values of 0.88, 0.95, 0.91, 0.94, 1, and 0.94 for the classified maps of 2015, 2016, 2018, 2020, 2022, and 2024, respectively (Table 3).

4.6 LULC Change Detection

Change detection is the process of determining the status of an object or phenomenon across time. This technique uses multi-temporal remote sensing data to quantitatively examine the historical consequences of an occurrence, assisting in evaluating changes connected with land use and land cover attributes in relation to the multi-temporal dataset. This study employs the post-classification technique to analyze the pixel-by-pixel supervised classification outcomes of 2015 and 2024 imagery.

4.7 Sediment texture analysis

Sediment samples were collected from four different places (Fig 1) in the selected study region and then brought to the laboratory for examination. The samples were first washed with fresh water to remove salt content, then the sediment was settled. The washing procedure was repeated two to three times to remove salt content. Surface water was removed after settling, and the entire sediment was collected in beakers for further processing. The collected samples were then dried in an oven set to 100 $\pm$ 5 degrees Celsius until they were completely dry.

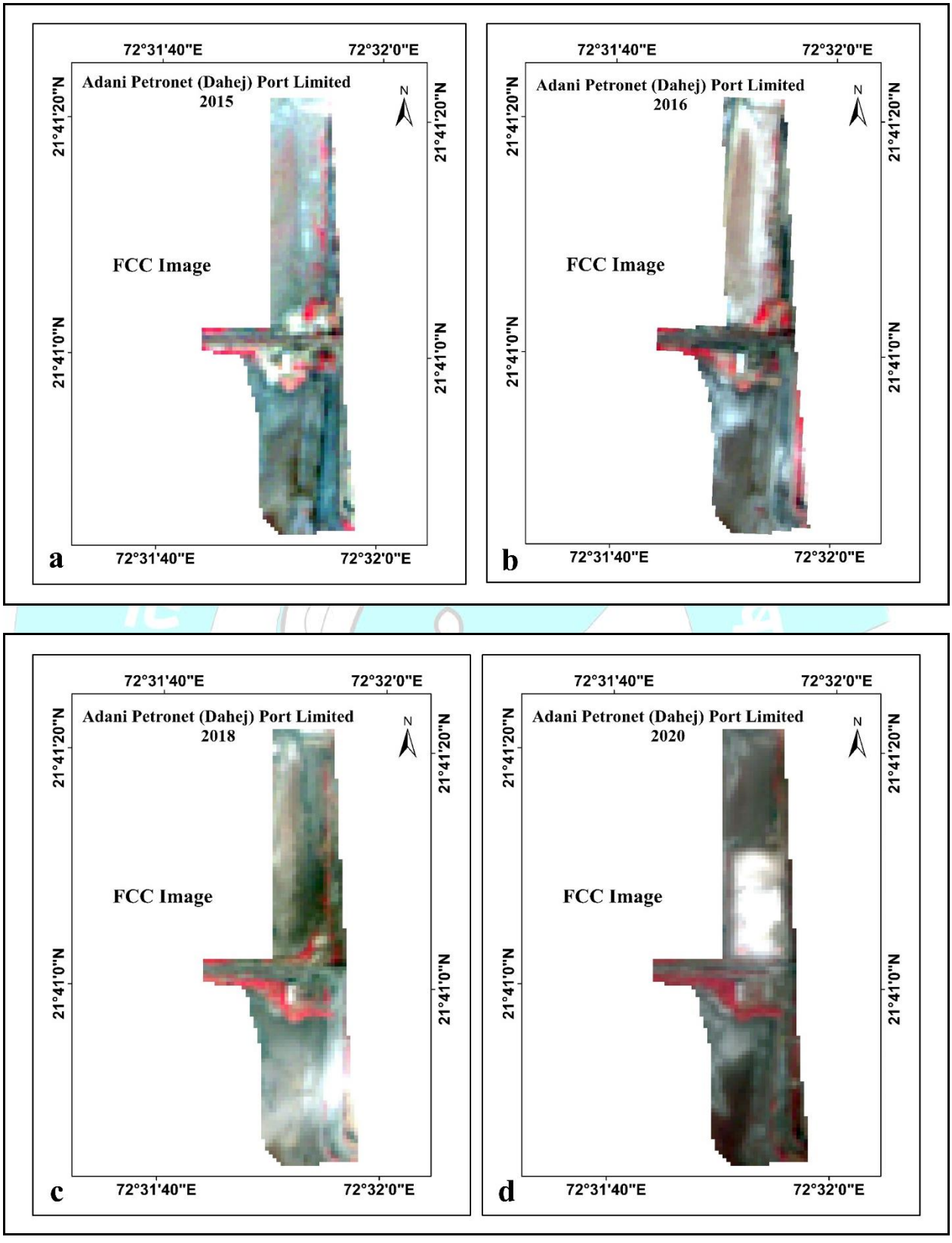
Once dry, 40 grams of each sample from the separate beakers were carefully weighed and sieved using a sieve shaker. Coarse sediments of size 75 microns and above were dry-sieved for particle size distribution. Standard sedimentation analysis by pipette method was performed for particle size distribution of sediments passing through 75 microns.

5 Results

5.1 Dynamics of LULC and Port Expansion

Fig. 6 shows the land use and land cover of the area under Phase III in M/s. Adani Petronet (Dahej) Port Limited for six different periods (2015, 2016, 2018, 2020, 2022, and 2024). Table 4 presents the calculated total area of each land use category and the percentage of each class between 2015 and 2024. The results show a drastic change in land use during the study periods. Due to the rapid expansion of port developmental activities, the built-up area has experienced the most dramatic change, increasing from 2.71% in 2015 to 57.20% at present, while the mud flat has significantly decreased from 85.38% in 2015 to 23.89% in 2024. The 2.71% area was inclusive of the access road to the existing jetty. Permissions must have been granted for this in the earlier EC & CRZ Clearance. Over the timeframe of the analysis, there has been a slight increase in coastal vegetation and scrubland. Figs. 7, 8, and 9 represent the temporal dynamics of each land use and land cover category.

Approved land reclamation (Annexure 1) for port expansion has led to constant growth in the total area of built-up land. Concurrently, there has been a development in the intertidal/mud flat and scrubland.



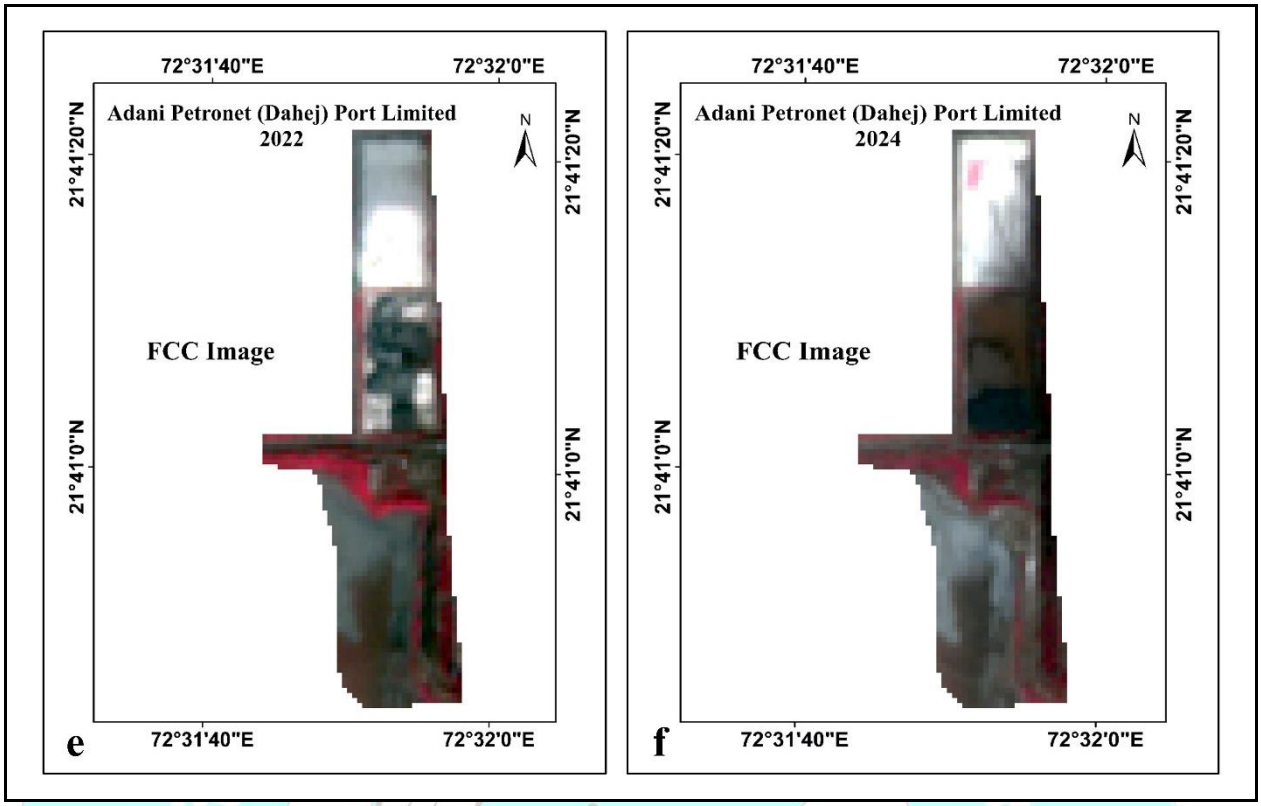
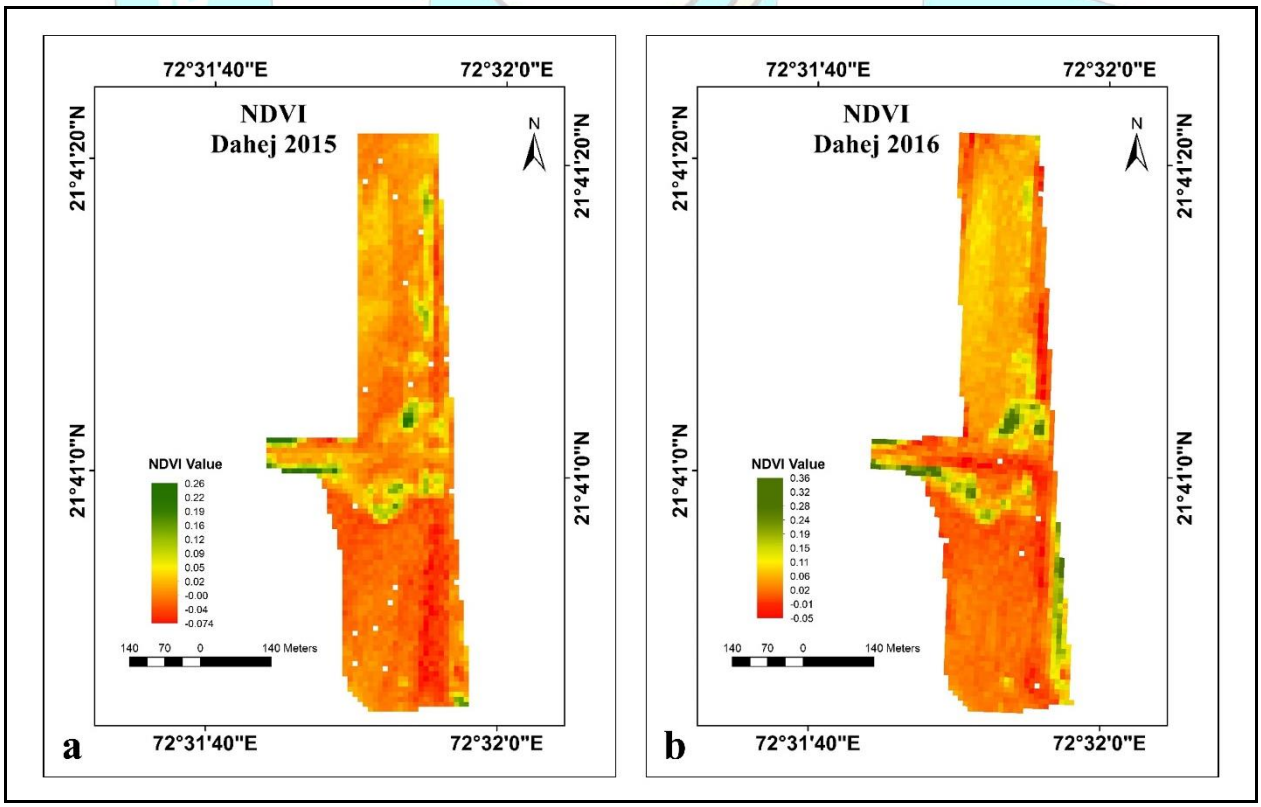


Fig. 3 *Time series of FCC Images between 2015 and 2024.*



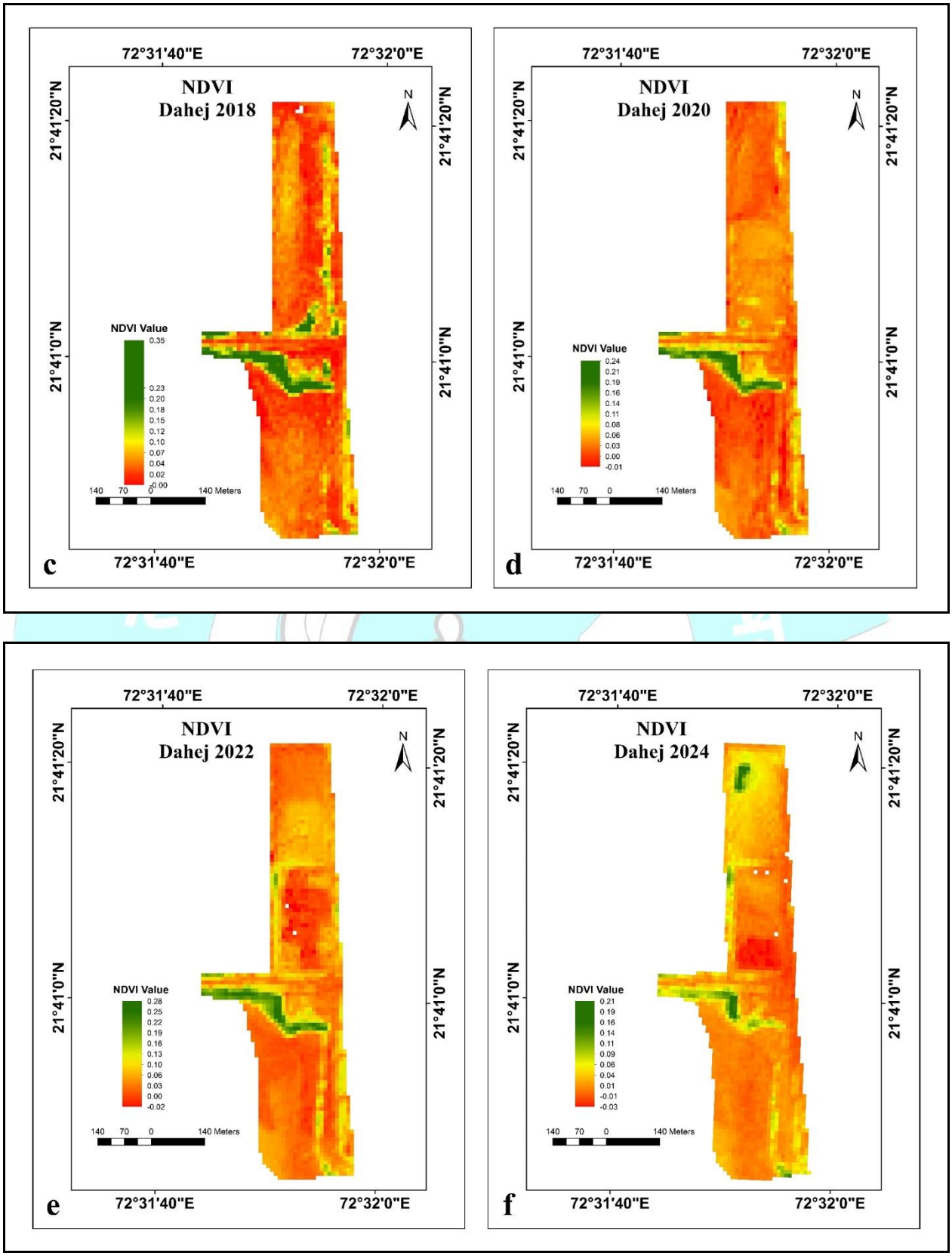
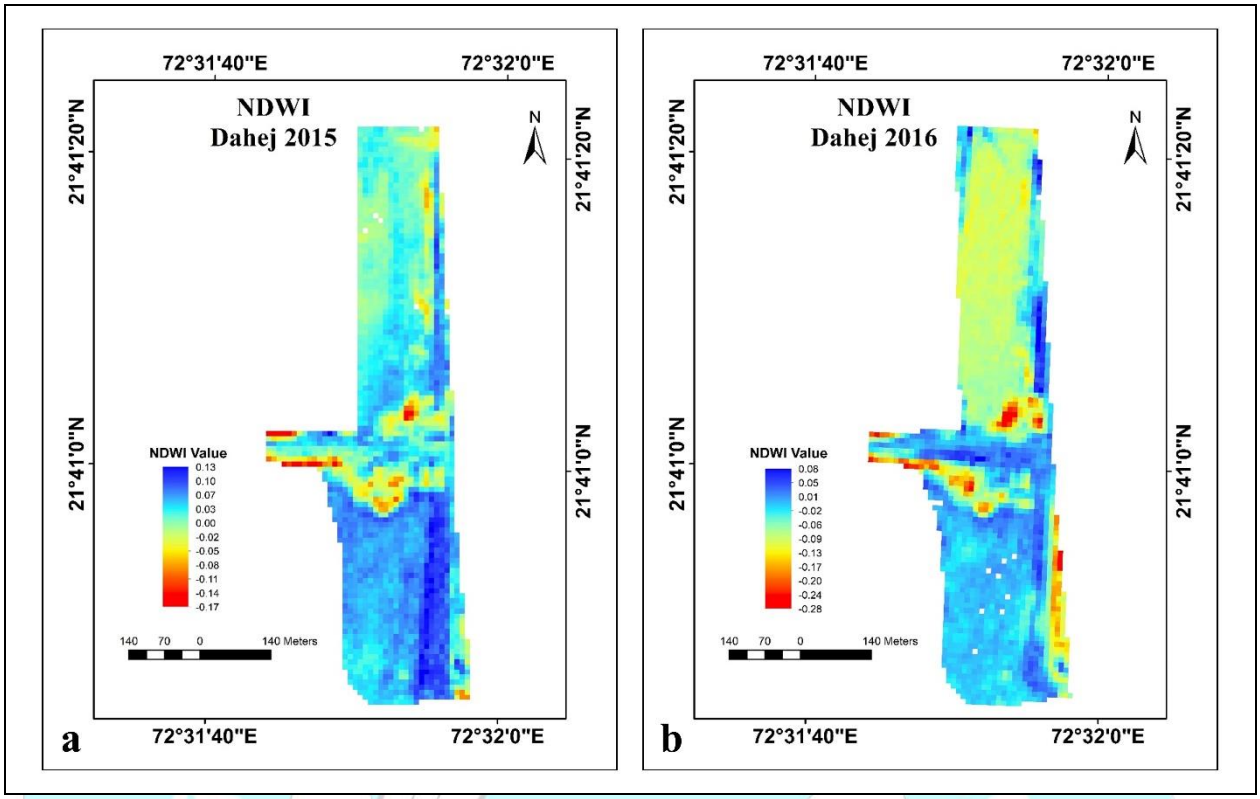


Fig. 4 *NDVI Time series Images between 2015 and 2024.*



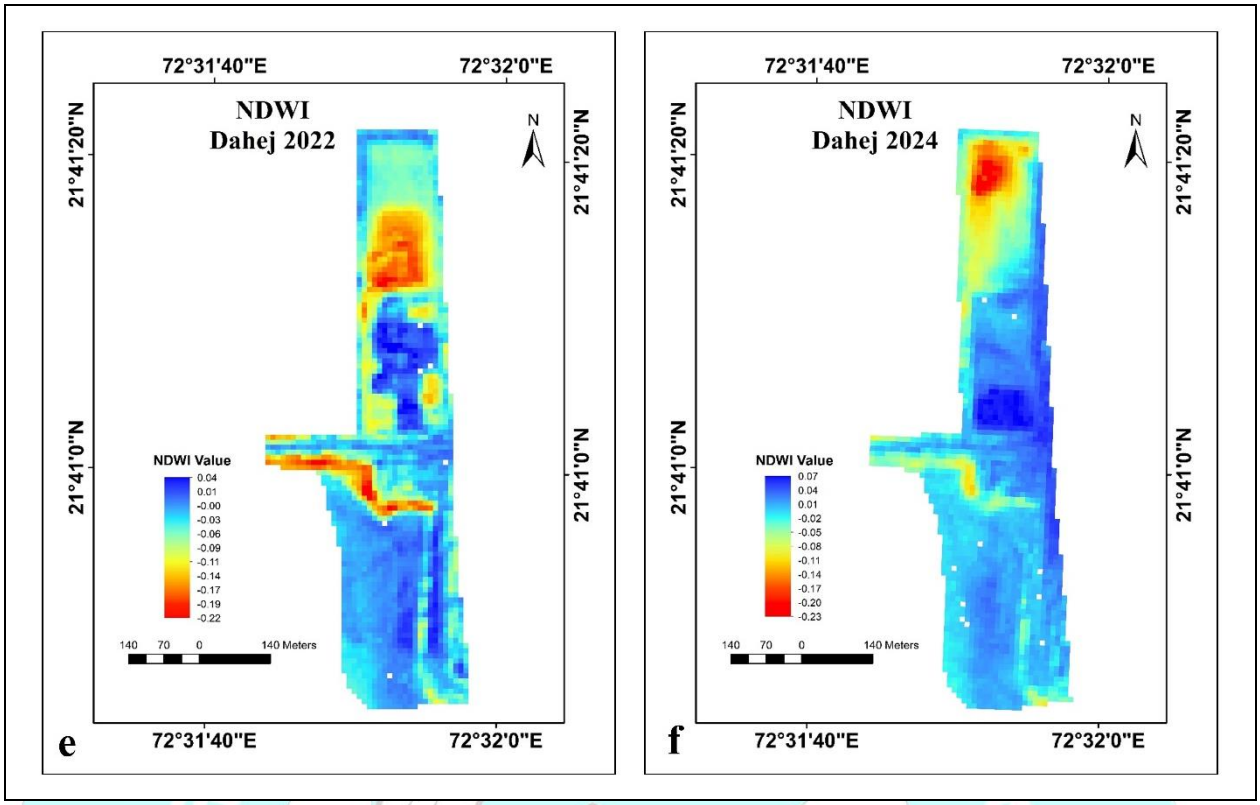
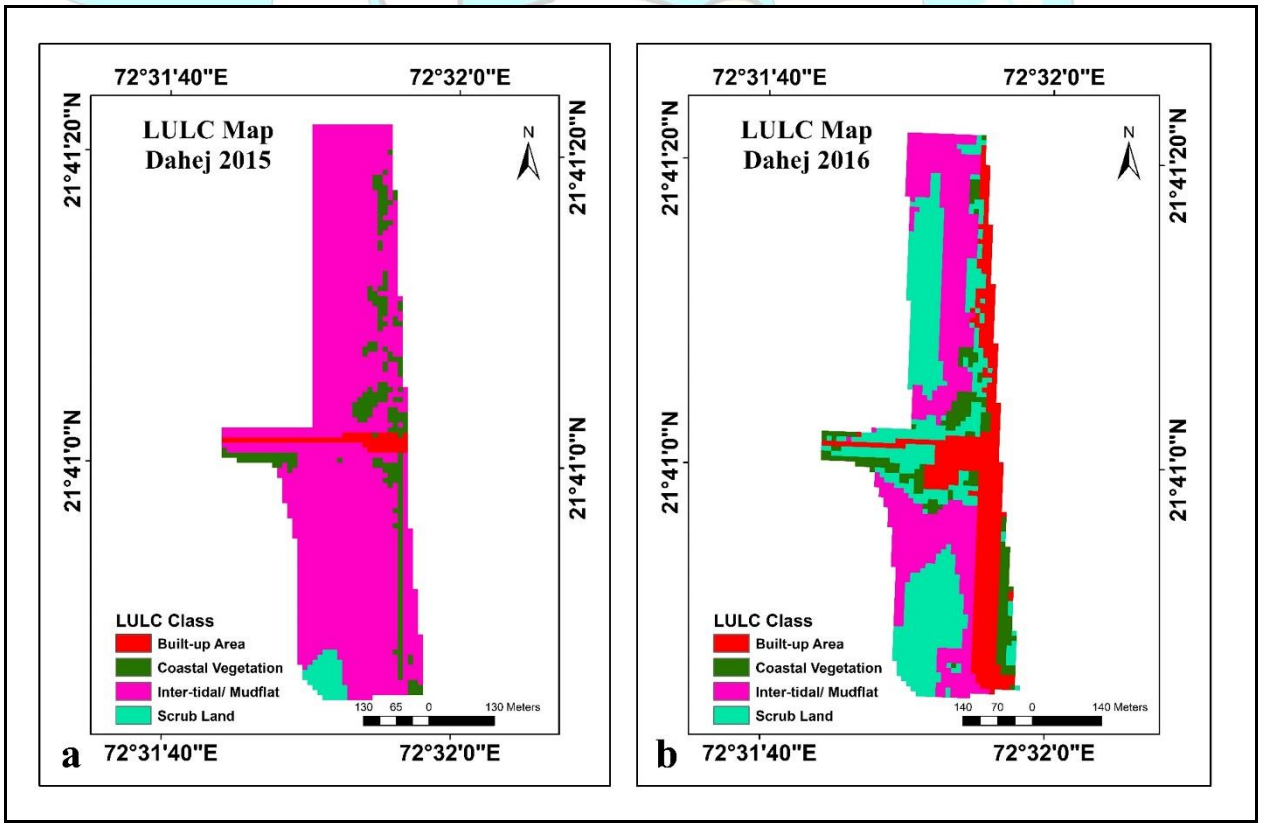


Fig. 5 NDWI Time series Images between 2015 and 2024.



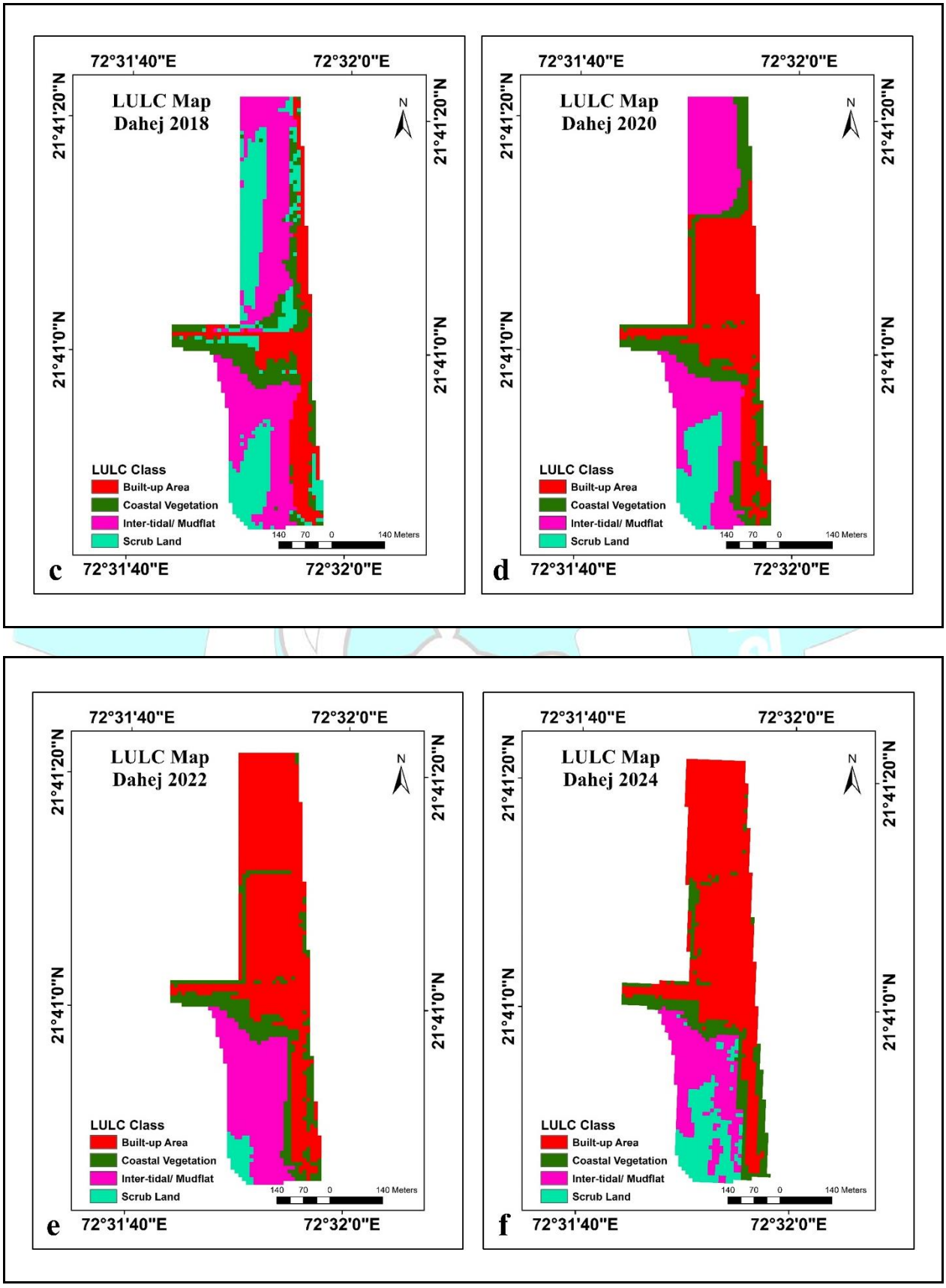


Fig. 6 *LULC Map between 2015 and 2024.*

Table 3 Accuracy Assessment of LULC

LULC Year	Overall Classification Accuracy (%)	Overall Kappa Statistics
2015	97.56	0.88
2016	96.67	0.954
2018	93.55	0.910
2020	96.15	0.947
2022	100	1.000
2024	96.3	0.945

Table 4 Details of LULC statistics

	Area in Hectares											
LULC Class	**2015**	**%**	**2016**	**%**	**2018**	**%**	**2020**	**%**	**2022**	**%**	**2024**	**%**
Builtup Area	0.65	2.71	4.56	18.91	6.76	28.04	8.95	37.12	13.55	56.20	13.79	57.20
Coastal Vegetation	2.36	9.83	3.76	15.60	2.27	9.42	4.41	18.29	3.36	13.94	3.91	16.22
Inter-tidal/ Mudflat	20.49	85.38	8.51	35.30	6.07	25.18	8.23	34.14	4.3	17.83	5.76	23.89
Scrub Land	0.61	2.54	7.28	30.19	9.01	37.37	2.52	10.45	2.9	12.03	0.65	2.70

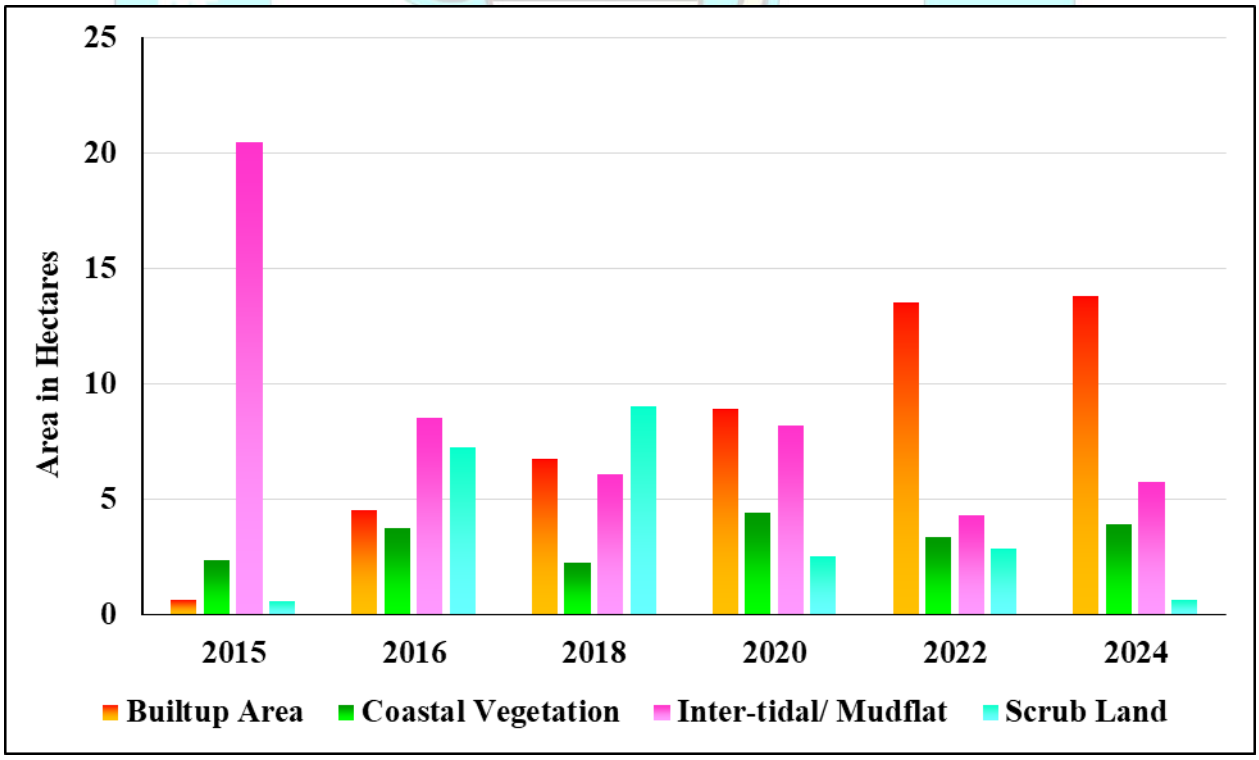


Fig. 7 Combined LULC change graph.

Fig. 8 *Year-wise LULC graph.*

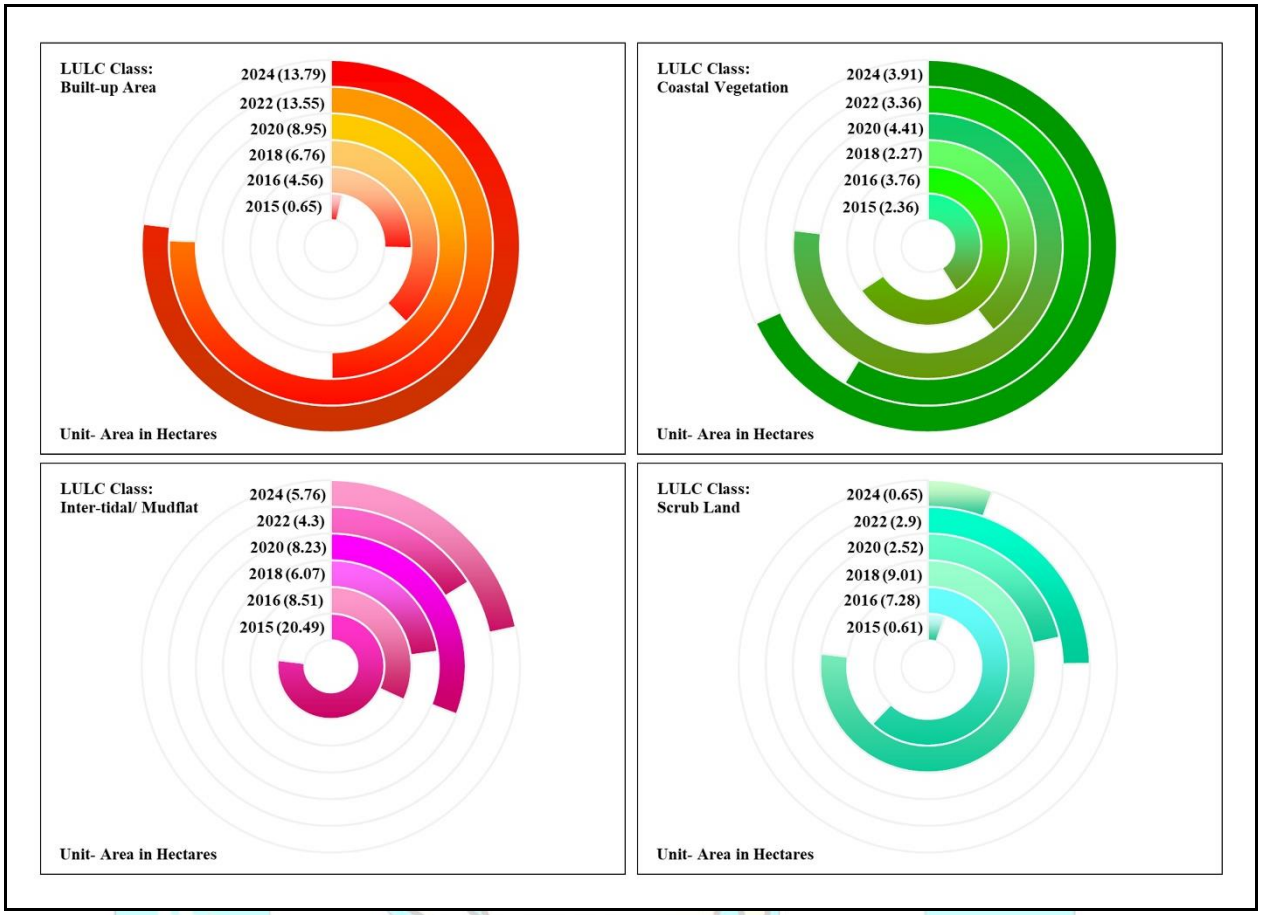


Fig. 9 *LULC changes as per different classes*

5.2 LULC Change Detection between 2015 and 2024

Post-classification approaches were employed to detect changes in land use and land cover within the study area during two distinct periods. The temporal patterns in land use and land cover are depicted in Figure 10. Before land reclamation at the study site in 2015, the built-up area was limited to the central section of the study area, accounting for just 2.71% of the total area (Fig. 6a). However, throughout time, the built-up areas experienced growth, resulting in a total coverage of 57.20% in 2024. This indicates that over the past 9 years, the built-up areas have expanded to 54.49% in line with the approved reclamation. The extent of built-up areas has expanded across the entirety of the northern, central, and southeastern regions within the designated study area. This observation highlights the significance of land reclamation and the environmental consequences associated with port expansion. The study moreover examines the rate of development in locations encompassing intertidal/mud flats, coastal vegetation, and scrubland. The intertidal/mudflat area has experienced a substantial

decline, decreasing from 20.49 hectares (85.38%) in 2015 to 5.76 hectares (23.89%) in 2024, resulting in a total reduction of 61.49%.

The study reveals that 1.89 hectares (80.08%) of the total area of coastal vegetation has been converted into built-up land. From 2015 to 2024, a slight increase was observed in the area of coastal vegetation in the mudflat. Tables 4 and 5 provide statistical information about the temporal dynamics in the area of each land use class. Figures 6 and 10 demonstrate that the studied area had a significant prevalence of mudflats before the commencement of reclamation activities. Over time, there has been a significant increase in expansion and the development of built-up regions. There are areas of intertidal/mudflat and scrubland of 7 Ha which are yet to be reclaimed as part of the approved land reclamation. They are located in the southern and southwestern regions of the study area. The field photographs of the various land use land cover categories were acquired throughout the study region and are presented in Figures 18 a, b, c, and d.

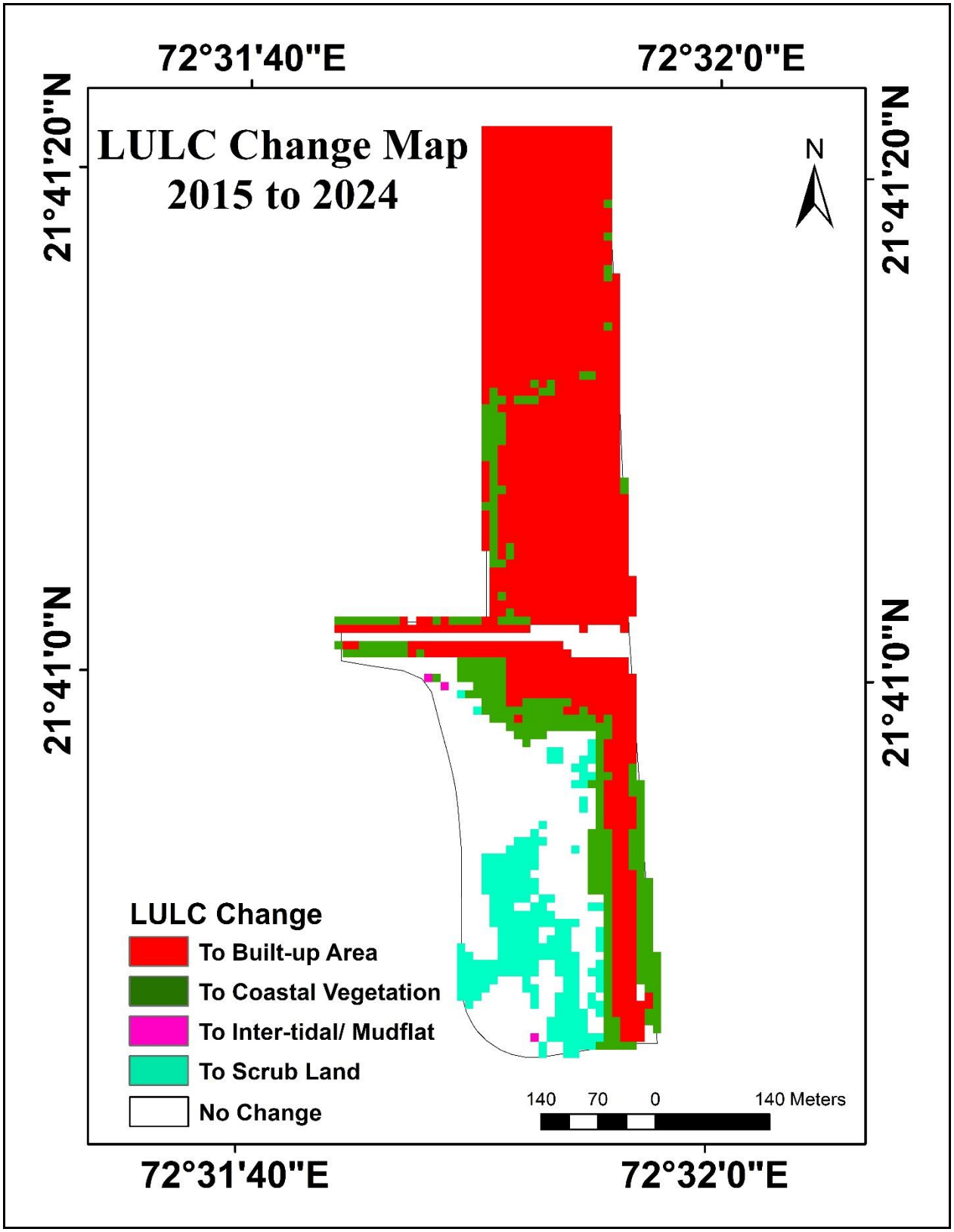
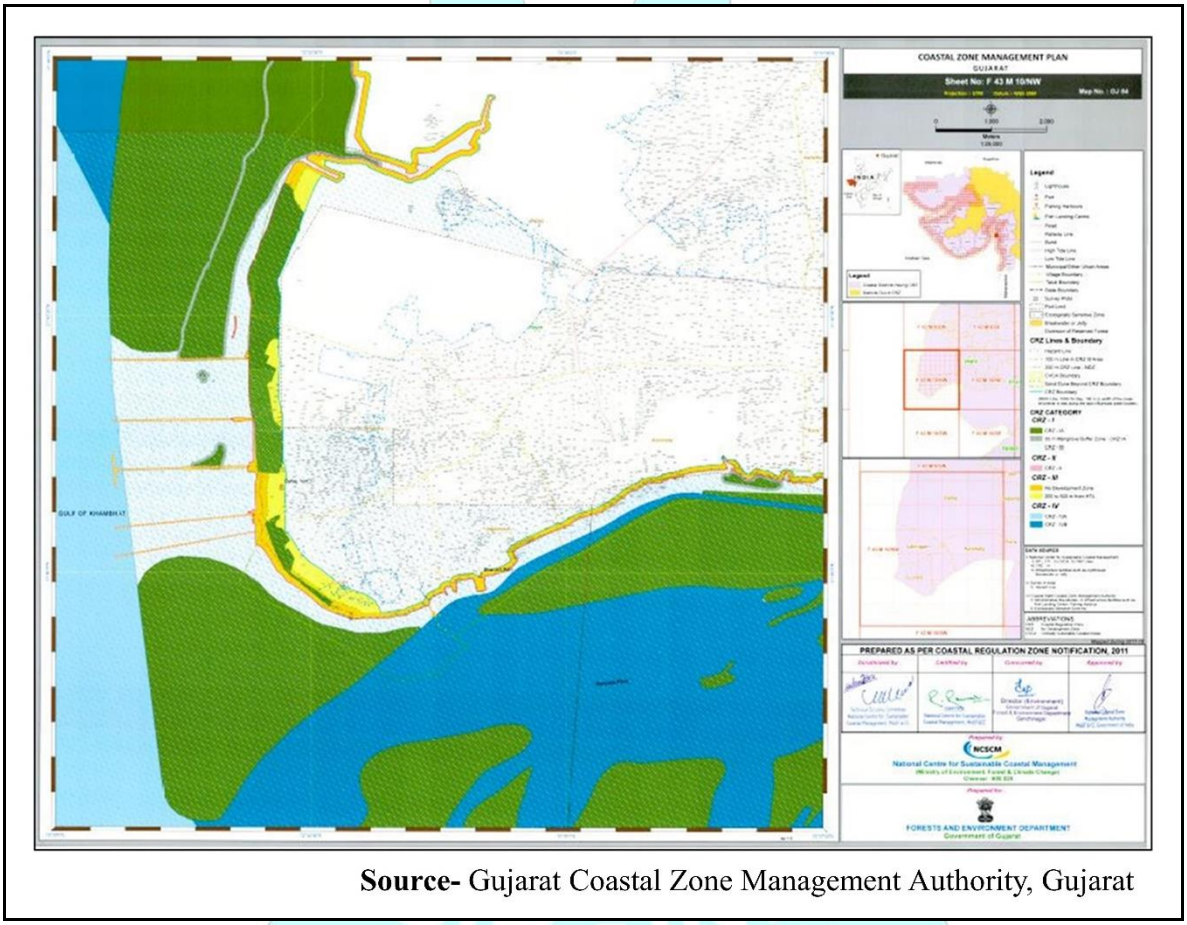


Fig. 10 *LULC change detection map.*

Table 5 Details of LULC change detection between 2015 and 2024

2015 to 2024 LULC Change Detection					
Labels	**Built up**	**Coastal vegetation**	**Inter-tidal/ Mudflat**	**Scrubland**	**Grand Total**
Built up	0.61	0	0	0	0.61
Coastal vegetation	1.89	0.35	0.02	0	2.26
Mudflat	10.77	2.94	4.22	2.28	20.21
Scrubland	0	0	0.01	0.6	0.61
Grand Total	13.27	3.29	4.25	2.88	23.69



Source- Gujarat Coastal Zone Management Authority, Gujarat

Fig. 11 BISAG approved the CZMP plan of the study area as per CRZ 2011 notification (https://gpcb.gujarat.gov.in/uploads/BISAG_APPROVED_CZMP_PLAN_BHARUCH.pdf)

5.3 Sediment Texture

Sediment classification has been accomplished by analyzing the percentage of sand, silt, and clay using six distinct triangle diagrams given by Shepard 1954, Folk 1954, Gorsline 1960, and Fleming 2000. Furthermore, the data display for the sediment samples is straightforward, allowing for rapid classification and comparison of samples using the Blott and Pye

technique (2012). In Phase III at M/s. Adani Petronet (Dahej) Port Limited, Dahej, Gujarat, nearly 99.55% of the sediment samples are mud, with 0.45% being sand (Figs. 12 and 13). Table 6 summarizes the statistical characteristics of grain size.

Figures 14, 15, and 16 depict a CM diagram of the grain size, transport mode, and depositional environment concerning the size, range, and energy level of transportation. It also identifies the processes and drivers involved in fluvial deposit formation. Using CM patterns, the present study attempted to establish the sediment deposition pattern at Phase III, Dahej Adani Petronet Port. We show the first percentile of coarse particle size (C) and median particle size (M), along with a half-phi interval graph of C and M made from cumulative curves in microns. This graph shows the Overbank-Pool Facies Suspension modes of transport. The connection between C and M demonstrates how bottom turbulence sorting works, as well as how easily the whole sample falls into the pelagic suspension and rolling process in Phase III.

The D1 to D95 notation denotes the particle sizes at which a specific proportion of the sample's mass is finer than the specified size. For example, D10 is the grain size below which 10% of the sample's mass is finer, whereas D50 is the median grain size below which 50% of the sample's mass is finer. Figure 17 typically depicts a graph charting percentage finer (Y-axis) versus grain size (X-axis). The curve demonstrates how the proportion of different grain sizes varies throughout the sediment sample.

Table 6 Sediment Grain size statistics details

Statistical Parameters	Sample 1	Sample 2	Sample 3	Sample 4
Mean	6.45	5.19	7.65	6.55
Median	5.41	5.07	8.04	5.51
SD	2.21	1.07	2.40	2.11
Skewness	0.63	0.52	-0.16	0.65
Kurtosis	0.68	3.15	0.59	0.67
Sand (%)	0.39	0.16	0.82	0.45
Mud (%)	99.61	99.84	99.18	99.55
KurtosisType	Platykurtic	Extremely Leptokurtic	Very Platykurtic	Very Platykurtic
SkewnessType	Very fine skewed	Very fine skewed	Coarse skewed	Very fine skewed
SortingType	Very poorly sorted	Poorly sorted	Very poorly sorted	Very poorly sorted
Type of Deposition mode	VII. Uniform suspension	VII. Uniform suspension	VII. Pelagic suspension	VII. Uniform suspension

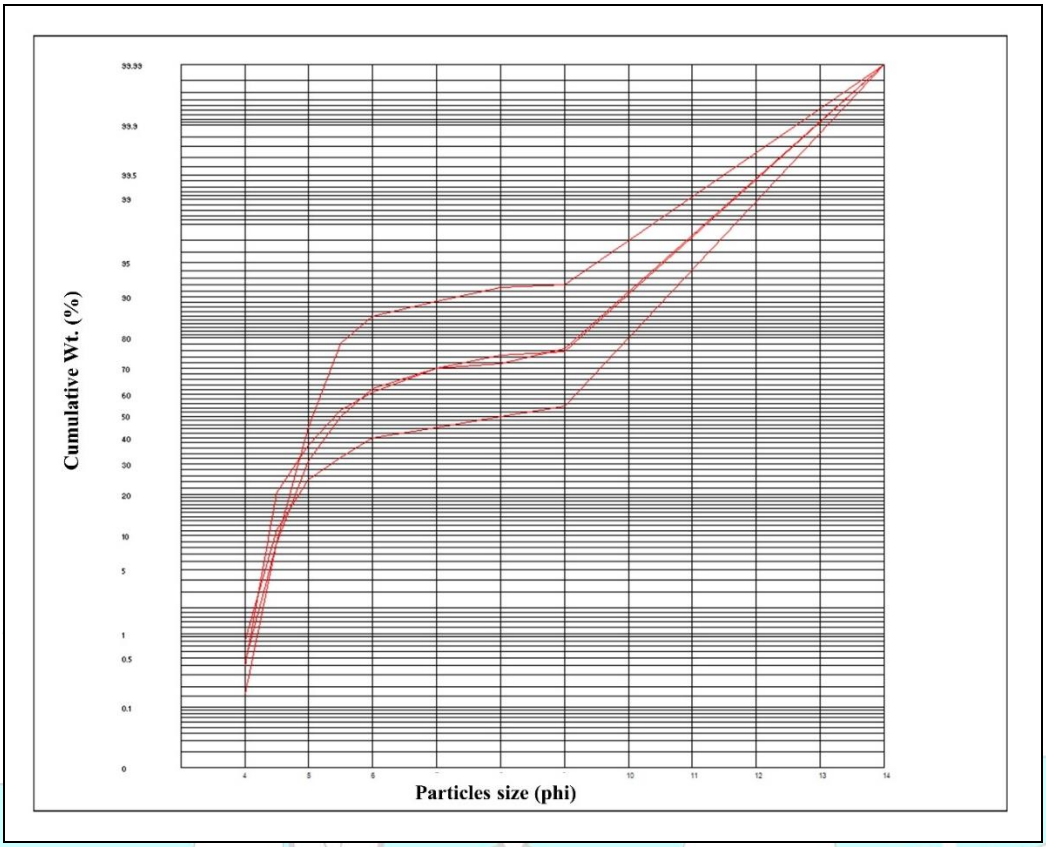


Fig. 12 *Logarithmic graph for Sediment particle size Distribution.*

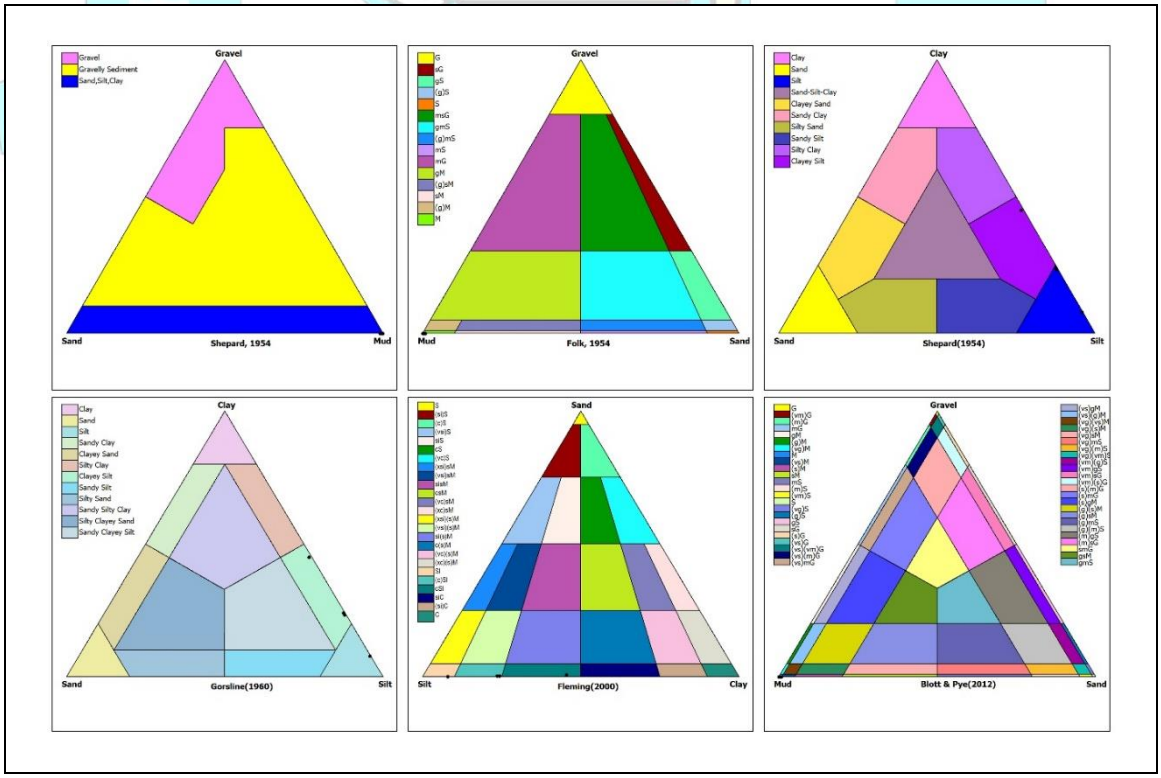


Fig. 13 *Triangular diagram showing the texture of sediment samples.*

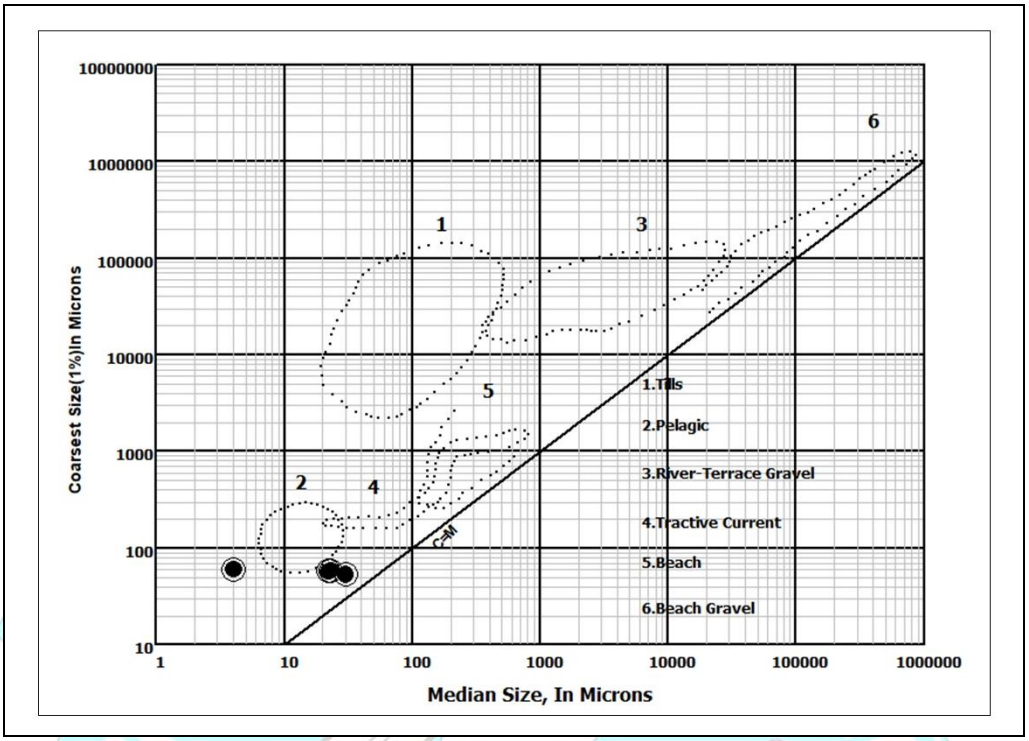


Fig. 14 *Passega's Basic C-M plot for Sediment particle size distribution.*

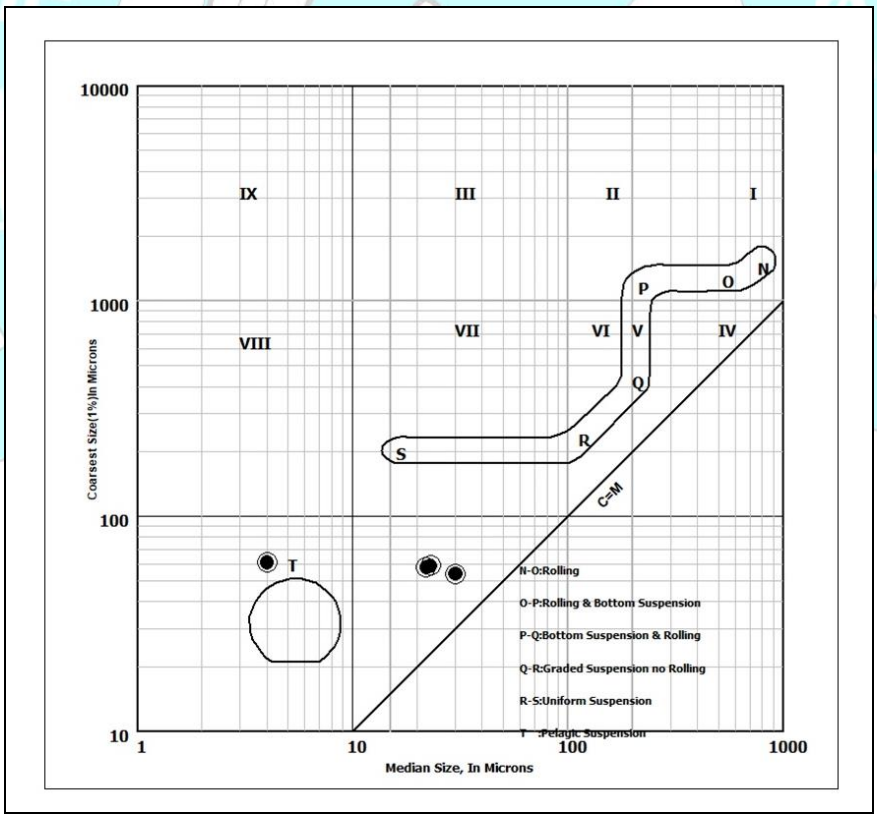


Fig. 15 *C-M plot for Tractive Current deposits.*

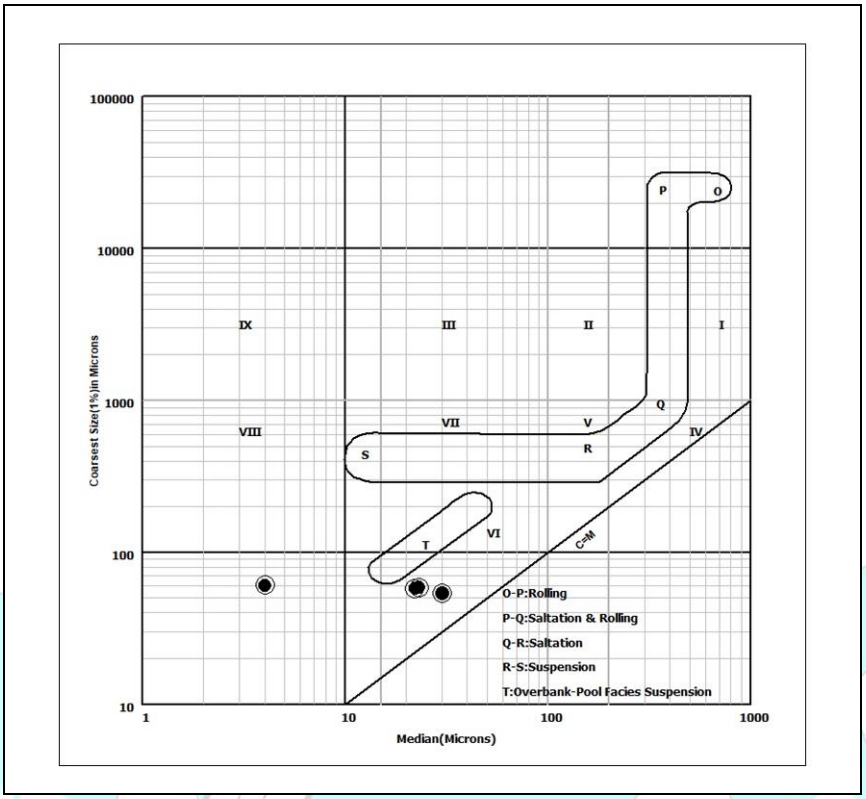


Fig. 16 C-M plot for the mode of deposition.

Table 7 Particles size distribution statistics details

PSD	Sample 1	Sample 2	Sample 3	Sample 4
D1	58.6	54.5	61.25	57.66
D5	51.55	47.11	50.12	47.82
D10	48.17	43.43	45.04	42.88
D16	45.65	39.99	38.2	38.23
D20	44.38	38.28	34.61	35.99
D25	39.99	36.47	30.75	33.65
D30	35.99	34.89	24.51	31.64
D40	29.2	32.22	15.69	26.09
D50	23.49	29.78	3.79	21.96
D60	16.31	27.25	1.74	16.74
D70	7.73	24.49	1.33	7.91
D75	2.96	23.1	1.15	2.45
D80	1.67	20.75	0.98	1.71
D84	1.4	17.26	0.85	1.44
D90	1.01	6.28	0.65	1.04
D95	0.67	1.39	0.46	0.68

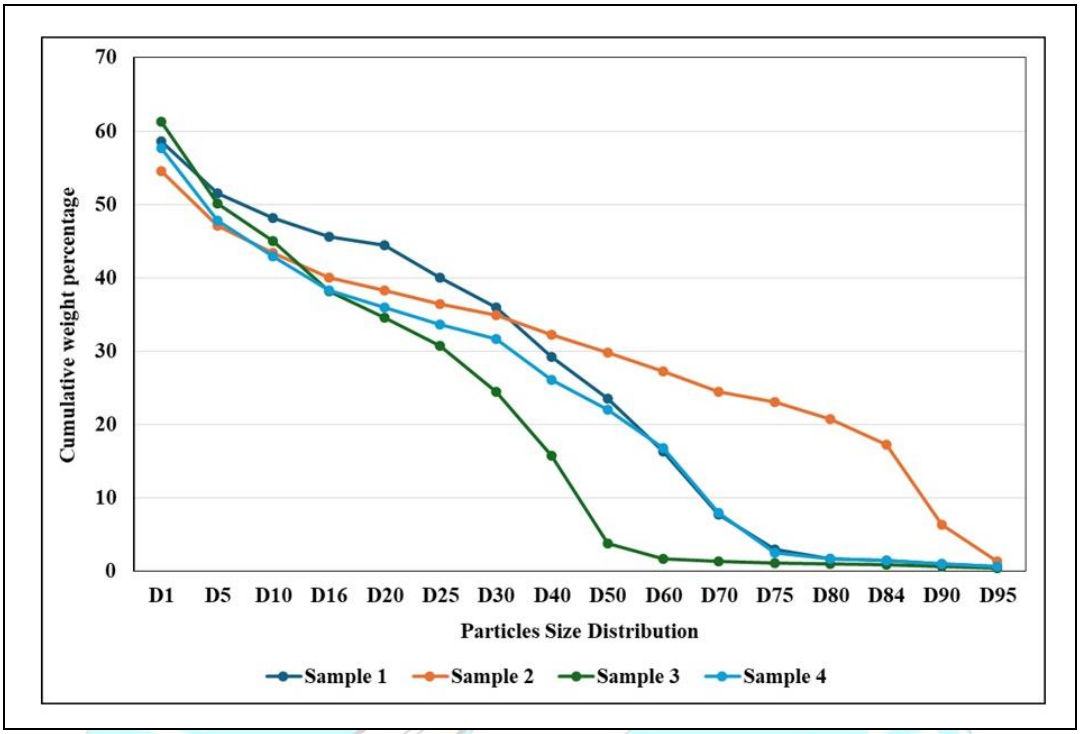


Fig. 17 Combined cumulative graph for Sediment particle size distribution.

Fig. 18 (a) Field Photographs: Built Up or Reclaimed land.

Fig. 18 (b) Field Photographs: Coastal vegetation.

Fig. 18 (c) Field Photographs: Inter-tidal/ Mudflat

Fig. 18 (d) Field Photographs: Scrub land.

5.4 Inference

The present study demonstrates the ecological and environmental sensitivity of Phase III, Dahej Adani Petronet Port (Gujarat), India which is significantly impacted by the land reclamation for the expansion of ports. The transformation of mudflat, coastal vegetation, and scrubland into built-up areas for various purposes, such as economic activities encompassing commercial and industrial sectors, as well as transportation networks, serves as evidence of the evolving land use and land cover patterns in this region over time.

Figures 6, 7, 8, and 9 show the types of land uses for six different periods (2015, 2016, 2018, 2020, 2022, and 2024), while Table 4 shows the area-wise distributions. In 2015, the built-up area accounted for only 0.65 hectares (2.71%) of the total land. During the initial phase of land reclamation in the study area, which started in 2016 as per the EC, the built-up area increased to 4.56 hectares (18.91%) and converted to 57.20% of total land in 2024.

The study also examines the pace of development in mud flats, coastal vegetation, and scrubland. The mudflat area has significantly decreased, from 20.49 hectares (85.38%) in

2015 to 5.76 hectares (23.89%) in 2024, for a total fall of 61.49%. One of the most significant changes seen is that the built-up area is rapidly expanding towards the northern, central, and southeastern regions of the study area. This demonstrates how land transformations affect the environment. Another key observation is that mudflats and scrublands are decreasing in proportion to the increase in built-up areas. Thus, the increase in built-up areas and roads while decreasing mudflat and scrub land demonstrates the spatiotemporal dynamics of land use and land cover changes in the study area, which must be considered in order to address future coastal land use issues. Effective land use and land cover management strategies are essential for fostering environmental sustainability and the efficient use of natural resources.

6 Remedial measures and recommendations

6.1 Field Observations

During our survey on January 29, 2024, we observed that the proposed reclamation area (7 hectares) is mudflats in nature (Figs. 18a–d). Scanty halophytic vegetation covered the site's mudflats. Mangroves and mudflats that are biologically active are classified as CRZ-1A and are protected under the CRZ (Coastal Regulation Zone) notification 2011 issued by the government of India under the Environmental (Protection) Act, 1986. However, mudflats that are not associated with an active tidal mechanism are generally referred to as paleo/inactive mudflats. Mudflats at the present vicinity site were found internally laminated with tidal clays and are classified as CRZ IB as per the CRZ classification, which is shown in Fig. 11.

6.2 Mangrove monitoring

The mangrove swamp is an association of halophytic trees, shrubs, and other plants growing in brackish to saline tidal waters of tropical and subtropical coastlines. They are the coastal swamps bordering major deltas of the country. A few mangrove saplings belonging to Avicennia marina have been observed near the proposed project site. Since there was no sparse or dense mangrove cover at the location, data on species composition, density, and canopy density, as well as surveillance monitoring and mapping of the mangroves' distribution, were not needed or gathered. However, it is important to take precautions to ensure that any activity or disturbance created during the reclamation of the planned site does not negatively affect the area where mangrove saplings were observed near the proposed site. Activities at the site will have a slight impact on the nearby terrestrial *Prosopis juliflora* patch.

6.2.1 Restoration of mangroves

Mangrove-degraded sites should be identified for mangrove plantations. Additionally, it is advisable to employ the common restoration techniques used on India's west coast, particularly in Gujarat state.

6.2.2 Site and species selection

A place, where mangroves have recently been present or where mangroves are currently in decline would be the ideal location for mangrove restoration. In open and scarce mangrove ecosystems, mangrove plantations may be established. The primary factor affecting the restoration or rehabilitation of mangroves is species selection. Three species of mangroves are employed in plantations in Gujarat: *Avicennia marina, Ceriops tagal,* and *Rhizophora mucronata*. *A.marina*, because of its environmental plasticity—it can withstand fluctuations in salinity, temperature, and light intensity—and its ability to adapt to various soil conditions, and is the favoured candidate species (Ye et al. 2005; Patel et al. 2010). Furthermore, *A. marina* exhibits good success rates due to its greater growth rates, ease of availability of seed, tolerance to protracted drought conditions, and faster germination rate in high salinity waters.

6.2.3 Tidal flushing pattern

Plantations should be established in intertidal areas with a mild gradient and at least 15 days of good tidal flushing per month. The optimum location for mangrove plantations in Gujarat is the mid-tidal zone of the intertidal belt at spring tide, which has a high tidal amplitude and is also favourable for other factors including tidal velocity, sediment type, and slope.
The proximity of a plantation site to the lowest tidal area may result in erosion and seedling collapse, whereas in a high tidal location, the seedlings would not have enough days to be flushed with seawater. It is important to choose an intertidal zone that is not excessively both convex and concave since a concave location will result in water logging and a convex site will create a high velocity of receding tide.

6.2.4 Abiotic parameters of the plantation site

Measuring environmental factors like pH, sediment texture, and salinity of the water and sediment can help us better understand how to grow and maintain mangroves. Salinity levels of 35 to 40 PSU are appropriate and within acceptable limits for species such as *A. marina*. The recommended pH range for plantation water is 6-8.5 close to the substrate.

6.3 Planting methods

Four types of plantation techniques are used:

- Transplantation of nursery-raised saplings
- Raised bed plantations (Otla method)
- Direct propagule/seed sowing (locally known as Sing plantation)
- Fishbone canal plantations

6.3.1 Raised bed plantations

This particular plantation process is unique and exclusive to Gujarat. The plantation technique works well in Gujarat's unsheltered intertidal zones because of the state's high tidal amplitude. Using this procedure, mangrove propagules, measuring 15 to 20 cm in length, are seeded on the surface of a raised bed of clay mounts that have been raised to a height of 15 to 30 cm.

More than 400 raised beds may be constructed per hectare, and with varied arrangements, that number could reach 1500 beds. The tidal velocity in the ebb and flow tidal currents is decreased by raising the mounts in each row in an alternative manner. Raised earthen mounts help to prevent the uprooting of planted saplings and propagules in coastal stretches with moderate tidal currents by countering the ebb and flow of the currents. The main concern with this approach is that seedlings may be exposed in areas with significant tidal currents and sediment erosion, and they may be overturned and swept away by the currents.

6.3.2 Direct propagule/seed sowing (locally known as Sing plantation)

In sheltered intertidal zones, this technique is applied. The land should be cleansed of algae and other biotic and abiotic materials before planting is started. In order to increase the survival rate, this technique is commonly employed to supplement other plantation methods. The technique involves dibbling seeds or propagules of the targeted mangrove species onto the substrate and is less expensive and labour-intensive.

A single propagule is dibbled for *C. tagal* and *R. mucronata*, whereas a group of five to six seeds is dibbled for *A. marina*. 1 x 1 meter is the ideal spacing between each seed or propagule; propagules should be dipped in such a way that about two-thirds stay outside the sediment and one-third are inside the substrate. The only concern with this type of plantation is the poor survival rate after the first round of dibbling.

6.3.3 Fishbone canal plantations

The intertidal areas that are high and do not experience regular tidal inundation are the most suited for this strategy. However, the land will be appropriate for mangrove development if flooding conditions are favourable. Using a technique akin to the bone structure of fish, canals or channels are excavated. The main canal, which is designed to open into sea waters, is known as the main canal. Secondary canals, which are designed to be 45-degree aligned, are known as distribution/feeder canals. The main canal should have a depth of around 1.25 m and a width of 3 m at its top and 2 m at its bottom. While the width of the feeder canal at the top and bottom should be preserved at 1 m and 0.80 m, respectively, the height should be 1 m. Plantation of mangrove saplings is suggested at 1/3rd slope of the feeder canal and the area between two consecutive feeder canals.

In Pichavaram, Tamil Nadu, mangrove forests, MSSRF (MSSRF, 2002) has effectively shown this technique. Several models have been built since the technique was first used in 1987 in the mangrove forests of Muthupet, Tamil Nadu (Baruah, 2004).

6.3.4 Transplantation of nursery-raised saplings

Transplanting nursery-raised saplings is the most dependable and effective approach for creating viable mangrove plantations. This approach takes longer than other plantations, but it is more expensive and labour-intensive. With this plantation approach, however, the likelihood of crabs harming the saplings is extremely low. It is advised to build a nursery on the plantation site since it will allow for an extended period of plantation activities and the availability of ready-made seedling stock for planting when it is appropriate.

The selection of site and seed for developing mangrove nursery site should be selected in the intertidal tidal area preferably in the vicinity of the creek.

The nursery that is intended for planting needs to be well-connected to roads and waterways, and it should be secured. It is necessary to gather mature seeds or propagules from the nearby mangrove areas with the assistance of the local community. Knowledge of botanist expertise is crucial to know when the local flowering and fruiting seasons are. *Avicennia marina, Ceriops tagal, Rhizophora mucronata,* and *Aegiceras corniculatum* are the four species for which seed/propagule collections are maintained in Gujarat for nursery growing. Table 8

provides the specifications regarding the collecting of seeds and propagules. Healthy, fully grown seeds or propagules ought to be selected for the nursery and for rapid germination of seeds, soaking seeds in fresh water for 24 hours before immersing them in sediment is desirable.

Table 8: Seed/propagule collection information*

Species	Seed availability period	Maximum storage period of seed/propagule
Avicennia marina	July – October	10 days
Ceriops tagal	March-May	10 days
Rhizophora mucronata	June- October	10 days
Aegiceras corniculatum	September - May	7 days

*Information from Training manual for mangrove plantation in Gujarat, GEC-ENVIS

Muddy silt that is naturally clayey is used to prepare nursery bags. For filling the nursery's biodegradable polythene bags, soft clayey mud free of debris and hard materials should be gathered from neighbouring creeks during low tide. To raise the saplings, nursery bags made of polythene measuring 5 by 8 inches could be utilized. To allow extra water to drain, tiny holes were punched out of the bottom of the bag, which was then stored in the shade to solidify.

A nursery bag typically holds 1000 bags in an arrangement. Typically, raised beds measuring about 20 cm are used in Gujarat instead of sunken nursery beds, which measure 10 m in length, 1 m in width, and 0.2 m in depth. Raised beds effectively block tidal currents and avoid the issue of water logging. A nursery bed kept partially shaded by the surrounding vegetation will increase the rate of survival. Facilities for the input and outflow of tidal water are necessary for nurseries because stagnant water kills saplings and seedlings. In Table 9, tidal flushing information is given.

Table 9: Flushing requirement for mangrove saplings

Species	Flushing frequency per month	Pest/Threats
Avicennia marina	Minimum 15 days	Crab, and algal encrustation
Ceriops tagal	Minimum 20 days	Crab, caterpillar, and algal encrustation
Rhizophora mucronata	Minimum 15 days	Crab, caterpillar, and algal encrustation
Aegiceras corniculatum	Everyday flushing	Crab, and caterpillar encrustation

After being successfully raised in the nursery, saplings between 30 and 45 cm tall should be chosen at different times to be transplanted at the intended location. To achieve the intended final tree density of 2400/ha, with 10% mortality of planted saplings, a spacing of 2 x 2.5 m must be observed. Below are the specifications of the plantation's sapling height and germination period (Table 10).

Table 10: Appropriate height of sapling for plantation

Species	Germination period (days)	Germination percentage	Height (cm)of saplings
Avicennia marina	6-10	70-80	40-45
Ceriops tagal	35-40	80	60-70
Rhizophora mucronata	30-35	50-60	60
Aegiceras corniculatum	35-45	50-60	70

As an alternative to building a nursery, healthy raised mangrove saplings could be acquired from the Gujarat Forest Department's neighbouring nurseries for transplantation. The Principal Chief Conservator of Forests and Head of the Forest Force, Government of Gujarat, has a website (https://forests.gujarat.gov.in/nursery-on-map.htm) that contains information about every nursery in the state along with a map of that nursery.

6.3.5 Monitoring after plantation

Following the transplantation of mangrove saplings using the aforementioned techniques, the saplings must be regularly observed. Young plants are more vulnerable to insect, barnacle, and crab attacks once they have grown. If algae or barnacles are discovered on the saplings, they must be removed. Increasing mangrove vegetation in regions, where it once existed, is the primary goal of mangrove restoration. When the environment has been altered to the point, where natural regeneration is impossible, mangrove restoration is frequently advised. Effective conservation management requires the involvement of local communities in the restoration process.

6.3.6 Green belt development

During our investigation, it was observed that the immediate proximity of the proposed site was dominated by exotic species, such as Prosopis juliflora. On the landward side of the project's proposed location, the same species was observed to be growing. It is suggested to create a green belt around the planned project site following CPCB's standards for greenbelt development (Programme objective series: PROBES/75/1999-2000). Green belts are generally advised to be planted with plants tolerance to the present environmental conditions, although it is quite difficult to say with certainty that the species will flourish and establish.

6.3.6.1 Methodology

- Observed the exotic species *Prosopis juliflora* close to the planned project site; as a result, it is advised that native species be used for new plantations.
- Exotic or undesirable plants, weeds, and items like stones, plastics, etc. should be removed before planting.
- Pits measuring 1 m by 1 m with a depth of 1 m should be dug; for smaller trees and shrubs, pits measuring about half of this size should be dug. The depth of the pits has been carefully considered to prevent plant roots from curled up once planting material has been added.
- Since the surrounding area water is saline, planting native plant seedlings there should be followed by the addition of a rich soil made up of earth, sand, silt, and organic manure to improve plant survival.

- Pits should receive abundant irrigation, and growing plants require special attention during the first three years due to ideal drainage and climate conditions.
- For plantation, trees 3 to 5 m in height and shrubs between 1 and 1.5 m in height are suitable plant choices. Following planting, it is important to make sure that the plants are receiving enough nutrients, are not experiencing water stress, and are exposed to a sufficient amount of light and wind.
- When there are prolonged periods of rain that result in runoff, usually in July or August, planting should take place. The ideal age for the seedlings is between nine and twelve months. Twenty litres of water per pit should be added as soon as the pits are planted, and if there isn't any rain, it should be irrigated at a rate of 20 litres per pit every two weeks. Plant mortality has been estimated to be 10%, hence re-digging the pit should be done before replacing a single plant.
- Three-tier greenbelt is proposed which is composed plantation of small bushes, shrubs and trees. Native species such as *Hamelia patens* (small bushes), *Calotrophis procera* (scrub) and Tree species such as *Azadirachta indica*; *Pongamia pinnata; Tectona grandis*, etc. are recommended as greenbelt plantation species around the proposed site area.
- However, the natural component of the bioclimate must be taken into consideration when choosing plant species for plantations. Given that the planned site is close to the sea, care should be taken while selecting native plant species that can withstand salinity and salt sprays. Apart from the above-mentioned species, other plant species in Appendix C of their instructions, CPCB (Programme goal series – PROBES/75/1999-2000) has recommended plant species for greenbelts based on agro-climatic zones and their subzones.
- The plantation of *Conocarpus lancifolius* should be avoided, as the plantation is banned by the Gujarat Forest Department.
- After the plantation, monitoring of plants is inspected, damaged plants should be replaced with new plants.

6.4 Intertidal Mudflats

Intertidal mud flats are the most unvegetated areas that are alternately exposed and inundated by the falling and rising of the tide. They may be mudflats or sand flats depending on the coarseness of the material of which they are made. In mud flats, algae predominate over vascular plants in terms of primary production. Worms and clams that filter and digest microalgae and debris find homes in intertidal/mud flats. At low tide, wading birds and beach birds consume these worms and clams, while at high tide, fish and crabs do the same. The proposed site is intertidal/mudflats, which were found to be saline and barren during the study and not biologically active under the current conditions. Since there is very little vegetation on the site now, significant vegetation removal is not required to develop the proposed reclamation.

6.4.1 Restoration of intertidal/mudflat

Mangroves are planted in mudflats to restore them in numerous places; nevertheless, experts believe that this intentional "conversion" of natural mudflats into artificial mangrove plantings is not the same as "restoration." Millions of molluscs, migrating birds, and other organisms rely on mudflats as essential ecosystem components in the intricate intertidal coastal zone for their survival.

To make the intertidal mudflats more frequently washed by tidal waters, it is suggested the deepening of the tidal entrance channel in our proposed site or nearby. As an alternative, the mudflat's silt may be cleared to guarantee a low enough tidal elevation to permit frequent flooding and mudflat development. This will help in the dispersal of macro and meio benthic species, which includes subtle larvae of mega benthic fauna. It is important to avoid disturbing intertidal mudflats while using this restoration technique since in future it could biologically activate, providing a home for a variety of benthic invertebrates and facilitating the natural colonization of mangroves from nearby places. The restoration of the coastal natural ecological environment and building of coastal natural conservation areas by narrowing and widening mouths promotes the creation of natural intertidal habitat.

7 Summary and Conclusion

- This study presents a comprehensive analysis of the environmental impact assessment due to the expansion of Phase III at the Adani Petronet (Dahej) Port Limited, Dahej, Gujarat (Fig. 1).

- The region was approved for 23 hectares of land reclamation (Annexure 1), out of which 16 hectares of the area have already been reclaimed and reclamation work has yet to be started on the remaining 7 hectares of area.

- The satellite images and other available archived satellite data for the study area have been used to map the presence of mudflats and mangroves in the study area.

- The sensitivity of the study area before the reclamation and the proposed expansion project on the study area is being analysed.

- Due to the rapid expansion of port developmental activities, the built-up area has increased from 2.71% in 2015 to 57.20% at present, while the mud flat has significantly decreased from 85.38% in 2015 to 23.89% in 2024.

- The mudflat area has experienced a substantial decline, decreasing from 20.49 hectares (85.38%) in 2015 to 5.76 hectares (23.89%) in 2024, resulting in a total reduction of 61.49%.

- The study reveals that 1.89 hectares (80.08%) of the total area of coastal vegetation have been converted into built-up land.

- Sediment samples collected at the Phase III expansion area at Adani Petronet (Dahej) Port Limited, Dahej, Gujarat comprise nearly 99.55% mud and 0.45% sand, confirming that the area is mudflat.

- The site's mudflats were covered with scanty halophytic vegetation and did not reflect any mangrove patches in the areas.

- The study reveals that 1.89 hectares (80.08%) of the total area of coastal vegetation in 2015 and scanty mangrove plants would have been present at that time.

- The proposed project involves approved reclamation over 23 hectares of intertidal / mudflat area (16 hectares completed) for expansion of port activities. In that, 7 hectares are found inactive currently during this study.

- The conditions of EC (50 Ha mangrove plantation) should be executed as per the standard methodology mentioned in this report or by the standard procedures of the Forest Department, Govt of Gujarat, if not implemented.

- Considering the development activities and their impact on the environment, the conditions related to mangrove afforestation are adequate and need to be complied in totality. The compliance status is required to be submitted to concerned regulatory authorities on half yearly basis.

- Shoreline change study of the project area is also recommended after completion of the proposed reclamation over an area of 23 Ha. The report may be submitted to the concerned regulatory authorities.

- The suggested greenbelt development of 6 hectares should be followed within the project area as per CPCB's standards or Gujarat State Government guidelines.

Abbreviations

CPCB – Central Pollution Control Board

CRZ – Coastal Regulation Zone

GEC ENVIS – Gujarat Ecology Commission Environmental Information Systems

MSSRF - M S Swaminathan Research Foundation

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End of Document

ANNEXURE 1

F. No. 11-37/2007 - IA III
Government of India
Ministry of Environment, Forest & Climate Change
(I.A. Division)

Indira ParyavaranBhawan
Aliganj, Jorbagh Road,
New Delhi -110003

Telefax:011: 24695398
Dated: 14th October, 2016

To,

The Managing Director,
M/s Adani Petronet (Dahej) Port Pvt Ltd.
Adani House,
Near Mithakhali Circle,
Navarangapura, Ahmedabad
Gujarat

E-mail: gudena.rao@adani.com; Phone: 079-25555603;

Subject: Expansion of Adani Petronet (Dahej) Port Private Limited, Dahej, Bharuch District, Gujarat by M/s Adani Petronet (Dahej) Port Pvt Ltd. –Environmental and CRZ Clearance reg.

Ref.: Your online proposal no. IA/GJ/MIS/30886/2013 dated 14th March, 2016.

Sir,

This has reference to your online proposal no. IA/GJ/MIS/30886/2013 dated 14th March, 2016 alongwith project documents including Form I, Terms of References, Pre-feasibility Report, EIA/EMP Report regarding above mentioned project.

2.0 The Ministry of Environment, Forest and Climate Change has examined the application. It is noted that the proposal is for expansion of Adani Petronet (Dahej) Port Private Limited, Dahej, Bharuch District, Gujarat. M/s Adani Petronet (Dahej) Port Private Limited (APPPL) has proposed to developed additional area for coal stockpiles, back up equipment's, coal storage silo at railway siding and other supporting infrastructure and to *expand* its cargo handling facility from 11.7 MMTPA to 23 MMTPA by proposing the following activities:

(i) Reclamation to the tune of 23 Ha Contiguous lands to the existing back-up area to store and handle multipurpose cargo.
(ii) Optimal utilization of existing back-up area for coal storage and handling of other designated cargo. Additional coal stock pile to be developed for storage of 1.1 Million Tonnes.
(iii) Widening of existing 15 m wide rubble bund to 60 m wide to handle project cargo (i.e. ODC).
(iv) Existing Ramp being used for port crafts and tugs will be strengthened to handle project cargo.

(v) Mechanization of south jetty to handle coal cargo.

(vi) Rail loading silo and other supporting infrastructure facilities.

(vii) No dredging, Break water, Jetties are proposed.

(viii) The overall Capacity and productivity of terminal will increase from 11.7 MMTPA to 23 MMTPA .

3.0 The proposal includes other cargoes like Steel, Gypsum, Project cargoes, Silica sand etc. It is reported that no national park, marine parks, sanctuaries, reserve forests, wildlife habitates, biosphere reserves are located at the project site. Mudflats are present at project site, which is reported to be biologically insensitive. Coastal areas rich in mangroves are located at Ban Khadi (7 km from the project site); Ghugar khadi (10.5 km) and Narmada Estuary (12 Km). Nearest water bodies /reservoirs are Lakhabava pond (1.3 km), Ambetha pond (6.8 km), Jolva Pond (13.4 km), Sabarmati Pond (4.3 km) and Narmada Estuary (3 Km). Marginal fishing is done by about 50 fishermen from Jageshwar village along the shore. Cost of expansion project is Rs. 464.32 Crore. Out of which, Rs 171.65 Crore and Rs 173.35 Crore are earmarked towards capital cost and recurring cost per annum for environmental management plan.

4.0 APPPL has developed the said port in phased manner. Existing berths, jetty, rubble bund, stack yard and supporting infrastructure were developed in phase-1. The CRZ clearance for phase-1 was accorded on 6th July, 2007 by MoEF. In phase-II, 38 ha of forest land were diverted for port backup area. MoEF granted environmental clearance for the same on 11th November, 2008. PP has submitted the copy of letter no 6-GJC060/2006- BHO/1508 dated 16.06.2008 issued by MoEF&CC, Regional office, Bhopal for diversion of 38.00 ha. of forest land. Current proposal of APPL, intends to expand Dahej Port under Phase-III.

5.0 Air pollution control measures will be taken to reduce the fugitive coal dust emissions viz. (i) water spray nozzle will be provided at the top of the mobile hopper; (ii) conveyor belt with hood and water spray arrangement to reduce the dust; (iii) at all transfer tower dry fog dust suppression system will be provided; closed transfer towers will be provided. Stacker cum reclaimer with water spray nozzles and use of mist canon for dust suppression during stacking will be provided (iv)water sprinkling in the coal storage yards, wind breaker of 14 m height and greenbelt along storage yard will be provided; (v) tyre washing system will be provided to minimize the dust problem; (vi) dust suppression system at the conveyor belt just before the chute will be provided at filling of silo for railway rack loading; (vii) Dry fog dust suppression system shall be provided to suppress the coal dust; water spray nozzles shall be provided to suppress the dust during wagon filing at railway rack loading. The total water demand for the proposed project will be increased from 600 m^3/day to 4500 m^3/day after expansion. Source of water supply is GIDC water supply. Water used for dust suppression system is collected in a solar evaporation pond. The collected water will be evaporated through solar evaporation and the sludge generated from the pond is sent to coal yard for recycling. Sewage will be treated in the sewage treatment plant (STP). The total power demand is estimated as 7000KVA. STP will be set up in modular phases for management of sewage. It is proposed to develop total greenbelt in an area of approximately 6 ha. within the project area. Existing greenbelt alignment on the north side and south side will be extended towards sea in the width of 5 m on both side of proposed reclamation area of 23 ha. On the eastern side (landward side) greenbelt area will be developed in the width of 5m.

6.0 Public hearing was held on 18th March 2015.

7.0 Gujarat Coastal Zone Management Authority vide letter no. ENV-10-2015-171-E dated 14th March, 2016 has recommended the proposal to MoEF&CC to grant CRZ clearance for proposed Phase- III expansion project at Dahej by M/s Adani Petronet (Dahej) Port Ltd. It is also reported that as per CRZ map duly demarcation of HTL CRZ Boundary etc. prepare by the National Centre for Earth Science Studies, Thiruvananthpuram, the proposed activities falls within CTZ-I (B), CRZ – III Categories, which are permissible as per CRZ Notification, 2011.

8.0 All the projects related to Ports and Harbour i.e. ≥5 million TPA of cargo handling capacity (excluding fishing harbours) are listed at 7(e) of schedule of EIA Notification, 2006 covered under category 'A' and appraised at central level.

9.0 The proposal was considered by the Expert Appraisal Committee (Infrastructure-2) in its meetings held during 28th- 30th October, 2013 and 28th – 29th March, 2016 respectively. Project Proponent and the EIA Consultant namely M/s Cholamandalam MS Risk Services Limited, have presented EIA / EMP report as per the TOR. EAC has found the EIA / EMP Report and additional information to be adequate and in full consonance with the presented TORs. The Committee recommended the proposal for environmental and CRZ clearance.

10.0 As per the recommendations of EAC, the Ministry of Environment, Forest & Climate Change hereby accords Environmental and CRZ Clearance for the above-mentioned project "Expansion of Adani Petronet (Dahej) Port Private Limited, Dahej, Bharuch District, Gujarat by M/s Adani Petronet (Dahej) Port Pvt. Ltd.", under the provisions of the Environment Impact Assessment Notification, 2006 & Coastal Regulation Zone (CRZ) Notification, 2011 and amendments thereto and Circulars issued thereon and subject to the compliance of the following specific conditions, in addition to the general conditions mentioned below:

A. SPECIFIC CONDITIONS:

(i) 'Consent for Establish' shall be obtained from State Pollution Control Board under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974.

(ii) Construction activity shall be carried out strictly according to the provisions of CRZ Notification, 2011. No construction work other than those permitted in Coastal Regulation Zone Notification shall be carried out in Coastal Regulation Zone area.

(iii) The Project proponent shall ensure that there shall be no damage to the existing mangorves patches near site and also ensure the free flow of water to avoid damage to the mangroves.

(iv) The Project proponent shall ensure that no creeks or rivers are blocked due to any activities at the project site and free flow of water is maintained.

(v) Shoreline should not be disturbed due to dumping. Periodical study on shore line changes shall be conducted and mitigation carried out, if necessary. The details shall be submitted along with the six monthly monitoring report.

(vi) The commitments made during the Public Hearing and recorded in the Minutes shall be complied with letter and spirit. A hard copy of the action taken shall be submitted to the Ministry.

(vii) All the conditions stipulated in the earlier Clearance including the recommendations of Environment Management Plan, Disaster management Plan shall be strictly complied with.

(viii) The material for reclamation shall be sourced only through Government approved quarry. The quarried material shall be free from all kinds of contamination and high organic carbon contents. The same should be tested prior to reclamation.

(ix) The coal shall be stored only in designated stock yard with dust control measures viz. wind screen of height at least 2 m above the coal stock, made of fabric/HDPE, water sprinkler arrangement, green belt of at least three layers of suitable trees and scrubs.

(x) The coal from the ships shall be conveyed through closed conveyor to the cola stock yard. The conveyor shall be seamless without joints/transfer points.

(xi) The dust from the roads shall be periodically cleaned and dust suppression by water spray be carried out.

(xii) The mangrove plantation of 50 ha shall be under taken in consultation with Gujarat Ecology Commission / State Forest Department.

(xiii) Cargo shall be unloaded directly into hopper from the ship and transported to the stack yards through closed conveyor system only. Inbuilt dust suppression systems shall be provided at hoppers and all the transfer points / storage yards. Cargo shall not be unloaded directly onto the berth. Water meters shall be provided at different locations to record the consumption of water used for dust suppression and daily log shall be maintained.

(xiv) Disposal sites for excavated material should be so designed that the revised land use after dumping and changes in the land use pattern do not interfere with the natural drainage.

(xv) The ground water shall not be tapped within the CRZ areas by the PP to meet with the water requirement in any case.

(xvi) Necessary arrangements for the treatment of the effluents and solid wastes must be made and it must be ensured that they conform to the standards laid down by the competent authorities including the Central or State Pollution Control Board and under the Environment (Protection) Act, 1986.

(xvii) All the operational areas will be connected with the network of liquid waste collection corridor comprising of storm water, oily waste and sewage collection pipelines.

A-1

(xviii) Marine ecology shall be monitored regularly also in terms of sea weeds, sea grasses, mudflats, sand dunes, fisheries, echinoderms, shrimps, turtles, corals, coastal vegetation, mangroves and other marine biodiversity components as part of the management plan.

(xix) The marine ecology management plan being drawn up with regards to the environmental impacts of natural disasters, oil spills and other wastes, dredging and dumping on marine ecology (all micro, macro and mega biotic components) shall be scrupulously implemented. It shall be ensured that the marine ecology in the area of influence is not adversely affected.

(xx) Marine ecology shall be monitored regularly also in terms of all micro, macro and mega floral and faunal components of marine biodiversity.

(xxi) Measures should be taken to contain, control and recover the accidental spills of fuel and cargo handle.

(xxii) All the mitigation measures submitted in the EIA report shall be prepared in a matrix format and the compliance for each mitigation plan shall be submitted to the RO,MoEF&CC along with half yearly compliance report.

(xxiii) Ships/barges/vessels shall not be allowed to release any oily bilge waste or ballast water in the sea. Any effluents from the Jetty which have leachable characteristics shall be segregated and recycled/disposed as per SPCB guidelines. Ships/vessels calling at the jetty shall not dump waste/bilge water during the berthing period.

(xxiv) Location of DG sets and other emission generating equipment shall be decided keeping in view the predominant wind direction so that emissions do not effect nearby residential areas. Installation and operation of DG sets shall comply with the guidelines of CPCB.

(xxv) All the mechanized handling systems and other associated equipments such as hoppers, belt conveyors, stacker cum reclaimers shall have integrated dust suppression systems. Dust suppression systems shall be provided at all transfer point.

(xxvi) No product other than permitted under the CRZ Notification, 2011 shall be stored in the CRZ area.

(xxvii) The quality of treated effluents, solid wastes, emissions and noise levels and the like, from the project area must conform to the standards laid down by the competent authorities including the Central or State Pollution Control Board and under the Environment (Protection) Act, 1986.

(xxviii) All the mitigation measures suggested in the EIA report and the marine environment study of CWPRS, Pune shall be implemented. The compliance for each of these measures shall be submitted to concerned SPCB and R.O. of this Ministry along with six monthly compliance reports.

(xxix) It shall be ensured by the Project Proponent that the activities does not cause disturbance to the fishing activity, movements of fishing boats and destruction to mangroves during the construction and operation phase.

(xxx) The Project Proponent shall take up and earmark adequate fund for socio-economic development and welfare measures as proposed under the CSR Programme. This shall be taken up on priority.

(xxxi) The project proponent shall set up separate environmental management cell for effective implementation of the stipulated environmental safeguards under the supervision of a Senior Executive.

(xxxii) The funds earmarked for environment management plan shall be included in the budget and this shall not be diverted for any other purposes.

(xxxiii) The proponent shall abide by all the commitments and recommendations made in the EIA/EMP report so also during their presentation to the EAC.

(xxxiv) Company shall prepare operating manual in respect of all activities. It shall cover all safety & environment related issues and system. Measures to be taken for protection. One set of environmental manual shall be made available at the project site. Awareness shall be created at each level of the management. All the schedules and results of environmental monitoring shall be available at the project site office.

(xxxv) Corporate Social Responsibility:

a. The Company shall have a well laid down Environment Policy approved by the Board of Directors.
b. The Environment Policy shall prescribe for standard operating process/procedures to bring into focus any infringements/ deviation/violation of the environmental or forest norms/ conditions.
c. The hierarchical system or Administrative Order of the company to deal with environmental issues and for ensuring compliance with the environmental clearance conditions shall be furnished.
d. To have proper checks and balances, the company shall have a well laid down system of reporting of non-compliances/ violations of environmental norms to the Board of Directors of the company and/or shareholders or stakeholders at large.

B. GENERAL CONDITIONS:

(i) Appropriate measures must be taken while undertaking digging activities to avoid any likely degradation of water quality.

(ii) Full support shall be extended to the officers of this Ministry/ Regional Office at Bhopal by the project proponent during inspection of the project for monitoring purposes by furnishing full details and action plan including action taken reports in respect of mitigation measures and other environmental protection activities.

(iii) A six-Monthly monitoring report shall need to be submitted by the project proponents to the Regional Office of this Ministry at Bhopal regarding the implementation of the stipulated conditions.

(iv) Ministry of Environment, Forest and Climate Change or any other competent authority may stipulate any additional conditions or modify the existing ones, if necessary in the interest of environment and the same shall be complied with.

(v) The Ministry reserves the right to revoke this clearance if any of the conditions stipulated are not complied with the satisfaction of the Ministry.

(vi) In the event of a change in project profile or change in the implementation agency, a fresh reference shall be made to the Ministry of Environment, Forest and Climate Change.

(vii) The project proponents shall inform the Regional Office as well as the Ministry, the date of financial closure and final approval of the project by the concerned authorities and the date of start of land development work.

(viii) A copy of the clearance letter shall be marked to concerned Panchayat/local NGO, if any, from whom any suggestion/ representation has been made received while processing the proposal..

(ix) A copy of the environmental clearance letter shall also be displayed on the website of the concerned State Pollution Control Board. The EC letter shall also be displayed at the Regional Office, District Industries centre and Collector's Office/ Tehsildar's office for 30 days.

11.0 These stipulations would be enforced among others under the provisions of Water (Prevention and Control of Pollution) Act 1974, the Air (Prevention and Control of Pollution) Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification 1994, including the amendments and rules made thereafter.

12.0 All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives, Fire Department, Civil Aviation Department, Forest Conservation Act, 1980 and Wildlife (Protection) Act, 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.

13.0 The project proponent shall advertise in at least two local Newspapers widely circulated in the region, one of which shall be in the vernacular language informing that the project has been accorded Environmental and CRZ Clearance and copies of clearance letters are available with the State Pollution Control Board and may also be seen on the website of the Ministry of Environment, Forest and Climate Change at http://www.envfor.nic.in. The advertisement should be made within Seven days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bhopal.

14.0 This Clearance is subject to final order of the Hon'ble Supreme Court of India in the matter of Goa Foundation Vs Union of India in Writ Petition (Civil) No.460 of 2004 as may be applicable to this project.

15.0 Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.

16.0 Any appeal against this Clearance shall lie with the National Green Tribunal, if preferred, within a period of 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010.

17.0 A copy of the clearance letter shall be sent by the proponent to concerned Panchayat, ZillaParisad/Municipal Corporation, Urban Local Body and the Local NGO, if any, from whom suggestions/representations, if any, were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent.

18.0 The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MoEFCC, the respective Zonal Office of CPCB and the SPCB.

19.0 The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEFCC by e-mail.

14/10/16

(A N Singh)
Scientist D

Copy to :-

1. The Principal Secretary, Forests & Environment Department, Government of Gujarat, Sachivalaya, 8th Floor, Gandhi Nagar - 382 010, Gujarat.
2. The Chief Conservator of Forests (Western Zone), Ministry of Environment & Forests, Regional Office, E-5, Arera Colony, Link Road -3, Bhopal -462 016, M.P.
3. The Chairman, Central Pollution Control Board Parivesh Bhavan, CBD-cum-Office Complex, East Arjun Nagar, New Delhi - 110 032.
4. The Chairman, Gujarat Pollution Control Board, Paryavaran Bhawan, Sector 10 A, Gandhi Nagar-382 043, Gujarat.
5. Monitoring Cell, Ministry of Environment, Forest and Climate Change, Indira Paryavaran Bhavan, *Jor bagh Road*, New Delhi.
6. Guard File/Monitoring File/Record File.

(A N Singh)
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