DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

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DEENDAYAL PORT AUTHORITY

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EG/WK/5202 (D)/Part (CRZ) 128 Dated: 30.06.2022

The Additional Secretary & Director (Environment), Govt. of Gujarat,
Forest & Environment Department,
Block No.14, 8th floor, New Sachivalaya,
Gandhinagar - 382 010.

Sub: CRZ Clearance for "Creation of water front facilities (Oil Jetties 8, 9, 10 & 11) and development of land of area 554 acres for associated facilities for storage at Old Kandla, Gandhidham, Kutch, Gujarat by M/s Deendayal Port Trust"- **Compliances of the stipulated conditions in CRZ Recommendations reg.**

Ref.: (1) Letter No. ENV-10-2018-24-T Cell dated 30/7/2020 of Director (Environment) & Additional Secretary, Forest & Environment Department, GoG.
(2) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/28 dated 29/06/2021
(3) DPT letter no. EG/WK/5202 (D)/ Part (CRZ 2)/142 dated 08/02/2022

Sir,

It is requested to kindly refer the above cited reference for the said subject.

In this connection, it is to state that, the Gujarat Coastal Zone Management Authority vide above referred letter dated 30/7/2020 had recommended the subject project of Deendayal Port Trust. Subsequently, the MoEF&CC, GoI had accorded the Environmental & CRZ Clearance vide letter dated 20/10/2020 for the subject project. Subsequently, DPT vide ref. 2 & 3 cited letter had submitted compliance report of the stipulated conditions for the period upto May, 2021 and for period June, 2021 to November, 2021 respectively.

Now, as directed under Specific Condition No. 26 mentioned in the CRZ Clearance letter dated 30/7/2020 i.e. ***A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the DPA on a regular basis to this Department and MoEF&CC, GoI,*** we have been regularly submitting the said report vide reference (2) & (3) cited letter. Further, please find enclosed herewith compliance report of the stipulated conditions for period upto May, 2022 along with necessary annexure, for kind information & record please **(Annexure I).**

....cont

Further, as per the MoEF&CC, Notification 5.0.5845 (E) dated 26.11.2018, in which it is mentioned that, "***In the said notification, in paragraph 10, in subparagraph (ii), for the words "hard and soft copies" the words "soft copy" shall be substituted***". Accordingly, we are submitting herewith soft copy of the same via e-mail in ID **gczma.crz@gmail.com** & **direnv@gujarat.gov.in** .

This has the approval of Chief Engineer, Deendayal Port Authority.

Yours Faithfully,

Manager(Environment)
Deendayal Port Authority

Copy to: -

Shri Amardeep Raju, MoEF&CC,GoI
Scientist E, Ministry of Environment, Forest and Climate Change,
& Member Secretary (EAC-Infra.1), Indira
Paryavaran Bhavan,
3rd Floor, Vayu Wing, Jor Bagh Road, Aliganj,
New Delhi-110003.
Email ID: ad.raju@nic.in

Annexure -I

Subject: Point-wise Compliance Status Report for CRZ clearance for proposed project for creation of water front facilities (oil jetties 8,9,10 and 11) and development of land (1432 acres – revised area 554 acres) for associated facilities for storage at old Kandla, Tal: Gandhidham Dist. Kutch, Gujarat by Deendayal Port Authority (Erstwhile Deendayal Port Trust) -reg

Ref No: - GCZMA CRZ recommendation vide Letter No- ENV-10-2018-24-T Cell dated 30.07.2020

S. No.	CRZ Conditions	Compliance Status
	SPECIFIC CONDITIONS	
1.	The DPA shall strictly adhere to the provisions of the CRZ Notification, 2011 issued by the Ministry of Environment, Forests and Climate Change, Government of India	It is assured that, the provisions of the CRZ Notification, 2011 shall be strictly adhere to by the DPA.
2.	Necessary permissions from different departments/ agencies under different laws/ acts shall be obtained before commencing any activity (including the construction)	The Consent to Establish (CTE) from the GPCB had already been obtained vide CTE No. 94118 granted by the GPCB vide letter no. PC/CCA-KUTCH 1524/GPCB ID 56985 dated 23/7/2018 (**Copy Annexure A**).
3.	The DPA shall ensure that that the all the provisions of CRZ Notification 2011 shall be complied with and storage facilities in CRZ areas shall be in compliance with Annexure-ll of the above said Notification	It is assured that all the provisions of CRZ Notification, 2011 will be complied with and only storage of permissible cargo as per CRZ Notification, 2011, Annexure II will be allowed to store in storage facilities to be developed.
4.	There shall not be any blockage of creek due to laying of pipeline. and free flow of water shall be maintained.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities). It is hereby assured that, no creeks or rivers shall be blocked, due to any activities at the project site and free flow of water will be maintained.
5.	There shall not be any mangrove destruction/ damage due to proposed activities and adequate buffer zone of 70 metres shall be maintained from mangrove areas	It is assured that all the proposed activities shall be carried out strictly as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020.
6.	The DPA shall effectively implement the Mangrove Development, Protection & Management plan for control of indirect impact on mangrove habitat	As per the directions of the GCZMA and MoEF&CC, GoI, till date (2005-06 to 2019-20), DPA had already undertaken Mangrove Plantation in an area of 1500 Ha. at various locations.

S. No.	CRZ Conditions	Compliance Status
		It is also relevent to submit here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA had already prepared & submitted a report on mangrove conservation and management plan formulated by Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted). Further, DPA appointed M/s GUIDE, Bhuj vide work order dated 1/9/2017 for "Regular Monitoring of Mangrove Plantation (1300 Ha.) carried out by DPA". DPA had already submitted final report along with compliance reports submitted to the GCZMA for the project of "Construction of 13th to 16th CB" dated 30/11/2019. Further, DPA appointed M/s GUIDE, Bhuj vide work order dated 03/05/2021 for "Regular Monitoring of Mangrove Plantation (1400 Ha.) carried out by DPA, Kandla". The report for period 2021-2022 is attached as **Annexure B**.
7.	The DPA shall have to make a provision that mangrove areas get proper flushing water and free flow of water shall not be obstructed	It is assured that necessary provisions will be made so that mangrove area get proper flushing water and to maintain free flow of water.
8.	The DPA shall have to dispose of the dredged material at the designated dredged material disposal point based on scientific study and approved by the MOEF&CC, GOI	No dredging activity has been started yet. However, it is assured that dredging activity will be carried out strictly as per the requirement of the condition and the same shall be disposed at designated dumping ground (25° 51′ 00″ N & 70°10′ 00″ E).
9.	The DPA shall have to maintain the record for generation and disposal of capital dredging and maintenance dredging	No dredging activity has been started yet. However, it is assured that necessary record will be maintained as per the requirement of the condition.
10.	No dredging, reclamation or any other project related activities shall be carried out in the CRZ area categorized as CRZ I (i) (A) and it shall have to be ensured that the mangrove habitat and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activities.	It is assured that all the project related activities will be strictly carried out as per the EC & CRZ Clearance accorded by the MoEF&CC, GoI dated 20/11/2020.

S. No.	CRZ Conditions	Compliance Status
11.	The DPA shall ensure that construction activities like dredging etc shall be caried out in confined manner to reduce the impact on marine environment.	No dredging activities have been started yet. However, it is assured that construction activities like dredging will be carried out as per the requirement of the condition.
12.	The DPA shall ensure that the dredging shall not be carried out during the fish breeding season	No dredging activities have been started yet. Point Noted for compliance.
13.	Construction waste including debris and dredged material shall be disposed safely in the designed areas as approved by MoEF&CC, GoI and it shall be ensured that there shall be no impact on flora and fauna	Point Noted for compliance.
14.	No effluent or sewage shall be discharged into the sea / creek or in the CRZ area and shall be treated to conform the norms prescribed by the Gujarat Pollution Control Board and would be reused / recycled as per the approval of the Board	It is assured that No effluent or sewage will be discharged into the Sea/creek or in the CRZ area. Further, the same will be treated in STP as per the norms prescribed by the GPCB.
15.	All the recommendations and suggestions given by the Cholamandalam MS Risk Services Limited in their Environment Impact Assessment report shall be implemented strictly by DPA	It is assured that all the recommendations and suggestions given by the EIA Consultant, M/s SV Enviro, Vizag in EIA Report will be implemented.
16.	The DPA shall exercise extra precautions to ensure the navigation safety and mitigation of the risk associated with the project activities especially due to collision, sinking or accidents of the vessels and would deploy the latest communication and navigation aids for this purpose. The proposed facilities shall also be covered under the VTMS being developed by the GMB	It is assured that emergency preparedness plan based on the Hazard Identification and Risk Assessment (HIRA) will be implemented.
17.	The cost of the external agency that may be appointed by this department for supervision / monitoring of the project activities during construction/ operational phases shall be paid by DPA	Point Noted.
18.	The DPA shall contribute financially for any common study or project that may be proposed by this Department for environmental management / conservation / improvement for the Gulf Kutch	Point noted for compliance.

S. No.	CRZ Conditions	Compliance Status
19.	The piling activities debris and any other type of waste shall not be discharged into the sea or creek or in the CRZ areas. The debris shall be removed from the site immediately after the piling activities are over	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities). Point Noted for compliance.
20.	The camps shall be located outside the CRZ area and the labour shall be provided with the necessary amenities, including sanitation, water supply and fuel and it shall be ensured that the environmental conditions are not deteriorated by the labours.	Point Noted for compliance.
21.	The DPA shall prepare and regularly update their Local Oil Spill Contingency and Disaster Management Plan in consonance with the National Oil Spill and Disaster Contingency Plan	Point Noted for compliance. DPA is already having Local Oil Spill contingency plan and updated DMP.
22.	The DPA shall bear the cost of the external agency that may be appointed by this Department for supervision / monitoring of proposed activities and the environmental impacts of the proposed activities	Point noted for compliance.
23.	The groundwater shall not be tapped to meet with the water requirements in any case	Point Noted for compliance.
24.	DPA shall take up greenbelt development activities in consultation with the Gujarat institute of Desert Ecology / Forest Department / Gujarat Ecology Commission	DPA has already developed Green belt in and around the Port area. Further, DPA assigned work for Green belt development in an area of about 32 hectares to the Forest Department, Govt. of Gujarat during August, 2019 at the cost of Rs. 352.32 lakhs. The work is completed. Further, DPA also undertook massive green belt development in and around the Port area and at Gandhidham area. Further, DPA also assigned the work of ***"Greenbelt Development in Deendayal Port Authority and its surrounding areas Charcoal Site (Phase I)"*** vide Work Order dated 31/05/2022 at the cost of Rs. 33.22 lakhs. The work is in progress.
25.	The DPA shall have to contribute financially for taking up the socio-economic upliftment activities in this region in consultation with the Forests and Environment Department and the District Collector / District Development Officer	As per the CSR Guidelines issued by the Ministry of Ports, Shipping & Waterways, Government of India, from time to time, DPA had undertaken CSR activities since the year 2011-12. The details of CSR Activities undertaken & planned is attached herewith as **Annexure C.**

26.	A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by DPA on a regular basis to this Department and MoEF&CC, GoI.	DPA has been regularly submitting the six-monthly report on compliance of the conditions mentioned in the CRZ Recommendation letter dated 30/7/2020 to the CRZ Authority and to the MoEF&CC, GoI.
27.	The DPA shall ensure that the numbers of the Vessels and machinery deployed during	Point Noted for compliance.

	marine construction, which are a source of low level organic and PHC pollution will be optimized to minimize risks of accidents involving these vessels.	Work is in progress (Oil Jetty No. 8 - Jetty & allied facilities).
28.	The noise level during transport and construction of marine facilities shall be kept minimum.	DPA appointed M/s Detox Corporation, Surat for Monitoring of environmental parameters since the year 2016. The work is in progress & DPA submitted monitoring data regularly to all the concerned authorities along with compliance reports submitted. The monitoring reports are attached herewith as **Annexure D**.
29.	The DPA shall regularly conduct the surveys to identify changes in the channel bathymetry to minimize navigation hazards. Proper navigational aids and guidance should be provided to ships navigating the channel and there should be a properly structured vessels traffic management strategy to avoid accidents.	Point noted for compliance.
30.	The DPA shall carry out separate study for further erosion and deposition pattern in the area after dredging through a reputed agency and shall follow the suggestions of the study done by reputed agency, for maintenance dredging, the recommendations /suggestions of the reputed agency shall be follow by the DPA.	No dredging activity has been started yet. However, it is assured that necessary will be conducted as per the requirement of the condition.
31.	Any other condition that may be stipulated by this Department and MoEF&CC, GoI from time to time for environmental protection / management purpose shall also have to be complied with by DPA.	Point noted.

Annexure -A

GPCB

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar** 382 010
Phone : (079) 23222425
(079) 23232152
Fax : (079) 23232156
Website : www.gpcb.gov.in

By R.P.A.D

CONSENT TO ESTABLISH
CTE- 94118

No. PC/CCA-KUTCH-1524/GPCB ID 56985/ **Date:**

To,
Deendayal Port Trust Land,
Kandla Port Trust Land,
A.O Building,P.O box No. 50,
Tal.:Gandhidham,
Dist.Kutch-370201

Subject : **Consent to Establish (NOC)** under Section 25 of Water (Prevention and Control of Pollution) Act 1974 and Section 21 of Air (Prevention and Control of Pollution) Act 1981

Reference : Your CTE Application **Inward ID No 133847 dated 04/04/2018**

Sir,

Without prejudice to the powers of the Board under the Water (Prevention and Control of Pollution) Act-1974, the Air (Prevention and Control of Pollution) Act-1981 and the Environment (Protection) Act-1986 and without reducing your responsibilities under the said Acts in any way, this is to inform you that the Board grants **Consent to Establish (NOC)** of industrial activity at **Kandla Port Trust Land,A.O Building,P.O box No. 50,Tal.:Gandhidham,**For Creation of water front facilities of oil jetties of 8,9,10,&11 & development of land (1432 Areas).

1. The validity period of the order shall be up to **03/04/2023**

SUBJECT TO FOLLOWING SPECIFIC CONDITIONS:

1. Proposed jetties shall be handled of 3 5 MMTP/Annum of liquid cargo of edible oil. Fertilizer & food grains etc.
2. Unit shall strictly adhere to all condition of TOR issued by MoEF & CC, Delhi dated 04/08/2017 & shall not carry out any construction activities till obtaining EC & CRZ from competent authority
3. No ground water shall be withdrawn without prior approval from competent authority.

2. **CONDITIONS UNDER WATER ACT 1974:**

2.1 There shall be no industrial water consumption and hence there shall be no industrial waste water generation from manufacturing process and other ancillary operations.

2.2 Domestic water consumption shall not exceed 20 KL/day.

2.3 The quantity of domestic waste water (Sewage) shall not exceed 16 KL/Day.

2.4 The quality of the sewage shall conform to the following standards

PARAMETERS	GPCB NORMS
pH	6.5 to 9.0
BOD (5 days at 20^0 C)	30 mg/L
Suspended Solids	100 mg/L
Fecal Coliform	1000 MPN/ 100 ml

2.5 The domestic sewage shall be treated in Sewage Treatment Plant and treated sewage conforming to standards mentioned in 2.4 shall be reused in various activities shall not be used for gardening and plantation purpose in premises.

3. CONDITIONS UNDER AIR ACT 1981:

3.1 There shall be no use of fuel hence there shall be no flue gas emission from manufacturing process and other industrial operations.

3.2 There shall be no process gas emission from manufacturing process and other industrial operations.

3.3 The concentration of the following parameters in the ambient air within the premises of the industry shall not exceed the limits specified hereunder as per National Ambient Air Quality Standards issued by MoEF&CC dated 16th November-2009.

Sr. No.	Pollutant	Time Weighted Average	Concentration in Ambient air in $\mu g/m^3$
1	Sulphur Dioxide (SO_2)	Annual	50
		24 Hours	80
2	Nitrogen Dioxide (NO_2)	Annual	40
		24 Hours	80
3	Particulate Matter (Size less than 10 µm) OR PM_{10}	Annual	60
		24 Hours	100
4	Particulate Matter (Size less than 2.5 µm) OR $PM_{2.5}$	Annual	40
		24 Hours	60

3.4 The level of Noise in ambient air within the premises of industrial unit shall not exceed following levels:

Between 6 A.M. to 10 P.M. : 75 dB(A)
Between 10 P.M. to 6 A.M. : 70 dB(A)

4. CONDITIONS UNDER HAZARDOUS WASTE:

4.1 The applicant shall provide temporary storage facilities and maintain the record for each type of Hazardous Waste as per Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2016 as amended from time to time.

4.2 The applicant shall be obtain membership of common TSDF site for disposal Hazardous Waste as categorized in Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2016 as amended thereof.

5. GENERAL CONDITION

5.1 Any change in personnel, equipment or working conditions as mentioned in the consents form/order should immediately be intimated to this Board.

5.2 The waste generator shall be totally responsible for (i.e. Collection, storage, transportation and ultimate disposal) of the wastes generated.

5.3 Records of waste generation, its management and annual return shall be submitted to Gujarat Pollution Control Board in Form – 4 by 31st January of every year.

5.4 In case of any accident, details of the same shall be submitted in Form – 5 to Gujarat Pollution Control Board.

5.5 Applicant shall comply relevant provision of "Public Liability Insurance Act-91".

GPCB

GUJARAT POLLUTION CONTROL BOARD
PARYAVARAN BHAVAN
Sector-10-A, **Gandhinagar** 382 010
Phone : (079) 23222425
(079) 23232152
Fax : (079) 23232156
Website : www.gpcb.gov.in

5.6 Unit shall take all concrete measures to show tangible results in waste generation reduction, voidance, reuse and recycle. Action taken in this regards shall be submitted within 03 months and also along with Form 4

5.7 Industry shall have to display on-line data outside the main factory gate with regard to quantity and nature of hazardous chemicals being handled in the plant, including wastewater and air emissions and solid hazardous waste generated within the factory premises.

5.8 Adequate plantation shall be carried out all along the periphery of the industrial premises in such a way that the density of plantation is at least 1000 trees per acre of land and a green belt of 10 meters width shall be developed.

5.9 The applicant shall have to submit the returns in prescribed form regarding water consumption and shall have to make payment of water cess to the Board under the Water (Prevention and Control of Pollution) Cess Act- 1977.

For and on behalf of
Gujarat Pollution Control Board

(Sushil Vegda)
Senior Environment Engineer

Annexure -B

Regular Monitoring of Mangrove Plantation (1400 ha) carried out by Deendayal Port Authority, Kandla

DPA Work Order No: WK/EG/4751/Part/ (Marine Ecology Monitoring)/10

Dt.03/05/2021

Submitted to

Deendayal Port Authority

Administrative office building

Post box no. 50

Gandhidham (Kachchh)

Gujarat-370201

Submitted by

Gujarat Institute of Desert Ecology

P.B. No. 83, Mundra road

Opp. Changleshwar Temple

Bhuj-Kachchh, Gujarat-370001

MAY 2022

Gujarat Institute of Desert Ecology

Certificate

This is to state that this Final report of the work entitled, **"Regular Monitoring of Mangrove Plantation (1400 Ha) carried out by Deendayal Port Authority (Statutory Requirement)"** has been prepared in the line with the work order issued by DPA vide No. EG/WK/4751/Part (Marine Ecology Monitoring))/10. Dt. 03.05.2021.

This report covers the study conducted during the period between May'2021 and May'2022.

Authorized Signatory **Institute Seal**

P. O. Box No. # 83, Opp. Changleshwar Temple, Mundra Road, Bhuj (Kachchh) - 370 001, Gujarat (India)
Tel : 02832 - 235025 Tele / Fax : 235027
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PROJECT TEAM

Project Co-ordinator: Dr. V. Vijay Kumar, Director

Name of the Staff	Designation	Role
Dr. M. Jaikumar	Senior Scientist	Principal Investigator
Dr. Durga Prasad Behera	Project Scientist	Team Member
Dr. R. Ravinesh	Project Scientist	Team Member
Dr. Dhara Dixit	Project Scientist	Team Member
Dr. Kapilkumar. N. Ingle	Project Scientist	Team Member
Dr. L. Prabhadevi	Advisor	Team Member
Mr. Dayesh Parmar	Project Officer (RS&GIS)	Team Member
Mr. Sai Vineeth Perla	Senior Research Fellow	Team Member
Ms. Bhagavati Kannad	Junior Research Fellow	Team Member
Ms. Pallavi Joshi	Junior Research Fellow	Team Member

Snapshot of the Project, "Regular Monitoring of Mangrove Plantation (1400 Ha) carried out by Deendayal Port Authority (Statutory requirement)"

S. No	Components of the Study	Remarks
1	Deendayal Port's letter sanctioning the project	EG/ WK/4751/Part/ (Marine Ecology Monitoring)/10 dated 3/5/2021
2	Duration of the project	One year from 24.05.2021 to 23.05.2022
3	Period of the survey carried out for various components	July-2021 – April 2022
4	Survey area within the port limit	Sat Saida Bet, Nakti creek and Kantiyajal mangrove plantation sites
5	No of locations sampled within the port limits	05 blocks in Sat Saida Bet, 02 blocks in Nakti creek and 3 block at Kantiyajal
6	Components of the report	
6a	Mangrove density	*Sat Saida Bet:* Density of *A. marina* varied from 1300 to 3500 and individuals/ha and tree height ranging from 70 - 260cm *Nakti creek:* Density of *A. marina* varied from 900 – 3400 individuals/ha and tree height ranges from 72 - 280 cm. *Kantiyajal:* Density of *A. marina* varied from 1200 - 5200 individuals/ha tree height ranges from 13-220 cm. The density of *R. mucronata* at Kantiyajal was 1800 to 3500 individuals/ha and height ranges from 13 to 210 cm.
6b	Mangrove survival	The highest survival rate for *A. marina* plantation in 150 ha area at Kantiyajal was 75%, followed by 50ha area at Sat Saida bet (62.7%) and Nakti (54%).
6c	Assessment of below ground Carbon stock	The below ground Total Biomass Carbon of *A. marina* plantation varied from 42.36t/ha to 79.5t/ha. The highest below ground carbon stock potential was at Sat Saida Island.
6d	Assessment of above ground carbon	The above ground biomass was maximum 210.0 gm at Sat Saida Bet while at Nakti it was 161.0gm and at Kantiyajal 164.60gm.
7d	Management	The restoration efforts to be done to improve the sparse mangrove patches with multi-species plantation initiatives along with promotion of natural regeneration through long term efforts.
8	Status of 2017-2018 plantation	Sat Saida Bet

		Average density of *A. marina* plants 2031 - 5387 individuals/ha with average height ranging from 39 - 113 cm. Nakti creek Plant density (*A. marina)* varied from 2340 – 2370 individuals/ha with average height from 53 - 84 cm. Very few *R. mucronata* and *C. tagal* plants survived. Kantiyajal *A. marina* average density between 1460 and 2220 individuals/ha with an average height between 32 -37 cm. Average density of *R. mucronata* was 1280 individuals/ha with an average height of 30 cm and *R. mucronata* as frontline vegetation along the fringes of the block. Highest survival rate (88.8%) for *A. marina* plantation in 150 ha at Kantiyajal followed by *A. marina* plantation in 20 ha at Sat Saida bet (81.6%) during 2017-2018. The Total Biomass Carbon of A. marina plantation varied from 0.041 to 0.202 Mg/ha. The highest Carbon sequestration potential was of Nakti creek during 2017-2018.

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1 Introduction

Mangrove forests make up one of the most productive and biologically diverse ecosystems on the planet. They grow in a variety of depths of salt water with breathing roots or Pneumatophores providing habitat for different macro and micro faunal species. The ability of mangroves to absorb up to four times more carbon dioxide by area than other terrestrial forests recognize their importance in global warming (Donato *et. al.,* 2011). The mangroves are economically important by supporting fisheries, ecotourism and carbon sequestration (Baig *et. al*., 2015). Over the years, the global scientific community has widely realized the ecological role of mangroves and the services they provide. Despite the benefits it provides, mangroves are being overexploited and deteriorated for various reasons and area under mangrove cover decreased at an alarming rate and poorly restored (UNEP, 2014). Thus, researchers eventually tried to restore mangrove through plantation/conservation to retain the ecological and economic values, and as a result the rate of loss has been decreased and stabilized during the period of 1980 to 2000 compared to the terrestrial forest loss (Duraiappah *et. al.*, 2005). India has a total of 7516.6 km coastline distributed among nine maritime states and four Union Territories (Anon, 2001), of which Gujarat possesses the longest coastline extending to 1650 km. A total of 46 true mangrove species belonging to 14 families and 22 genera are found in Indian mangrove habitats (Ragavan *et. al.,* 2016). Around 3 % of the earth's total mangrove vegetation is found in India (FSI, 2021). Gujarat has the country's second-largest mangrove cover (1175Km^2).

Mangrove being the woody habitats forms the vital carbon sinks in the coastal regions. Deendayal Port Authority (hereafter DPA) has been involved in the mangrove plantation activity as per the specifications by the Ministry of Environment Forests and Climate Change, Govt. of India, (hereafter MoEFCC) in the port premises and the adjoining creek environments in order to mitigate the environmental impacts due to the Port's regular activities in the coastal waters and the land. The coastal water itself can absorb the atmospheric carbon dioxide, and the microscopic phytoplankton tends to remove a huge amount of it through photosynthesis and diffusing oxygen into the water. The monitoring of the mangrove plantation carried out by the DPA has been undertaken by Gujarat Institute of Desert Ecology (hereafter GUIDE) regularly as per the specification in the work order (EG/WK/4751/part Marine Ecology Monitoring)/10 dated 03.05.21. This report describes the monitoring results of the mangrove plantation managed by the DPA at Nakti creek, Kantiyajal and Sat Saida Bet during the period of 2021 to 2022.

2 Objectives of the study

This study aims to assess the growth and survival rate of mangrove plantations, factors affecting the health of the mangrove and suggest appropriate remedial measures and techniques for conserving them.

The specific objectives are:

i. To evaluate 1400 Ha of mangrove plantation at Sat Saida Bet, Nakti creek in Kachchh coast, and Kantiyajal in Bharuch district carried out by the Gujarat Ecology Commission (GEC), and the Department of Forest, Govt. of Gujarat.

ii. To assess the extent of the plantation, health status, survival of the sapling, mortality rate and growth of the planted mangroves.

iii. To provide a comprehensive overview of both the composition and distribution of the planted mangroves.

iv. To assess the potential below ground carbon stock of the mangrove plantation in view of climate change.

3 Mangroves as blue-carbon stock

Mangrove ecosystems are large and dynamic carbon reservoirs, involved in the global carbon cycle and a potential sink of atmospheric carbon dioxide (Clark, 2001; Matsui *et. al*., 2010). Currently, the world's mangroves store carbon equivalent to over 21 gigatons of CO_2. Destruction of mangrove ecosystems releases this carbon into the atmosphere, accelerating the rate of climate change. (Lovelock *et. al*., 2022). It has been estimated that mangroves prevent more than $65 billion in property damages and reduce flood risk to some 15 million people every year (Spalding *et. al*.,.2021). In the face of accelerating climate change, mangroves are significant contributors to ecosystem-based adaptation, with a robust capacity to support lives and livelihoods, even in the expected future changes predicted by most of the general circulation models (IPCC 2013). A salient feature of mangrove forests is converting carbon dioxide to organic carbon at higher rates than almost any other existing habitat on earth (Ezcurra *et al.,* 2016). This 'blue carbon' is stored both in the living plants and their thick muddy soils, where it can remain fixed for centuries.

Although the area covered by mangrove forests represents only a tiny fraction of the tropical forests, their position at the terrestrial-ocean interface and possible exchange with coastal ocean

waters make a unique contribution to the total carbon cycle in the coastal ocean (Twilley, 1992). The contribution of coastal and marine ecosystems to mitigate climate change through carbon sequestration and storage is much more compared to their terrestrial counterparts (Steven *et. al*., 2008; Yee. 2010). Blue carbon sinks include open oceans, kelp forests, salt marshes, sea grass beds, coral reefs and mangroves. Management of these blue carbon sinks is currently not being accounted for in most of the climate change policies and is excluded from national carbon inventories and international carbon payment schemes (Lasco, 2004). There are two different mangrove biomass estimation methods well established viz. field measurement and remote sensing & GIS-based approach. Amongst them, the field measurement has been considered to be precise and accurate (Petrokofsky *et al.*, 2012). Further, field-based data is also required for validation in remote sensing and GIS-based approach. Hence, in recent years, field measurements have been conducted to support and collate satellite data for meaningful estimations. Approximation of the global carbon cycle done through, scaling- up of successful protection and restoration measures (Lovelock *et. al*., 2022). And additionally, these coastal ecosystems provide numerous benefits and services that are essential for climate change adaptation, including coastal protection and food security for many communities globally (IUCN 2017). On an implementation global level, carbon stores in different level *viz*., mangroves, salt marshes and seagrasses can be included in national accounting**,** according to the Intergovernmental Panel on Climate Change (IPCC 2013). Although there was no record of sea grass in the DPA area (GUIDE 2018).

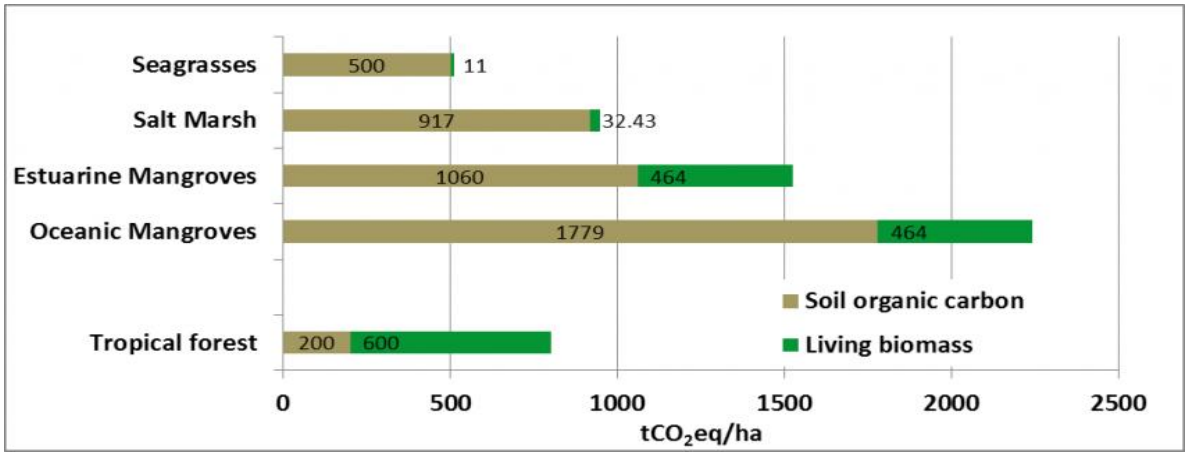

Figure 1. Different level of Carbon Storage
(Source-**IPCC, 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands).**

4 Rationale

DPA is one of the largest ports in India, having one of the largest coastal habitats, with mangroves (24328.7ha) and mudflats (31089.06 ha) around its jurisdiction. The Port Authority has been very keen and dedicated in restoring the environmental quality of both the shore line and the coastal zone by implementing reliable modern technologies with the participation of the state and central government departments and the local people. Besides the legal mandates, the port authority itself has been implementing projects, time to time towards the conservation of the mangrove and other plants and protecting their coastal habitats and measures been taken to conserve and preserve mangroves within the DPA area, to retain the ecosystem services of mangroves. Accordingly, DPA has carried out mangrove plantation in 1400 ha between 2005 and 2019 through various implementing agencies at Sat Saida Bet and Nakti creek in Kandla and Kantiyajal in Bharuch district. The DPA has entrusted the task of evaluating the status of 1400 ha of mangrove plantation in these locations to the GUIDE, Bhuj. The detailed report on the mangrove plantation evaluation is submitted to the DPA time to time.

5 Study Area

5.1 Deendayal Port Environment

Deendayal Port in Kachchh District of Gujarat State (formerly Kandla Port Trust), operated by Deendayal Port Authority (DPA), is a gateway Port to the hinterland in the western and northern states of India. It is one of the 11 major Ports of India situated at 22°59'39.77'' N latitude and; 70°13'20.14'' E longitude on Kandla creek at Gulf of Kachchh. The inclusion of Karachi Port in Pakistan after India's partition and heavy traffic congestion at the then Bombay Port gave impetus for promoting Deendayal Port during the 1950s. In 1955, Deendayal Port acquired the status of a major Port in India. Because of its proximity to the Gulf countries. Large quantities of crude petroleum and other assorted cargo are imported through Deendayal Port.

The Port presently has 14 jetties, six oil terminals, and several allied facilities for handling dry and liquid cargo. Regular expansion/developmental activities such as the addition of jetties, allied Special Economic Zones (SEZ hereafter), industrial parks and ship bunkering facilities are underway to cope with the increasing cargo handling demands. Shri Mansukh Mandaviya, Minister of State for Ports, Shipping and Waterways (I/C) appreciated the efforts taken by Deendayal Port and added that it is indeed the major achievements in the challenging COVID

times and it is significant indication that economy is bouncing back to achieve pre-COVID times. Major commodities handled by the Deendayal Port are Crude Oil, Petroleum product, Coal, Salt, Edible Oil, Fertilizer, Sugar, Timber, Soya bean, Wheat. This major achievement can be attributed to the user-friendly approach of port with the Shipping fraternity / stakeholders and constant consultations with them to improve Ease of Doing Business. An assortment of liquid and dry cargo is being handled at Deendayal Port. The dry cargo includes fertilizers, iron crap, steel, food grain, metal products, ores, cement, coal, machinery, sugar, wooden logs, salt extractions, etc. The liquid cargo includes edible oil, crude oil and other petroleum products. DPA created a new record by handling 127.10 million metric tonnes of cargo during FY 2021-22 compared to 117.566 MMT in FY 2020-21, with a growth of 8.11%. Incidentally, DPA is the only major Indian Port to handle more than 127 MMT cargo throughput, and it has also registered as the highest cargo throughput in its history. The Port has handled 3151 vessels during FY 2021-22 compared to 3095 vessels in FY 2019-20. While the Port has flagged off several projects related to infrastructure creation, DPA has successfully awarded the work of augmentation of Liquid cargo handling capacity by revamping the existing pipeline network at the oil jetty area in September 2021.

Deendayal Port is a natural harbour located on the eastern bank of North-South trending Kandla creek at an aerial distance of 145 km from the Gulf's mouth. Being located at the inner end of the Gulf of Kachchh (GoK), Deendayal Port has a fragile marine ecosystem with a vast expanse of mangroves, mudflats, creek systems and allied biota. The Port location is marked by a network of major and minor mangrove-lined creek systems with a vast extent of mudflats. The coastal belt in and around the Port has an irregular and dissected configuration. Due to its location, the tidal amplitude varies, experiencing 6.66 m during Mean High-Water Spring (MHWS) and 0.78 m during Mean Low Water Spring (MLWS) with an MSL of 3.88 m. Commensurate with the increasing tidal amplitude, vast intertidal expanses are present in and around the Port environment. This, along with the occurrence of mudflats, enables mangrove formations at the intertidal belts. Annual rainfall during 2021 was 466 mm, which is often irregular (GWRDC, 2021). There are no perennial or seasonal rivers in Gandhidham taluka. Total rainy days during the monsoon season is limited to only 15-20 days and used to be erratic. Freshwater input into the near coastal waters is relatively meagre and appears to have less influence on the ambient coastal water quality except during monsoon months, during which freshwater through flash floods get discharged in the near coastal waters. The annual average humidity is 60%, which increases to 80% during the southwest monsoon (June to September)

and decreases to 50% during November-December. The average wind speed is 4.65 m/s, with a maximum wind speed of 10.61 m/s during June. The drought phenomenon is common with two drought years in a cycle of 5 years. The annual mean maximum and minimum temperatures are 42.8°C and 21.3°C, respectively (Table 1).

The coastal belt in and around the Kandla region is characterized by a network of creek systems and mudflats covered by sparse halophytic vegetation, creek water and salt-encrusted land mass, which forms the major land forms. The surrounding environment in a radius of 10 km from the Port is mostly built-up areas consisting of salt works, human habitations and Port related structures on the west and north, creek system, mangrove formations and mudflats on the east and south. The Deendayal Port and its surroundings have mangroves, mudflats and creek systems as major ecological entities. Various ecosystem services provided by the mangrove ecosystem is depicted in Fig-2 (IUCN-2017).

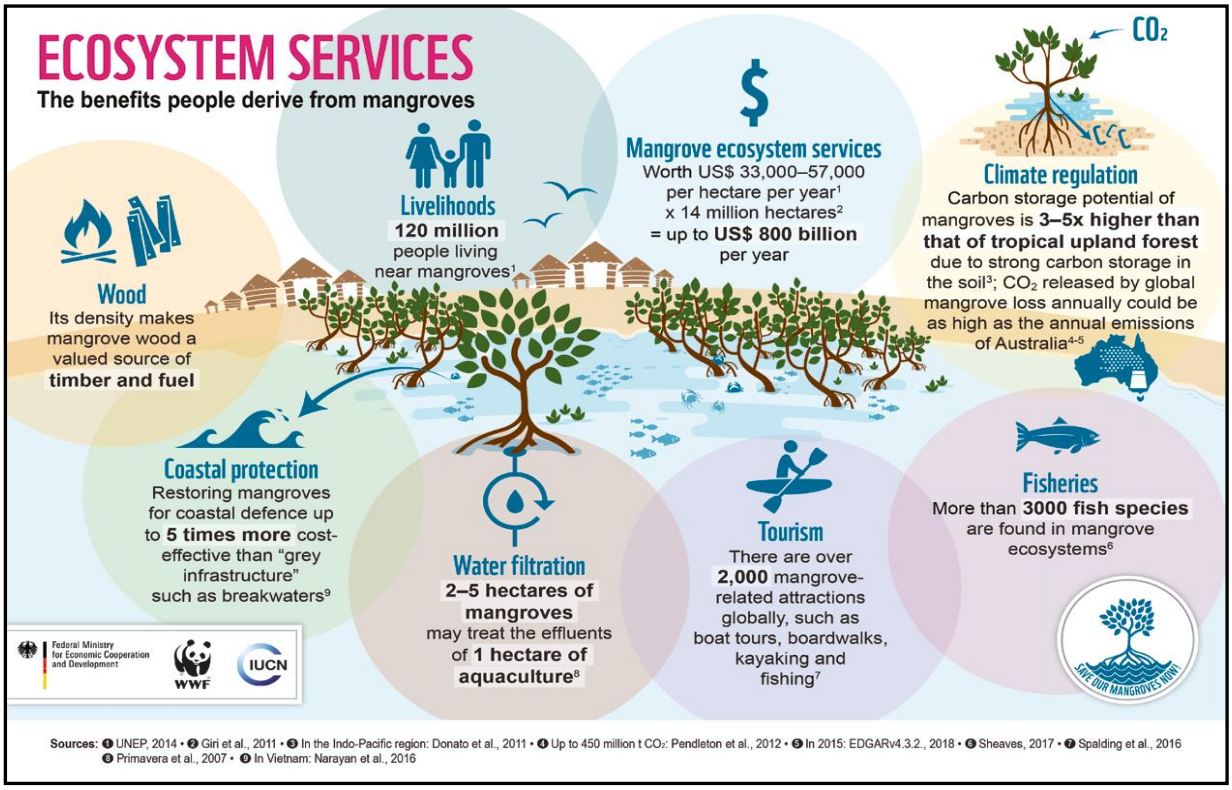

Figure 2. Schematic diagram of Ecosystem services of Mangroves (IUCN, 2017)

Table 1. Environmental setting of the Deendayal Port region

Sl. No.	Particulars	Details
1	Deendayal Port Co-ordinates	22° 59'39.77' N, 70°13'20.14'' E
2	Elevation above Mean Sea level	~20 ft
3	Climatic Conditions	As per Meteorological Station, Deendayal Port Annual Mean Max Temp: 42.8°C Annual Mean Min Temp: 21.3°C Rainfall: 466 mm (Annual mean 2021)
4	Land Use of nearby areas	Comparatively flat marshy land with stunted and dense mangrove formation, mudflats, creek systems, coastal halophytes, saltpans and salt swamps
5	Nearest Highway	National Highway 8A
6	Nearest Railway Station	Gandhidham RS
7	Nearest major airport	Bhuj (~60 km, NW)
8	Nearest Village habitation	Tuna (~12 km, North)
9	Nearest Major Town	Gandhidham (12 km, Northwest)
10	Reserved Forest	Nil
11	Historically Important Places	Nil
12	Rivers/streams around the project environs	Nil
13	Major Dams and barrages	Nil
14	Survey of India Topo sheet covering the proposed site and surroundings	41J1and 41I4
15	Seismic Zone	Zone –V

5.2 Details of plantation sites

The present study focused on the assessment of the present status of the mangrove at Sat Saida bet and Nakti creek in the Kandla (Kachchh) and Kantiyajal in the Bharuch district vicinity covering eight blocks occupying an area of 1300 ha, where plantation activities have been conducted during the period between 2005 and 2017. However, the present study (2021-2022) will also cover the additional 100 ha plantations carried out at Sat Saida bet (50 ha), and Kantiyajal (50 ha) during 2018 and 2019 with a total coverage area of 1400ha. The primary goal of this study is to assess the survival rate of mangrove plantations and the carbon sequestration potential of planted mangroves and suggest achievable conservation measures. The details of the mangrove plantation work carried out in a phased manner by the DPA is presented in Fig -3 & 4 and Table 2, 3 & 4.

Table 2. Details of the implemented mangrove plantation activities by DPA

Location	**Year of Plantation**	**Area (ha)**	**Species planted**	**Implementing Agency**
Sat Saida Bet, Kachchh district	2005-2006	20	*A. marina*	Gujarat Institute of Desert Ecology, Bhuj
	2011-2012	200	*A. marina*	Forest Department, GoG
	2012-2013	300	*A. marina*	Forest Department, GoG
	2013-2014	330	*A. marina*	Forest Department, GoG
	2018-2019	50	*A. marina*	Gujarat Ecology Commission
Nakti Creek, Kachchh district	2008-2009	50	*A. marina*	M/s. Patel Construction Co, Gandhidham
	2010-2011	100	*A. marina* *R. mucronata* *C. tagal*	Gujarat Ecology Commission
Kantiyajal, Bharuch District	2015-2016	150	*A. marina*	Gujarat Ecology Commission
	2016-2017	150	*A. marina* *R. mucronata*	Gujarat Ecology Commission
	2018-2019	50	*A. marina*	Gujarat Ecology Commission
Total		**1400**		

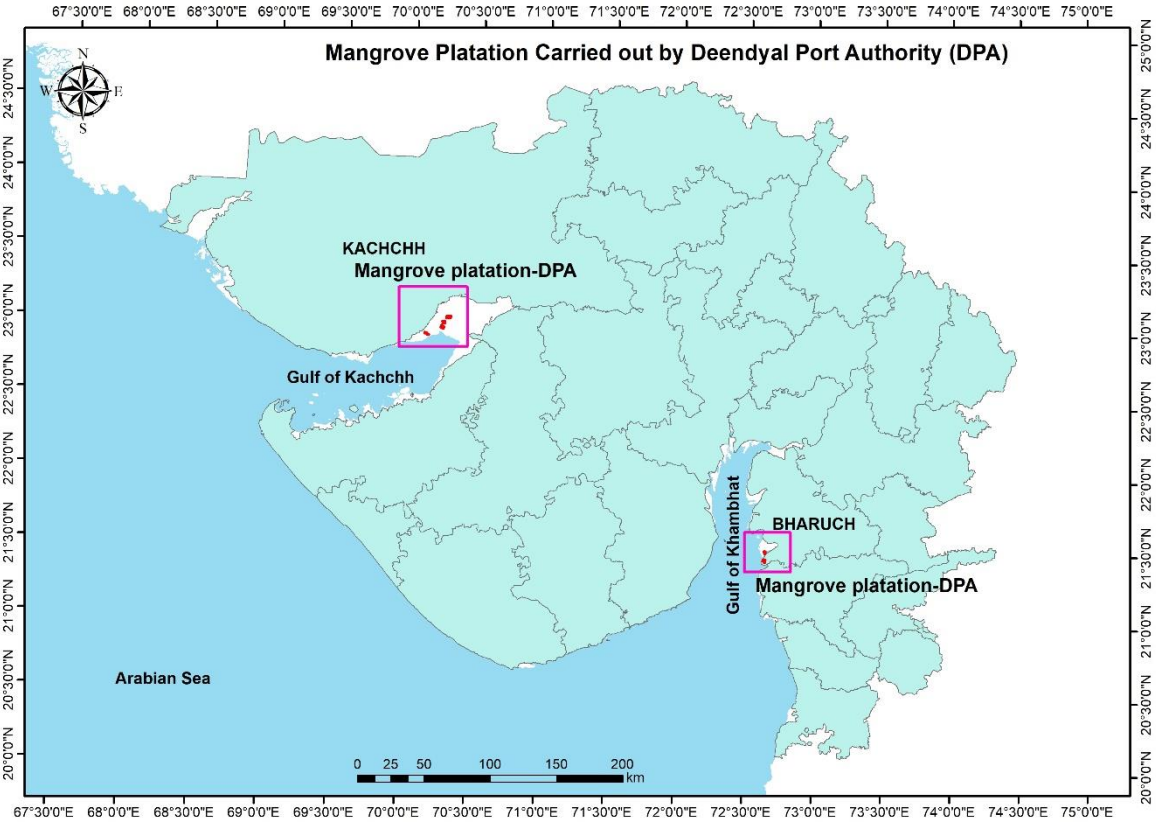

Figure 3. Mangrove plantation carried out by DPA at Kantiyajal and in the Gulf of Kachchh

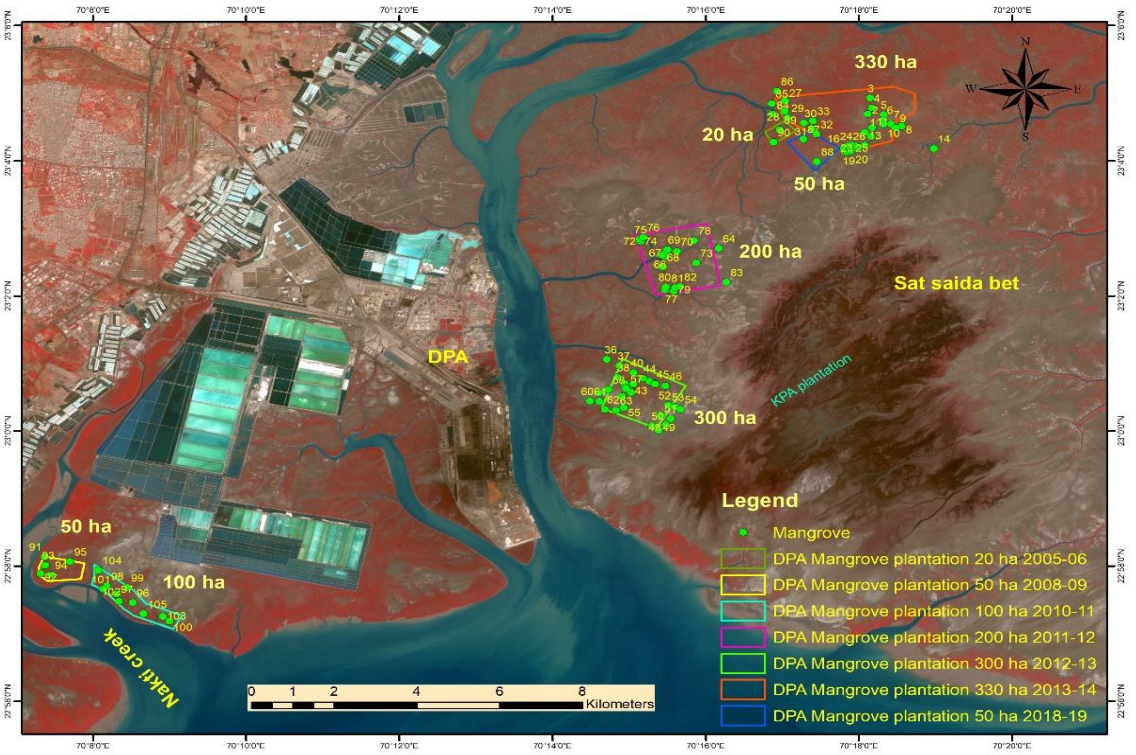

Figure 4. Location of Mangrove Plantation sites at Sat Saida Bet and Natki creek

5.3 Regular mapping through GIS & RS

Mangrove plantations in 1400 ha was regularly monitored and mapped using RS and GIS facilities as part of the conservation and management efforts. The difference in mangrove density was assessed through ArcGIS (version 9.3) and ERDAS (version 9.3) and areas having restoration priority was identified for plantation activity.

5.4 Land use/ Land cover

From April, 2017 to March, 2022 within the span of 5 years the overall mangrove area increased from 19319 ha to 24328 ha (43.7%) (Table-5). Most of the mudflat area converted to Mangrove area, and hence a decreasing trend of the mudflat is clearly observed. Good monsoon and favorable environmental conditions have positively impacted the mangroves to flourish (Saravanakumar *et. al.*, 2008, Das *et. al* 2019). The Figure -5 and 6 clearly depicts the year wise increase in mangrove area in the DPA vicinity and at present 24% of the total area is covered by mangroves.

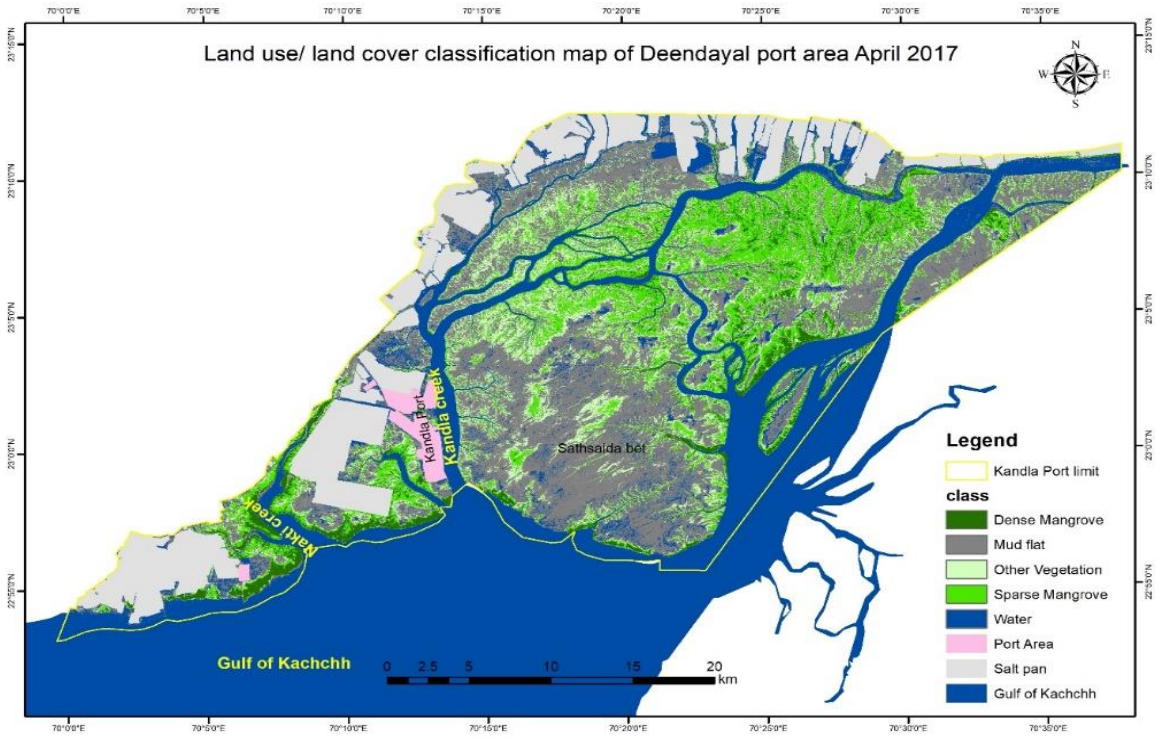

Figure 5. Land use/Land cover classification in Deendayal port area – (April 2017)

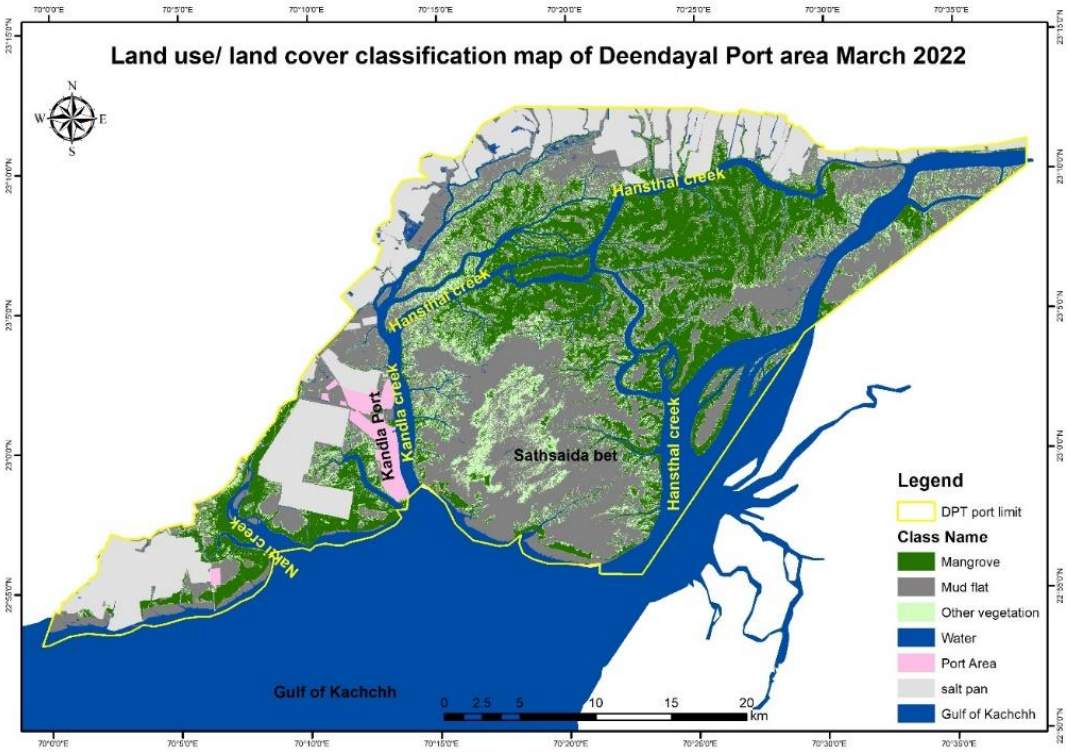

Figure 6. Land use/ land cover classification map of DPA (March-2022)

Table 3. Land use /land cover statistics in the DPA area for April-2017 and March-2022

Class name	**Area (ha) in 2017**	**Area(ha) in 2022**	**Area (ha) difference in 5 years**	**Percentage (%)**
Mangrove	19319.71	24328.7	+5009	+43.7
Mudflat	31293.43	31089.06	-204.37	-1.8
Other vegetation	12438.8	11561.2	-877.6	-7.7
Port Area	1243.67	1436.75	+193.08	+1.7
Salt pan	15016.1	15545.7	+529.6	+4.6
Water bodies	20674.3	16024.6	-4649.7	-40.6
Total	**99986.01**	**99986.01**	**11463.35**	**100**

5.5 Mangrove plantation at Nakti creek (150 ha)

A total of 150 ha of mangrove plantation was carried out in Nakti creek with two blocks with an area of 100 ha and 50 ha, by two agencies; M/s. Patel Construction Co, Gandhidham (2008-09) (Fig.6,7 & Table 4) and Gujarat Ecology Commission (2010-11), respectively. The plantation was carried out using three different techniques like transplantation of nursery raised saplings, *otla* bed, and direct seed dibbling methods. For the 50ha block in Nakti creek, *A. marina* was planted (Table 6). In the second block (other side of Nakti creek) *Ceriops tagal* was also sown. In the third block, located on the eastern side of the second block, seeds of *A. marina* were sown. The fourth block plantation was done alongside the minor creek system along the bund and road, where propagules of *Rhizophora mucronata* and *Ceriops tagal* were planted in the 100ha (Table 5). The mangrove plant density at the 100 Ha and 50 Ha plot was found increased from 2007 as deduced from the imageries as shown in Figure 8 and 11.

Table 4. Sampling location of Nakti Creek (150 ha)

Block Area covered	**Quadrate no.**	**Latitude**	**Longitude**
100ha	1	22°58’8.09”	70°7.’ 22.34”
	2	22°57’53.06”	70°7.’ 18.92”
	3	22°58’0.58”	70°7.’ 22.43”
	4	22°57’51.90”	70°7.’ 27.09”
	5	22°58’3.87”	70°7.’ 42.02”
	6	22°57’27.48”	70°8.’ 30.93”
	7	22°57’35.06”	70°8.’ 18.55”
	8	22°57’42.10”	70°8.’ 10.82”
	9	22°57’40.82”	70°8.’ 26.84”
	10	22°57’11.00”	70°8.’ 59.69”
50ha	1	22°57’39.35”	70°8.’ 8.05”
	2	22°57’28.36”	70°8.’ 20.38”
	3	22°57’15.00”	70°8.’ 54.57”
	4	22°57’56.23”	70°8.’ 4.12”
	5	22°57’17.46”	70°8.’ 39.60”

Table 5. *A marina* plantation (2010-2011) in 100 ha at Nakti creek

S. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	22˚ 57 50.0 N	70˚ 09 40.8 E	1200	55.3	14.7
Q2	22 ˚57 47.8 N	70˚ 09 42.4 E	2000	67.1	21.04
Q3	22 ˚57 46.1N	70 ˚09 42.8E	1200	70.1	29.3
Q4	22˚ 57 42.4N	70 ˚09 44.3E	2000	80.1	41.4
Q5	22˚ 57 41.6N	70˚ 09 46.2E	3200	90.9	28.3
Q6	22˚57 31.1N	70˚ 09 49.6E	2700	90.9	23.4
Q7	22˚57 39.8 N	70˚ 09 48.8E	3400	82.8	19.9
Q8	22˚57 38.6 N	70 ˚09 51.2E	3500	88.9	20.6
Q9	22˚57 38.2N	70 09 54.5 E	2500	115.9	28.2
Q10	22˚57 37.5 N	70 09 52.9 E	2000	99.5	17.8
Average			**2370**	**84**	**--**

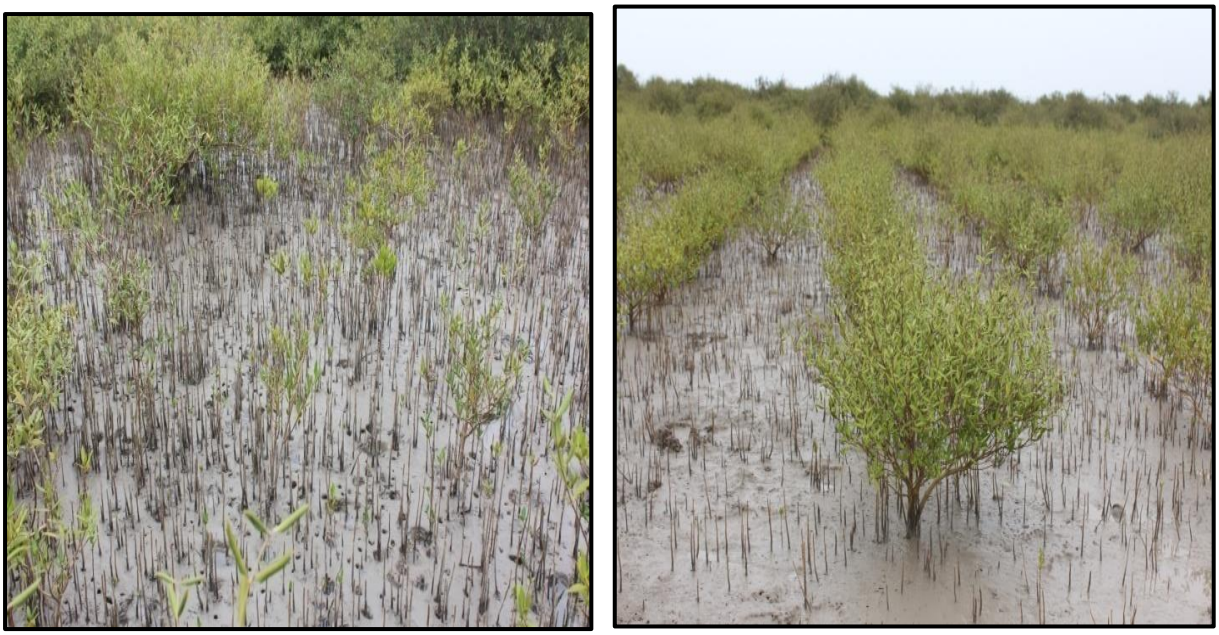

Figure 7. Mangrove plantation 100 ha at Nakti creek during 2017-2018

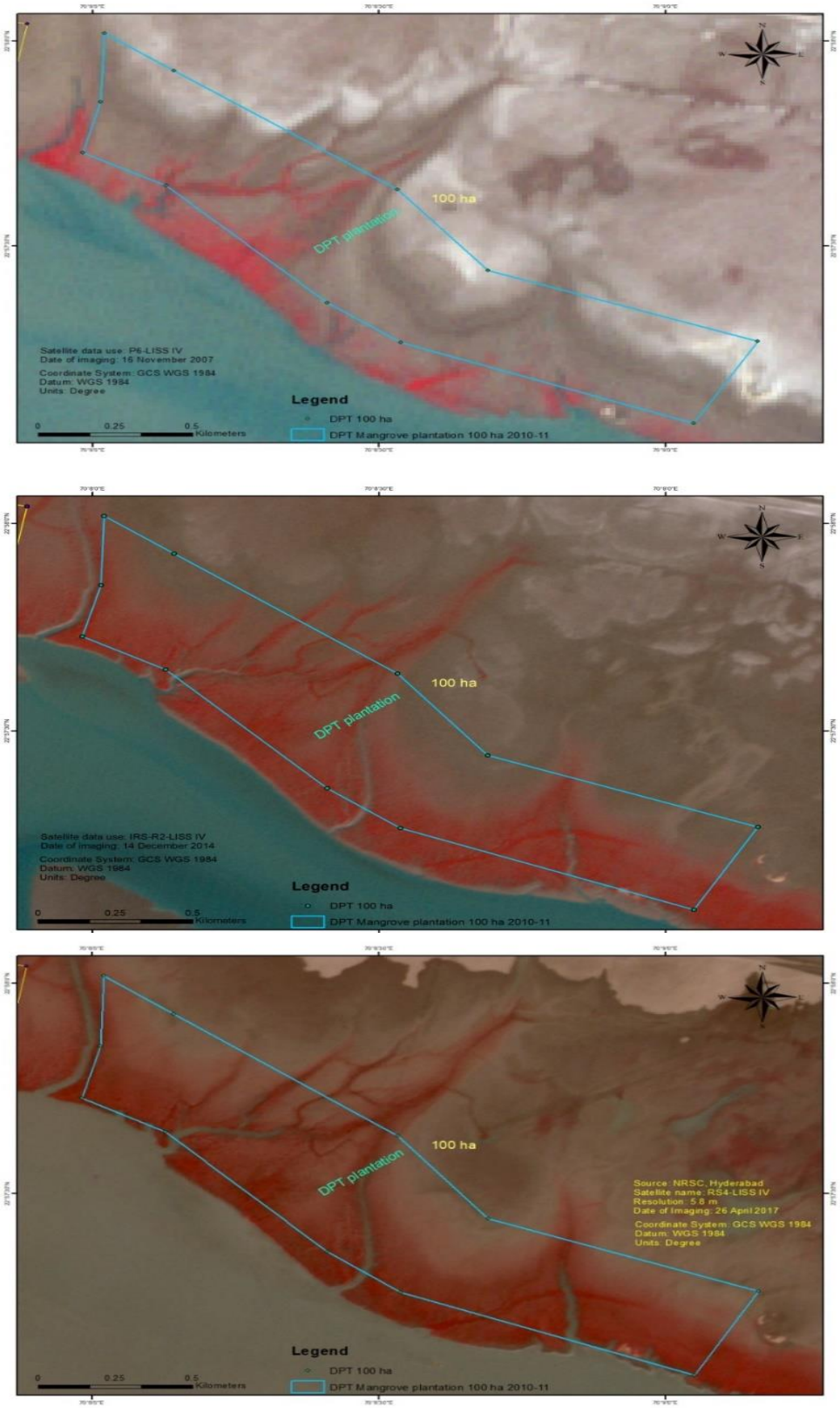

Figure 8. Satellite images of mangrove plantation at Nakti creek (2007,2014 & 2018).

Table 6. *A marina* plantation (2008-2009) in 50 ha at Nakti creek

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	22° 57' 12. 9N	70° 09' 04.9 E	3000	53.8	19.6
Q2	22°57' 11.6 N	70° 09'04.5 E	3000	64.8	18.4
Q3	22°57'10.9 N	70°09' 04.7 E	2400	70.5	24.0
Q4	22°57'10.3 N	70°09' 05.4 E	2800	65.8	19.2
Q5	22°57'09.6 N	70°09'06.2 E	2500	63.0	15.9
Q6	22°57'09.1 N	70°09'07.2 E	2700	60.2	15.2
Q7	22°57'09.1 N	70°09'08.2 E	2500	40.9	15.6
Q8	22°57'09.2 N	70°09'08.4 E	0	0.0	0.0
Q9	22°57'08.1 N	70°09'10.0 E	2700	54.1	15.6
Q10	22°57'07.7 N	70°09'10.3 E	1800	60.9	24.6
Average			**2340**	**53**	**--**

Figure 9. Mangrove plantation 50 ha at Nakti creek during 2008-2009

Figure 10. Mangrove plantation 50 ha at Nakti creek during 2017-2018

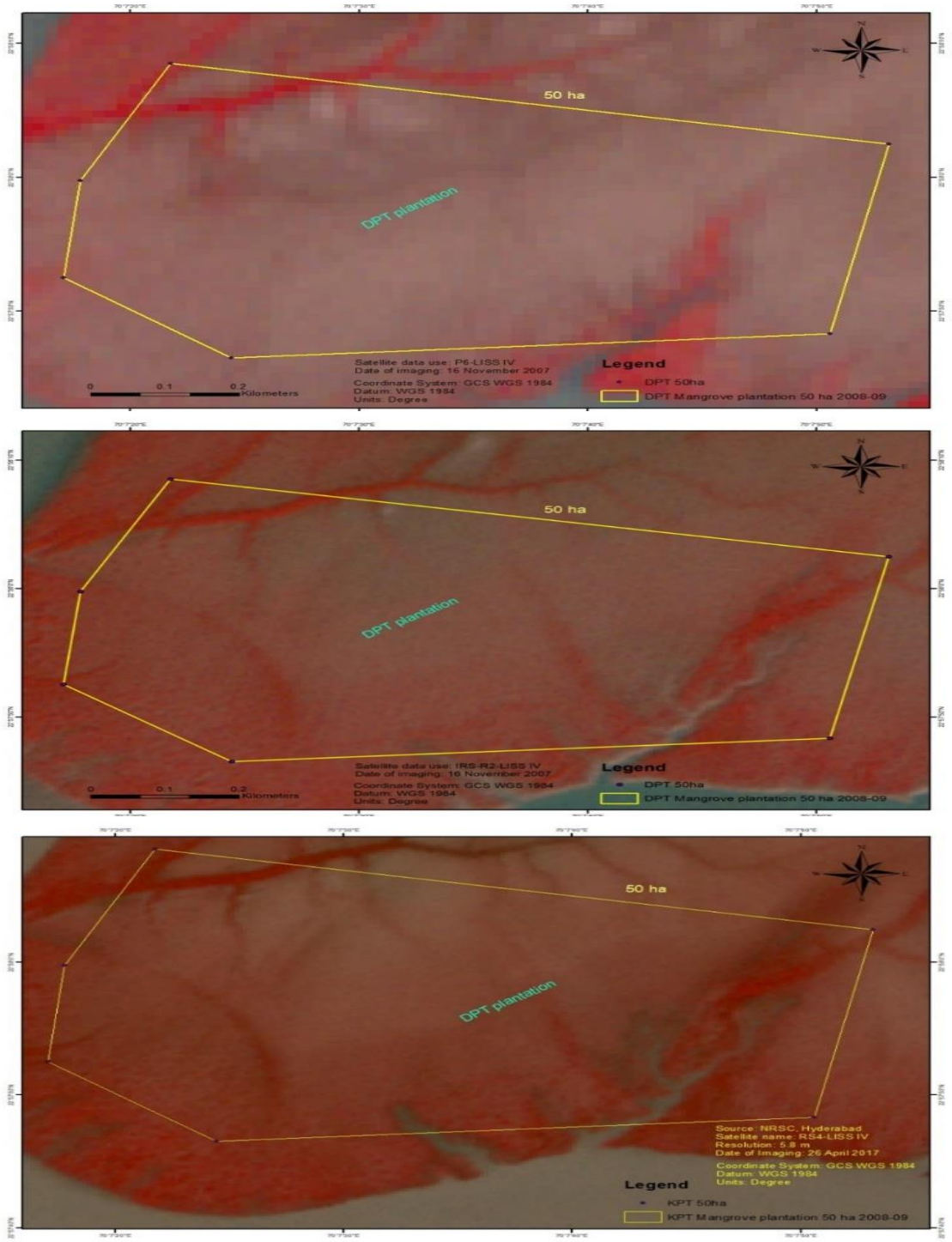

Figure 11 Satellite images of 50 ha mangrove plantation at Nakti creek during the years 2007,2014 & 2018.

5.6 Plantation at Kantiyajal (350 ha)

The plantation site at Kantiyajal has naturally growing *A. marina* extending from the lower littoral to the mid-littoral zone. The plantation site is located near (N 21°27'01.1'', to 21°26'54. 24'' and E 72°40'36.04, to 72°38'58.22'') to this luxuriantly growing mangrove patch. The site is behind the naturally growing plants away from the waterline; however, everyday tidal flushing keeps this site relatively healthy. The total 350 ha mangrove plantation was conducted in separate blocks, like 150 ha each during 2015-2016 and 2016-2017 and 50ha during 2018-2019 at Kantiyajal (Fig-12,15 & 16). Of the total 150 ha, 70 ha plantation activities were carried out following nursery raised saplings and the remaining 80 ha area by *Otla* beds of 1 x 1 x 1 m prepared to improve mangrove density. *A. marina* saplings were transplanted at a distance of 2.5 x 2 m. In total, 32,000 such beds were prepared in the 80 ha (Table 7,8 & 9). All plantation activities were taken care of by Gujarat Ecology Commission. *A. marina* was the preferred species for plantation in both blocks. The Figures 15 and 16 explains the sparse distribution of the plants as well as their stunted growth on the monitored plots.

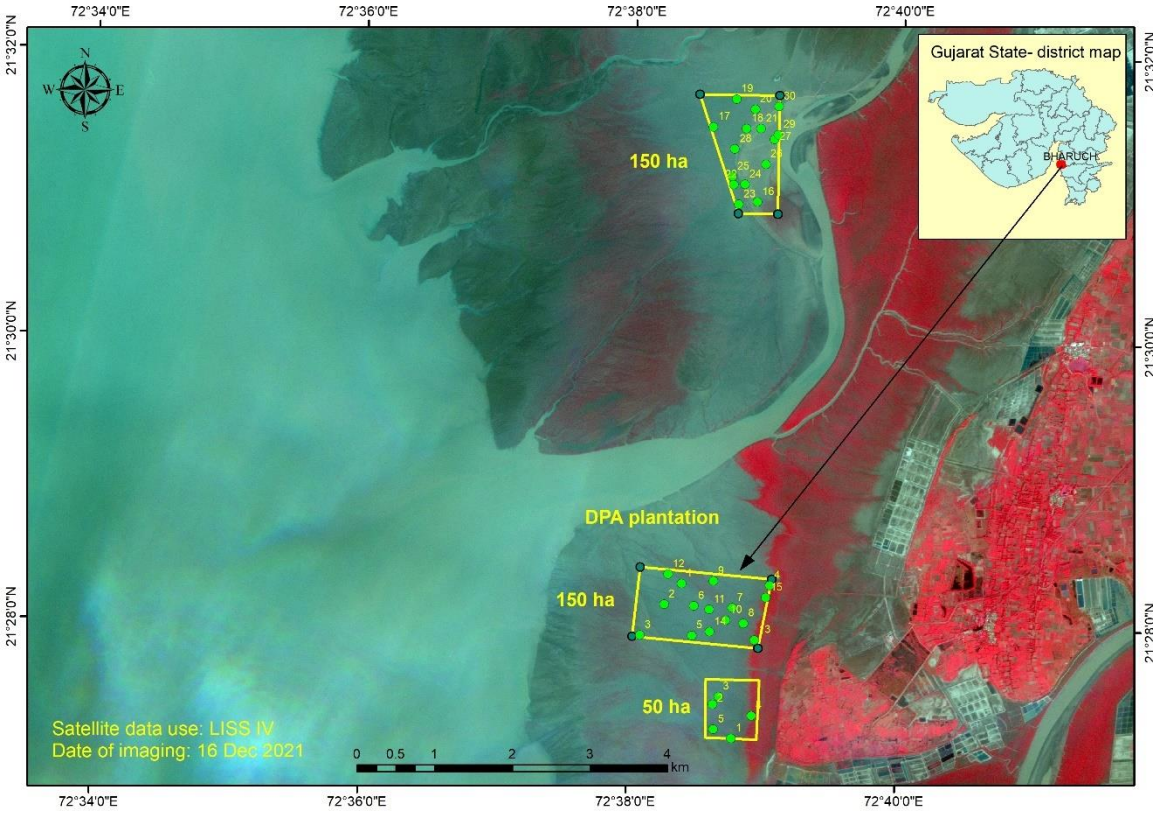

Figure 12. Mangrove plantation at Kantiyajal (350 ha)

Table 7. Sampling location of Kantiyajal (350 ha)

Block area covered	**Quadrate no.**	**Latitude**	**Longitude**
150ha	1	21°28’17.76”	72°38’24.00”
	2	21°28’9.12”	72°38’16.08”
	3	21°27’56.16”	72°38’5.64”
	4	21°28’17.76”	72°39’3.24”
	5	21°27’56.16”	72°38’28.68”
	6	21°28’8.76”	72°38’29.40”
	7	21°28’8.04”	72°38’46.68”
	8	21°28’1.56”	72°38’51.72”
	9	21°28’19.20”	72°38’38.04”
	10	21°28’3.00”	72°38’43.80”
	11	21°28’7.32”	72°38’36.24”
	12	21°28’21.72”	72°38’17.88”
	13	21°27’54.72”	72°38’56.76”
	14	27’57.96”	72°38’36.60”
	15	21°28’12.72”	72°39’1.44”
Block area covered	**Quadrate no.**	**Latitude**	**Longitude**
150 ha	1	21°30’58.68”	72°38’55.32”
	2	21°31’30.00”	72°38’35.16”
	3	21°31’29.64”	72°38’49.92”
	4	21°31’41.88”	72°38’45.24”
	5	21°31’37.56”	72°38’53.52”
	6	21°31’29.64”	72°38’56.40”
	7	21°31’5.88”	72°38’44.52”
	8	21°30’57.60”	72°38’46.68”
	9	21°31’5.88”	72°38’49.56”
	10	21°31’9.12”	72°38’43.80”
	11	21°31’14.52”	72°38’58.92”
	12	21°31’24.96”	72°39’2.52”
	13	21°31’20.64”	72°38’44.88”
	14	21°31’27.12”	72°39’4.32”
	15	21°31’39.00”	72°39’4.32”
Block area covered	**Quadrate no.**	**Latitude**	**Longitude**
50ha	1	21°27’13.32”	72°38’47.04”
	2	21°27’27.36”	72°38’38.40”
	3	21°27’30.60”	72°38’40.92”
	4	21°27’22.68”	72°38’56.04”
	5	21°27’16.92”	72°38’39.12”

Table 8 Mangrove plantation (2015-2016) in 150 ha at Kantiyajal

A. marina					
Sl. No.	**Sampling Location**		**Density (Ha)**	**Height (cm)**	**St. Dev**
Q1	21° 28'5.2″ N	72° 38'57.0" E	2000	29.8	9.0
Q2	21° 28' 22.19" N	72°38` 12. 43"	2200	42.4	10.9
Q3	21 °28'14.73"N	72°38`52. 97"	1900	41.1	13.9
Q4	21°28'05.00"N	72° 38`58. 66"	1000	38.1	7.1
Q5	21°28'56.68"N	72° 38`50.88"	0	0.0	0.0
Q6	21°28'59. 18" N	72°38`28.70"	1600	40.9	11.6
Q7	21°28'15.05"N	72°38`32.30"	1900	36.0	11.3
Q8	21°28'17.86"N	72°38`39. 86"	0	0.0	0.0
Q9	21°28'18.73"N	72°38`50.30"	2200	44.2	12.0
Q10	21°28'00.43"N	72°38` 08.02"	1800	45.8	9.7
Average			**1460**	**32**	**--**
R. mucronate					
Sl. No.	**Sampling Location**		**Density (Ha)**	**Height (cm)**	**St. Dev**
Q1	21° 28' 20.93″ N	72° 38' 22.20″E	1700	32.5	7.4
Q2	21° 28'16.56″ N	72° 38'27.88″E	1400	41.4	4.5
Q3	21° 28'19.69″ N	72° 38'11.96″E	0	0.0	0.0
Q4	21° 28'9.32″ N	72° 38'7.73″ E	700	39.4	7.4
Q5	21° 28'19.73″ N	72° 38'57.43″E	0	0.0	0.0
Q6	21° 28'11.18" N	72° 38'5.68″E	400	36.0	2.0
Q7	21° 28'5.26″ N	72° 38'4.07″E	300	26.0	1.8
Q8	21° 28'8.12″ N	72° 38'57.79″E	0	0.0	0.0
Q9	21° 28'23.34″ N	72° 38'48.32″E	800	45.6	8.6
Q10	21° 28'17.6″ N	72° 38'40.84″E	800	48.4	13.0
Q11	21°31'7.25"N	72°38'44.82"E	2800	40.6	11.5
Q12	21°31'6.76"N	72°38'52.51"E	2300	43.4	10.4
Q13	21°31'3.83"N	72°38'49.30"E	0	0.0	0.0
Q14	21°31'0.54"N	72°38'45.11"E	2200	35.9	6.8
Q15	21°31'0.58"N	72°38'39.17"E	2600	42.4	8.7
Q16	21°31'1.28"N	72°38'33.98"E	0	0.0	0.0
Q17	21°31'5.42"N	72°38'33.96"E	2300	44.9	9.8
Q18	21°31'7.28"N	72°38'38.40"E	2800	39.4	11.5
Q19	21°31'7.10"N	72°38'42.80"E	2400	42.7	12.7
Q20	21°31'3.75"N	72°38'44.30"E	2100	44.8	12.9
Average			**1280.0**	**30**	**--**

Table 9. *A marina* (2016-2017) in 150 ha at Kantiyajal

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	21˚ 30 58.13″ N	72˚ 38 59.38″ E	2600	44.4	13.9
Q2	21˚ 31 0.49″ N	72˚ 38 48.24″ E	2200	41.9	12.7
Q3	21˚ 31 11.8″ N	72˚ 38 41.61″ E	2300	42.9	14.7
Q4	21˚ 31 15.00″ N	72˚ 38 49.07″ E	3000	44.0	9.2
Q5	21˚ 31 26.22″ N	72˚ 38 46.59″ E	2800	37.3	11.8
Q6	21˚ 31 25.92″ N	72˚ 38 53.85″ E	0	0.0	0.0
Q7	21˚ 31 35.09″ N	72˚ 38 5.04″ E	2100	42.1	12.2
Q8	21˚ 3113.63″ N	72˚ 38 58.43″ E	2400	40.5	12.0
Q9	21˚ 31 5.94″ N	72˚38 53.41″ E	2500	41.2	10.4
Q10	21˚ 31 41.71″ N	72˚ 38 34.34″ E	2300	40.0	10.9
Average			**2220.0**	**37**	**--**

Figure 13. Mangrove plantation 150 ha at Kantiyajal-Block 1 during 2018

Figure 14. Mangrove plantation 150 ha at Kantiyajal-Block 2 during 2018

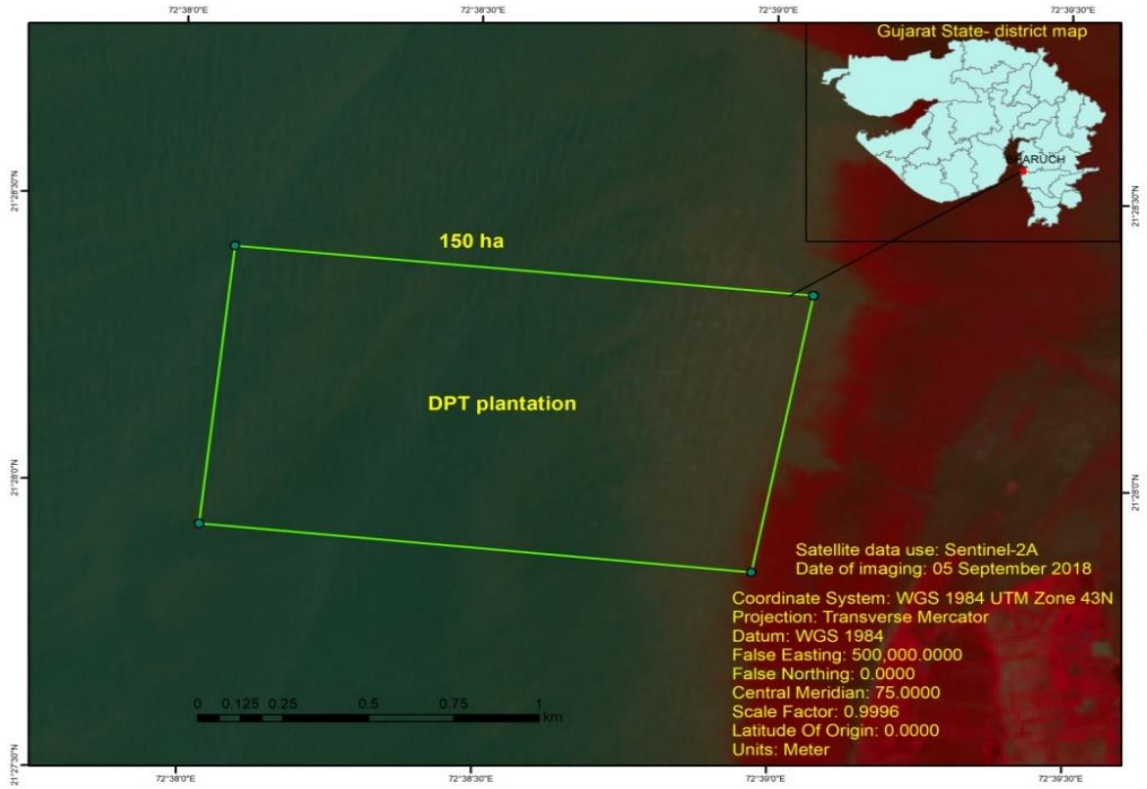

Figure 15. Satellite imageries of the plantation at Kantiyajal-block 1 (2018)

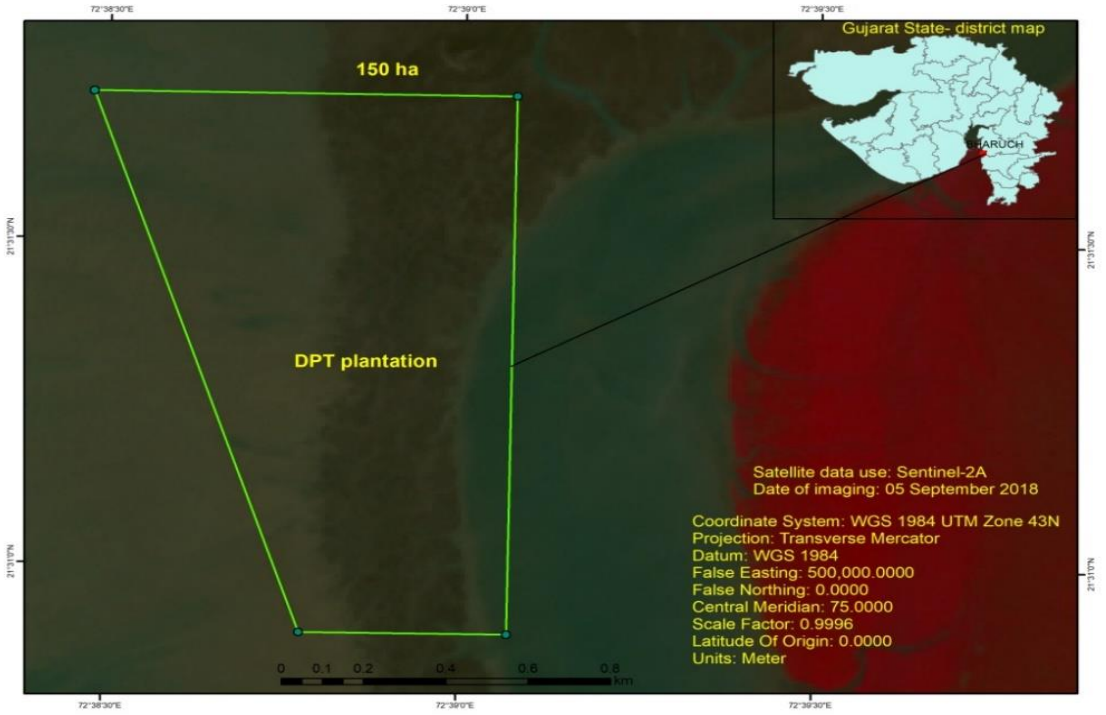

Figure 16. Satellite imageries of the plantation at Kantiyajal-block 2 (2018)

5.7 Plantation at Sat Saida bet (900 ha)

A total of 900 ha of mangrove assessment were carried out in Sat Saida bet with five blocks mentioned in Table 10 and 11 with an area of 330ha, 300 ha, 200 ha, 20 ha and 50ha by Gujarat institute of desert ecology (2005-2006), Department of Forest, Government of Gujarat (2011-2014), and Gujarat Ecology Commission during (2018-2019) the period between 2005 and 2019respectively. Sat Saida bet is situated on the eastern bank of Kandla creek of Gulf of Kachchh, the unique Island of 253.8 km^2 area is located opposite to Deendayal port, having sparse mangroves, dense mangroves, mudflats and halophytic vegetation. Surrounded by Kandla creek and its branches in the west, Navlakhi creek and its branches on the east and Sara and Phang creek on its north, Sat Saida bet is a highly potential site for mangrove plantation with its vast mudflat. Many major, medium and minor creek systems of Kandla and Navlakhi creeks ramify into this Island in varying length and dimension, supplying tidal water to the interior regions. Southern border of the Island represents the innermost end of Gulf of Kachchh with very few minor creek systems (Fig. 18,20,22 & 24). It is known that mudflats experiencing favourable tidal amplitude are suitable for mangrove plantation. Therefore, Sat Saida Bet area was chosen by DPA to carry out the mangrove plantation and restoration activities. The details showing five years (2017-2022) change in the land cover area is given in Table 12,13,14 & 15. The present study was conducted to evaluate the plantation success including the percentage of survival rate, growth, and tree density. The baseline density was fixed at the rate of 4000/ha of *A. marina* was considered for calculating survival percentage as per GEC (2015-2017). The year wise analysis of the imageries of the sites at Sat Saida Bet clearly shows the increase in the plant density at 20 Ha, 300 Ha and 330 Ha, though the survival and height of the plants are comparatively less. Whereas, at 200 Ha plantation site, the plant density has been decreased than the previous monitoring period (2018).

Table 10. Sampling locations at Sat Saida Bet (630 ha)

Block Area covered	**Quadrate no.**	**Latitude**	**Longitude**	**Block Area covered**	**Quadrate no.**	**Latitude**	**Longitude**
330 ha.	**1**	23°4'25"	70°18'4"	**300 ha.**	**1**	23°0'44"	70°15'16"
	2	23°4'41"	70°18'6"		**2**	23°0'42"	70°15'20"
	3	23°4'55"	70°18'8"		**3**	23° 1'3"	70°14'42"
	4	23°4'46"	70°18'10"		**4**	23° 0'57"	70°14'52"
	5	23°4'40"	70°18'19"		**5**	23° 0'47"	70°14'50"
	6	23°4'36"	70°18'18"		**6**	23° 0'42"	70°14'56"
	7	23°4'32"	70°18'24"		**7**	23° 0'51"	70°15'3"
	8	23°4'30"	70°18'33"		**8**	23° 0'38"	70°14'57"
	9	23°4'29"	70°18'28"		**9**	23° 0'41"	70°15'3"
	10	23°4'32"	70°18'19"		**10**	23° 0'34"	70°15'1"
	11	23°4'29"	70°18'10"		**11**	23° 0'46"	70°15'10"
	12	23°4'21"	70°18'9"		**12**	23° 0'41"	70°15'20"
	13	23°4'13"	70°18'4"		**13**	23° 0'39"	70°15'28"
	14	23°4'10"	70°18'58"		**14**	23° 0'10"	70°15'32"
	15	23°4'12"	70°17'49"		**15**	23° 0'5"	70°15'28"
	16	23°4'11"	70°17'48"		**16**	23° 0'0"	70°15'22"
	17	23°4'8"	70°17'49"		**17**	23° 0'4"	70°15'17"
	18	23°4'7"	70°17'51"		**18**	23° 0'13"	70°15'24"
	19	23°4'8"	70°17'52"		**19**	23° 0'22"	70°15'30"
	20	23°4'9"	70°17'54"		**20**	23° 0'21"	70°15'35"
	21	23°4'11"	70°17'57"		**21**	23° 0'19"	70°15'40"
	22	23°4'11"	70°17'59"		**22**	23° 0'20"	70°14'55"
	23	23°4'12"	70°17'59"		**23**	23° 0'30"	70°14'54"
	24	23°4'13"	70°17'57"		**24**	23° 0'37"	70°14'57"
	25	23°4'14"	70°17'54"		**25**	23° 0'36"	70°14'43"
	26	23°4'13"	70°17'52"		**26**	23° 0'33"	70°14'36"
	27	23° 4'53"	70°17'2"		**27**	23° 0'26"	70°14'29"
	28	23° 4'43"	70°17'1"		**28**	23° 0'26"	70°14'36"
	29	23° 4'38"	70°17'3"		**29**	23° 0'18"	70°14'40"
	30	23° 4'33"	70°17'16"		**30**	23° 0'18"	70°14'49"
	31	23° 4'28"	70°17'22"				
	32	23° 4'23"	70°17'26"				
	33	23° 4'35"	70°17'24"				

Table 11. Sampling location of Sat Saida Bet (270 ha)

Block Area covered	**Quadrate no.**	**Latitude**	**Longitude**	**Block Area covered**	**Quadrate no.**	**Latitude**	**Longitude**
200 ha.	**1**	23°2'42"	70°16'10"	**50 ha.**	**1**	23° 4'41.24"	70°16'52.19"
	2	23°2'35"	70°15'28"		**2**	23° 4'50.78"	70°16'51.53"
	3	23°2'36"	70°15'26"		**3**	23° 5'1.73"	70°16'55.65"
	4	23°2'39"	70°15'29"		**4**	23° 4'19.15"	70°17'16.46"
	5	23° 2'25.36"	70°15'26.37"		**5**	23° 3'59.06"	70°17'27.14"
	6	23°2'41"	70°15'30"				
	7	23° 2'39.21"	70°15'37.25"	**20 ha.**	**1**	23° 4'27.43"	70°16'58.03"
	8	23°2'48"	70°15'8"		**2**	23° 4'16.41"	70°16'53.03"
	9	23°2'48"	70°15'9"				
	10	23° 2'29.30"	70°15'52.53"				
	11	23°2'51"	70°15'9"				
	12	23°2'50"	70°15'8"				
	13	23°2'52"	70°15'11"				
	14	23°2'5"	70°15'28"				
	15	23° 2'48.85"	70°15'50.81"				
	16	23°2'4"	70°15'35"				
	17	23° 2'7.74"	70°15'28.60"				
	18	23°2'7"	70°15'36"				
	19	23°2'8"	70°15'40"				
	20	23°2'12"	70°16'16"				

Table 12. *Avicennia marina* plantation (2005-2006) in 20 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚ 04” 43.38N	70˚ 16”47.88E	4400	109	28.34
Q2	23˚ 04” 48.18N	70˚ 16”48.18E	4900	115	24.7
Q3	23˚ 04” 43.77N	70˚ 16”48.41E	5600	110	26.2
Q4	23˚ 04” 44.38N	70˚ 16”47.99E	5700	110	27.7
Q5	23˚ 04” 44.10N	70˚ 16”48.18E	5100	124	29.2
Q6	23˚ 04” 48.17N	70˚ 16”48.17E	4900	135	30.7
Q7	23˚ 04” 44.37N	70˚ 16”48.99E	5300	103	32.2
Q8	23˚ 04” 43.49N	70˚ 16”48.69E	5300	100	34.44
Q9	23˚ 04” 44.14N	70˚ 16”48.93E	6100	121	35.2
Q10	23˚ 04” 44.99N	70˚ 16”47.63E	5200	104	36.7
Q11	23˚ 04” 43.07N	70˚ 16”49.06E	4900	136	29.2
Q12	23˚ 04” 43.85N	70˚ 16”49.88E	5200	105	28.22
Q13	23˚ 04” 44.61N	70˚ 16”48.75E	6100	102	32.15
Q14	23˚ 04” 43.53N	70˚ 16”49.25E	6300	110	33.22
Q15	23˚ 04” 44.04N	70˚ 16”50.02E	5800	110	31.2
Average			**5387**	**113**	**--**

Figure 17. Mangrove plantation at Sat Saida bet 20 ha during 2005-2006

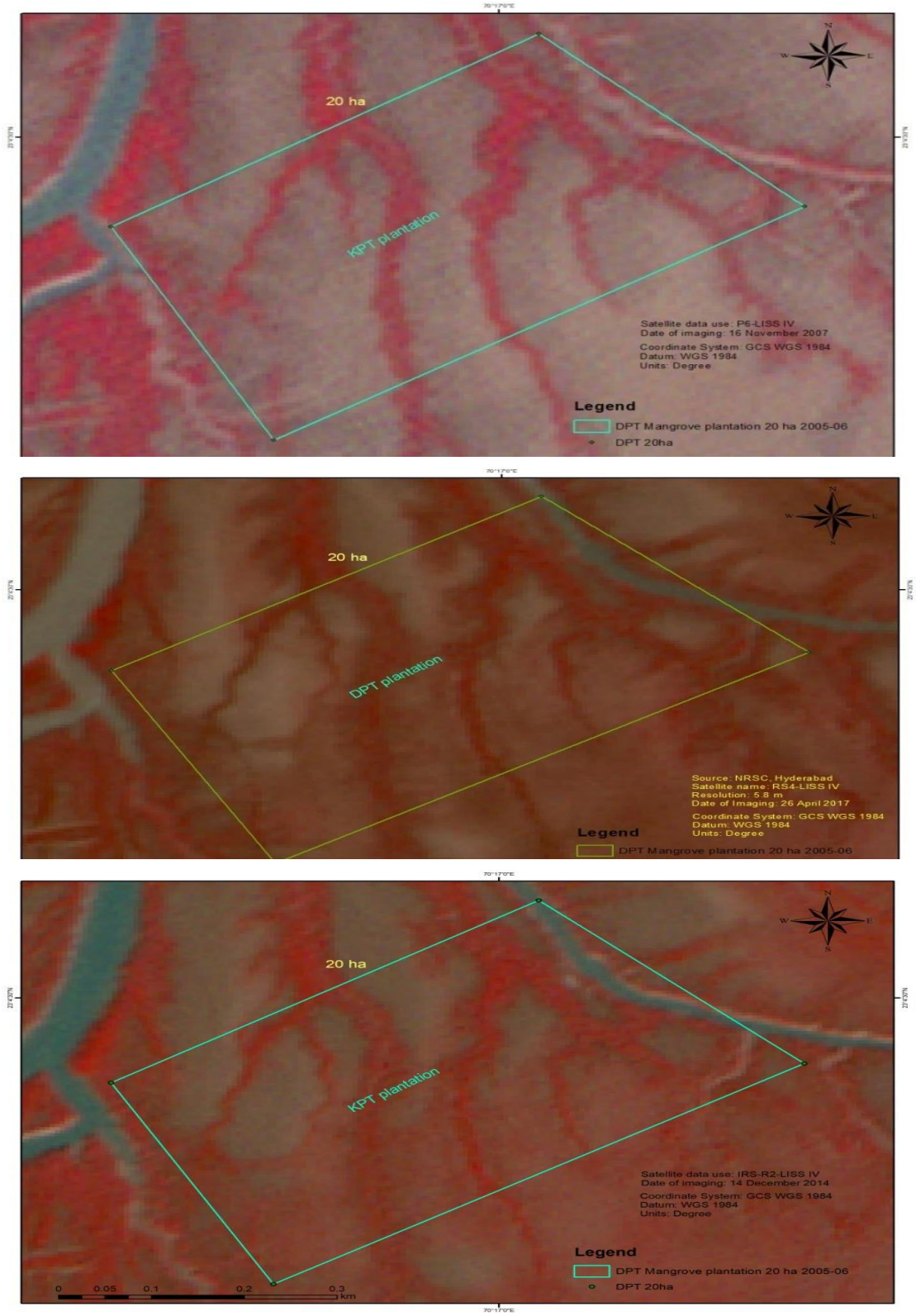

Figure 18. Satellite imageries of the plantation at Sat Saida Bet (2005-2006, 2014 & 2018)

Table 13. *Avicennia marina* plantation (2011-2012) in 200 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚ 00” 48.4N	70˚ 15”49.5E	3000	33.6	9.6
Q2	23˚ 00” 50.5˚ N	70˚ 15” 50.0 E	0	0	0
Q3	23˚ 00 ”53.1˚ N	70˚15” 49.2 E	2700	55.9	9.5
Q4	23˚ 00 ”50.9˚ N	70˚ 15” 47.2 E	3300	31.8	14.9
Q5	23˚ 00 ”50.1˚ N	70˚15” 45.4 E	3500	43.7	14
Q6	23˚ 00 ”49˚ N	70˚15” 43.5 E	3500	53.5	16.6
Q7	23˚ 00” 49.3˚ N	70˚15” 41.3 E	3500	58.8	26.5
Q8	23˚ 00” 51.4˚ N	70˚15” 42E	1700	47.9	18.7
Q9	23˚ 00” 76.9˚ N	70˚13”.50 E	4000	52.7	18.9
Q10	23˚ 00 ”52.2˚ N	70˚15” 37.9E	4600	53.6	24
Q11	23˚ 00” 51.7˚ N	70˚15” 35.6E	2100	69.9	22.1
Q12	23˚ 00 ”52.4N	70˚15” 34.4E	2600	52.7	19.6
Q13	23˚ 00 ”53.2˚ N	70˚15” 33.3E	3500	63.4	19.2
Q14	23˚ 00” 55.1˚ N	70˚15” 32.4 E	4000	57.6	18.9
Q15	23˚ 00” 57.2˚ N	70˚15” 33.4 E	2500	40.8	15.7
Q16	23˚ 00 ”57.9˚ N	70˚15 ”35.6 E	0	0	0
Q17	23˚ 00” 3.6˚ N	70˚15” 35.6 E	500	46.6	14.9
Average			**2647**	**45**	**--**

Figure 19. Mangrove plantation 200 ha at Sat Saida bet during 2017-2018

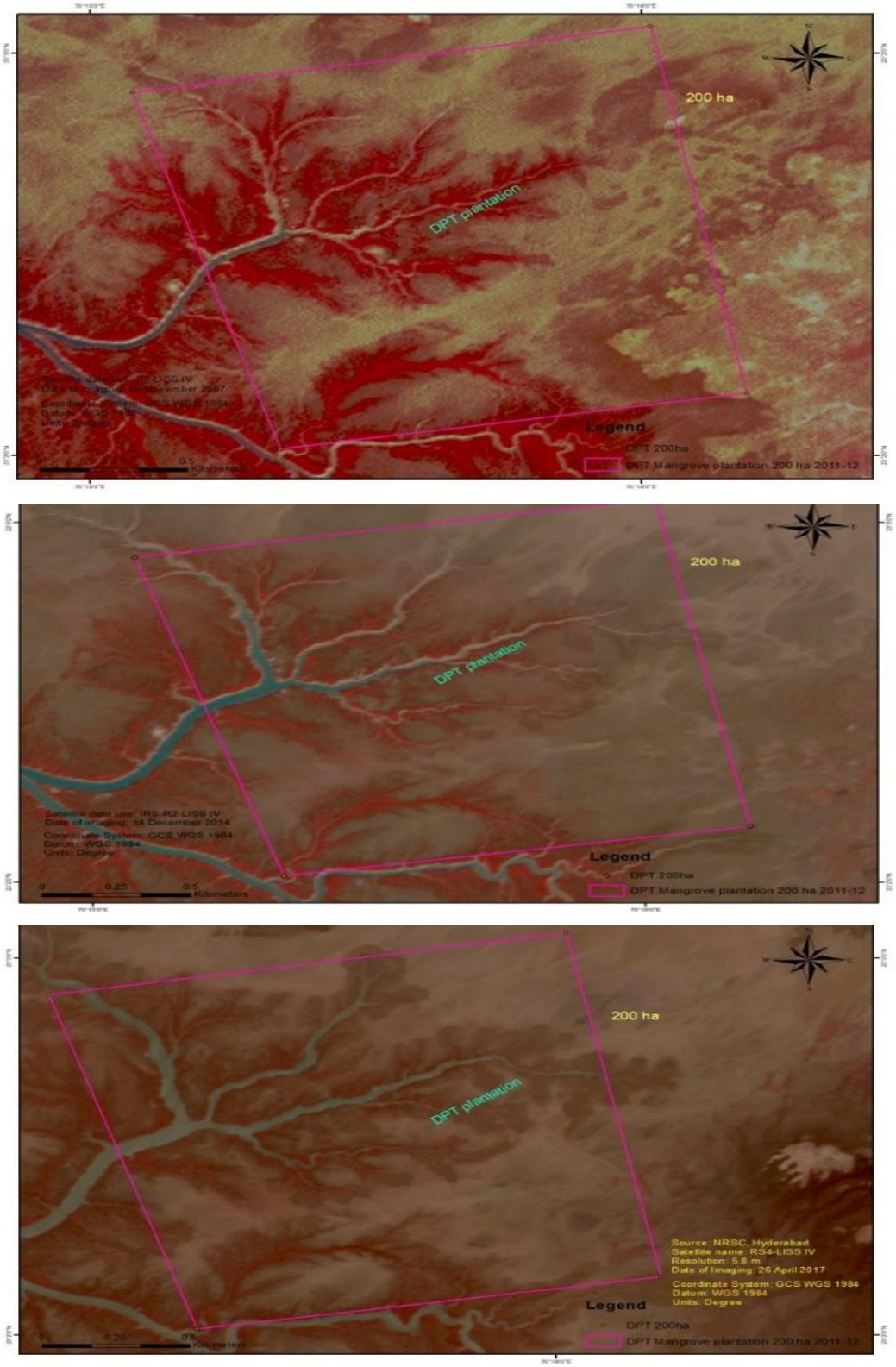

Figure 20 . Satellite imageries of the plantation at Sat Saida Bet (2007, 2014 & 2018)

Table 14. *Avicennia marina* plantation (2012-2013) in 300 ha at Sat Saida bet

Sl. No.	Sampling Location		Density (Ha)	Height (cm)	St. Dev
Q1	23˚02.06604 N	70˚ 13.25285 E	3600	68.1	25.9
Q2	23˚01.93788 N	70˚13.244884 E	3700	46.1	19.7
Q3	23˚ 1.507972 N	70˚13 23.2248E	1500	40.9	10.8
Q4	23˚ 14.5986N	70˚15.2648E	1100	35.5	15.6
Q5	23˚15.948N	70˚15.28626 E	0	0	0
Q6	23˚17.128 N	70˚15. 30816 E	0	0	0
Q7	23˚19.636 N	70˚15. 29886 E	0	0	0
Q8	23˚18.814N	70˚15. 27636 E	1000	31.4	13.4
Q9	23˚18.838N	70˚15.27648 E	4200	44.5	20.5
Q10	23˚19.768N	70˚15. 26198 E	1400	31.6	13.8
Q11	23˚11.3704N	70˚15.231 E	2800	59	20.3
Q12	23˚1 1.3644N	70˚15. 231 E	3600	56	22.1
Q13	23˚11.7004N	70˚15.2334 E	2500	70.2	23.5
Q14	23˚16.61N	70˚15.25192 E	2900	59.4	21
Q15	23˚1 1.4514 N	70˚15.27484 E	500	22.2	6.4
Q16	23˚1 1.4418 N	70˚15.27336 E	3700	57.2	22.7
Average			**2031**	**39**	**--**

Figure 21. Mangrove plantation 300 ha at Sat Saida bet during 2017-2018

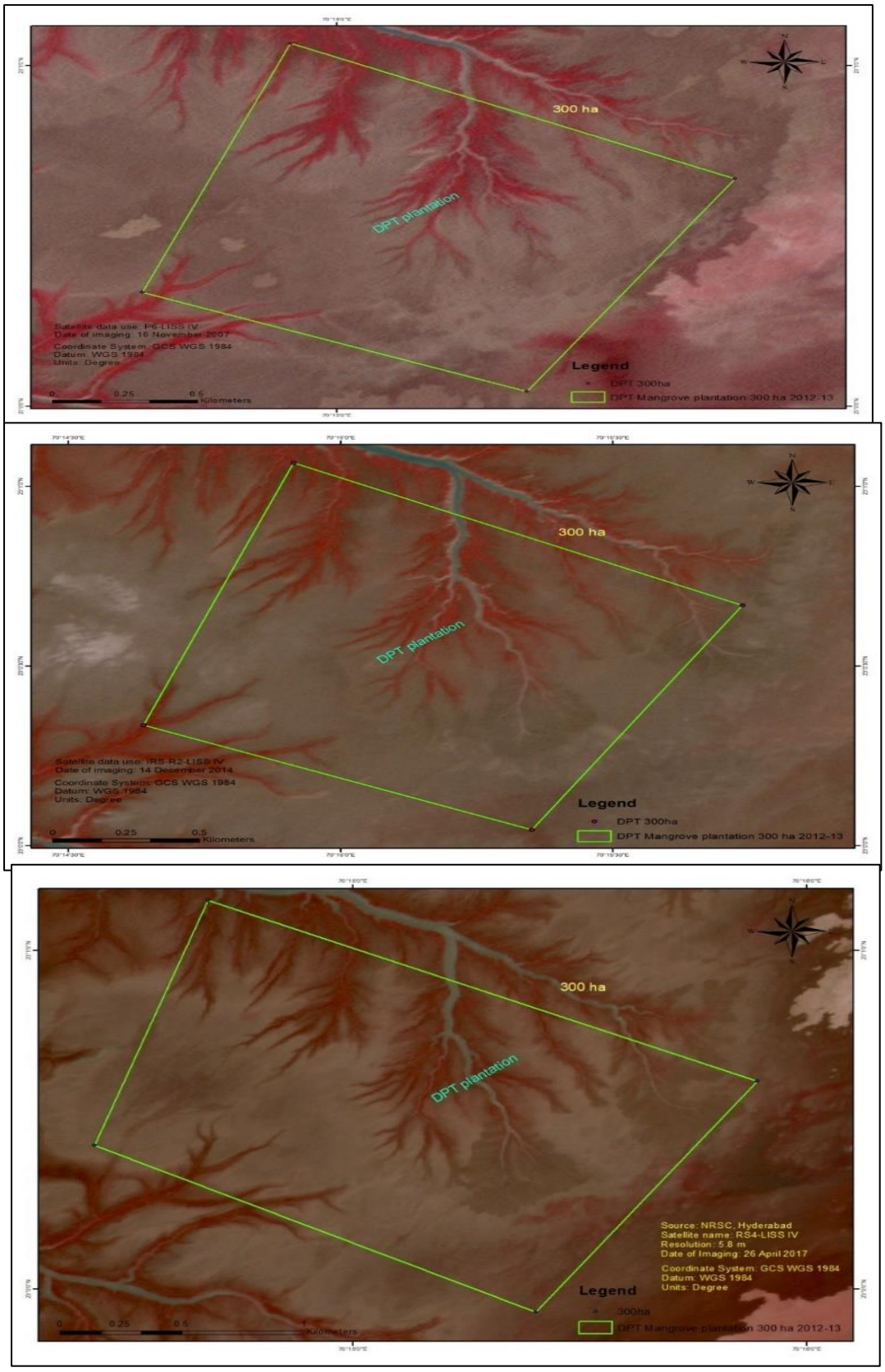

Figure 22. Satellite imageries of the plantation at Sat Saida Bet (2007, 2012-13 & 2014)

Table 15. *Avicennia marina* plantation (2013-2014) in 330 ha at Sat Saida bet

S. No.	Sampling Locations		Density (Ha)	Height (cm)	St. Dev
Q1	23°04'48.34" N	70° 17' 10.05" E	4400	109	28.34
Q2	23°04'46.55" N	70° 17' 13.94" E	4900	115	24.7
Q3	23°04'45.14" N	70° 17' 18.65" E	4100	110	26.2
Q4	23°04'41.97" N	70° 17' 16.66" E	5600	110	27.7
Q5	23°04'50.58" N	70° 17' 16.68" E	2900	124	29.2
Q6	23°04'44.43" N	70° 17' 16.54" E	4900	135	30.7
Q7	23°04'49.39" N	70° 17' 15.54" E	2800	103	32.2
Q8	23°04'45.35" N	70° 17' 06.79" E	5300	100	34.44
Q9	23°04'42.94" N	70° 17' 09.32" E	5200	121	35.2
Q10	23°04'40.49" N	70° 17' 13.53" E	2900	86	36.7
Q11	23°04'46.46" N	70° 17' 12.37" E	4900	73	29.2
Q12	23°04'44.26" N	70° 17' 15.86" E	5200	105	28.22
Q13	23°04'48.25" N	70° 17' 12.93" E	6100	102	32.15
Q14	23°04'44.174" N	70° 17' 16.32" E	6300	70	33.22
Q15	23°04'38.25" N	70° 17' 10.33" E	5800	110	31.2
Q16	23°04'40.41" N	70° 17' 12.07" E	3500	62	16.1
Q17	23°04'40.76" N	70° 17' 12.89" E	2600	51	14.7
Q18	23°04'38.16" N	70° 17' 20.60" E	3600	43	12.2
Q19	23°04'38.76" N	70° 17' 10.60" E	3300	45	11.1
Q20	23°04'40.69" N	70° 17' 06.48" E	2300	66	23.7
Q21	23°04'49.68" N	70° 17' 14.62" E	3600	72	9.3
Q22	23°04'47.10" N	70° 17' 03.65" E	3100	78	17.6
Q23	23°04'49.42" N	70° 17' 07.81" E	3300	85	19.2
Q24	23°04'49.87" N	70° 17' 10.23" E	2600	64	17.2
Average			**4133**	**89**	**--**

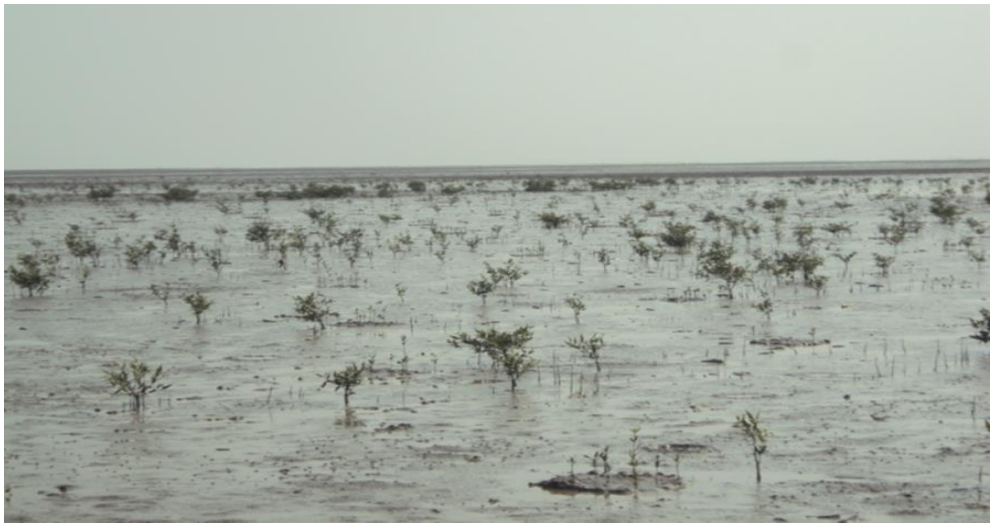

Figure 23. Mangrove plantation 330 ha at Sat Saida bet during 2013-2014

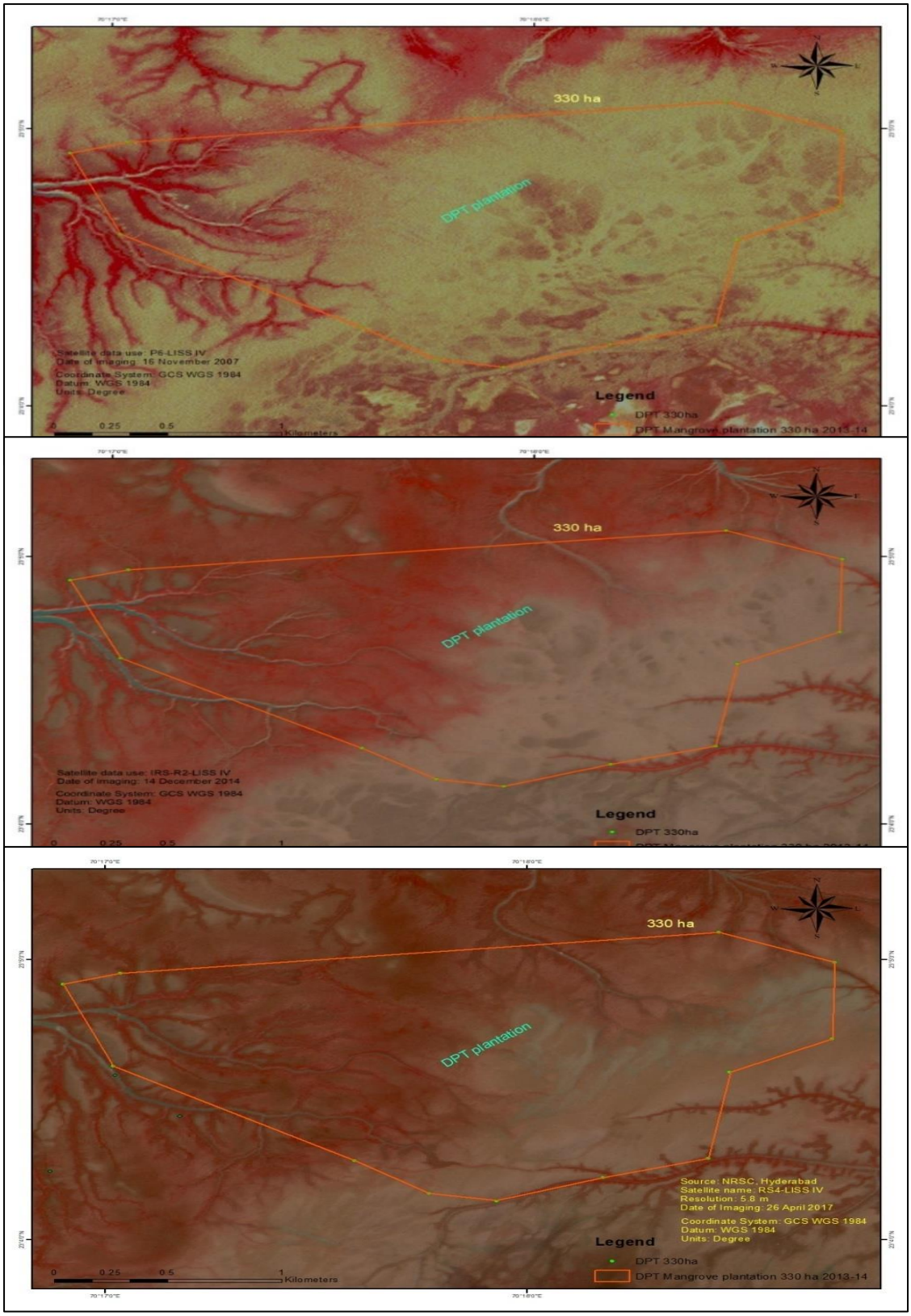

Figure 24. Satellite imageries of the plantation at Sat Saida Bet (2007, 2014 & 2018)

6 Results

The mangrove monitoring study results of the three sites, Nakti creek Kantiyajal and Sat Saida bet are presented below.

6.1 Mangrove plantation evaluation at Nakti creek

6.1.1 Evaluation of *Avicennia marina* Plantation at Nakti creek (2021-2022) 100 ha

In total, ten quadrats were laid at Nakti creek block to assess the *A. marina* survival percentage. The survival rate was recorded to be 40%, lower than the survival rate of recorded in Nakti creek within 50 ha plot. The plantation density ranged from 900 individuals/ha to 3400 individuals/ha, with an average density of 1600 individuals/ha (Table 16). In this block, the height of the plants ranged between 70- 280 cm, with an average height of 118.9 cm was recorded. The GBH in this plantation varied from 6 to 12 cm, with an average value of 6.8 cm. The minimum and maximum canopy cover in this plantation stand ranged from 0.30 to 1.5 m2 with a mean value of 0.8 m^2. Even though the plantation activities were carried out near the creek system, the poor survival of planted mangroves could be due to mixed plantation techniques. *R. mucronata* saplings were recorded outside the quadrats with heights varying from 50-60 cm. Around ten individuals were seen during the entire survey. Thus, it was apparent that the plantation of *R. mucronata* showed poor survival rate as this species needs 20-25 days of tidal flushing in a month and can tolerate only moderate salinity.

Table 16. Details of mangrove plantation at Nakti creek (100 ha)

S. No	Density (Plants/Ha)	Height (cm)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
1	2200	70	170	120	7	9	8	0.42	1.25	0.8
2	1700	100	280	190	6	11	8.5	0.42	1.5	0.96
3	2300	100	235	167.5	7	12	9.5	1.32	1.5	1.4
4	1700	70	170	120	7	11	9	0.3	0.85	0.6
5	0	0	0	0	0	0	0	0	0	0
6	3400	70	180	125	7	8	7.5	1.32	0.75	1.03
7	2900	100	190	145	8	7	7.5	1.56	1.1	1.3
8	900	80	210	145	7	10	8.5	0.56	1.25	0.9
9	900	100	252	176	7	12	9.5	0.72	1.5	1.1
10	0	0	0	0	0	0	0	0	0	0
Overall average Density (plants/ha) 1600.0		**69.0**	**168.7**	**118.9**	**5.6**	**8.0**	**6.8**	**0.7**	**1.0**	**0.8**

6.1.2 Mangrove evaluation at Nakti creek (2021-2022) 50ha

Two mangrove plantation sites with an area of 50 ha and 100 ha were developed at the north-eastern bank of Nakti creek, one of the major creek systems of Kandla. The main creek and its branches are getting inundated by 3-4 m of tidal water during the high tide period. The two mangrove plantation sites developed is adjacent to each other with a good tidal flooding area. The findings based on-site visits and subsequent data are given in Table in 17.

To evaluate the *A. marina* plantation success at Nakti creek i.e., survival percentage and growth rate, an initial plantation density of 4000 saplings/ha as a baseline density was considered. Therefore, in the present study, six quadrates of 10×10m each were laid to evaluate the growth and survival of *A. marina*. The results revealed that the survival rate of *A. marina* in this block was 55 percent. The density ranged from 900 individuals/ha as high as 2800 individuals/ha, with an average density of 2200 individuals /ha. Similarly, the plant height ranged between 70 cm and 210 cm, with an average of 129.2 cm. The canopy cover ranged between 0.3 m^2 to 1.5 m^2 with an average of 0.8 m^2. The Girth at base (here after GB) values are ranged from 7 cm to 46 cm, with an average of 20.4 cm. The larger values of GB indicate the presence of multiple stems. It is known that direct dibbling and plantation of nursery raised trees are superior to the *Otla* bed technique. Moderate survival (55%) of the planted *A. marina* could be attributed to mixed plantation techniques as more than two species, namely *Rhizophora mucronata* and *Ceriops tagal* were also planted at this site.

Table 17. Details of mangrove plantation at Nakti creek (50 ha)

S. No	Density (Plants/ Ha)	Height (cm)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
1	2400	100	175	137.5	7	37	22	0.42	1.2	0.8
2	2300	100	185	142.5	7	37	22	0.3	1.35	0.8
3	2800	100	210	155	7	46	26.5	0.3	1.5	0.9
4	2300	100	160	130	7	26	16.5	0.3	1.1	0.7
5	2500	80	120	100	7	34	20.5	0.56	0.75	0.7
6	900	70	150	110	8	22	15	1	0.8	0.9
Avg	**2200.0**	**91.7**	**166.7**	**129.2**	**7.2**	**33.7**	**20.4**	**0.5**	**1.1**	**0.8**

During the field surveys, it was recorded that the saplings were invaded by the alga *Enteromorpha* sp. and regular tidal flushing was lacking. Due to all these factors a variation of mortality of different tree species was recorded along the Nakti creek.

6.2 Kantiyajal mangrove plantation (350 ha)

The 350 ha mangrove plantation was carried out at the coastal stretch of Katpor village near Kantiyajal in Bharuch district. This plantation was carried out in two blocks of 150 ha each during the year 2015-16 and 2016-17 and 50 ha during the year 2019-20. The Gujarat Ecology Commission (GEC), Gandhinagar executed this plantation with the help of community participation by Samity at the Katpor village.

6.2.1 *Avicennia marina* and *Rhizophora mucronata* plantation (2015-2016) 150 ha

Sixteen quadrats were laid in this block for assessing mangrove species survival success. As per the earlier report by GEC (2015-2017), at this site, it was evident that this block had *R. mucronata* saplings in addition to *A. marina* (Table 18, 19 & 20). An overall average density of 3000 individuals/ha was recorded for *A. marina*. The tree density varied from 1200 to 5200 individuals/ha. The height of the plants ranged from 0.90 m to 2.20 m, with an average of 1.5 m. The GB of the plants ranged from 7.0 to 25 cm with an average of 14.2 cm. The canopy cover of the mangrove plants varied between 0.56 m^2 and 2.4 m^2 with an average of 1.3 m^2.

Plate 1. *Ceriops tagal* stands at Nakti creek Plantation site

Plate 2. *Rhizophora mucronata* stands at Nakti creek Plantation site

Plate 3. *Avicennia marina* (100 ha) plantation at Nakti creek

Table 18. Details of *A. marina* & *R. mucronata* plantation at Kantiyajal (150 ha)

Quadrate	Density	Height (m)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q1	5200	1	1.9	1.45	7	20	13.5	0.56	1.82	1.19
Q2	3600	1.2	2	1.6	11	25	18	1.1	2.1	1.6
Q3	4000	0.9	1.9	1.4	8	16	12	0.9	1.56	1.23
Q4	3600	1.25	1.9	1.575	9	25	17	0.72	2.4	1.56
Q5	3600	1.1	1.75	1.425	9	22	15.5	0.72	1.1	0.91
Q6	3200	1	2.1	1.55	7	20	13.5	0.72	1.82	1.27
Q7	2800	1.2	2.1	1.65	12	23	17.5	1.2	2.4	1.8
Q8	1200	1.1	1.6	1.35	7	13	10	1.1	1.2	1.15
Q9	1600	1.2	2.2	1.7	8.5	18	13.25	0.72	2.1	1.41
Q10	1200	1	1.2	1.1	8	15	11.5	0.72	1.1	0.91
Overall average	**3000**	**1.1**	**1.9**	**1.5**	**8.7**	**19.7**	**14.2**	**0.85**	**1.76**	**1.3**

6.2.2 *Rhizophora mucronata* plantation (2016-2017) 150 ha

The assessment of the *R. mucronata* plantation at this site showed an overall density of 2520 individuals/ha (Table 19). The average height of *R. mucronate* plants was 129.5 cm, and the average canopy cover was 0.9 m^2 in this block. *R. mucronata* being a frontline mangrove, its plantation was carried out towards the lower intertidal region. Continuous tidal flushing following appropriate zonation patterns during plantation could be attributed to a higher survival percentage of *R. mucronata*. The survival and growth of the mangrove plantation at this site was (63%) comparatively good because of continuous water inundation and availability of extensive intertidal mudflats.

Table 19. Details of mangrove plantation of *Rhizophora mucronata* at Kantiyajal (150 ha)

Quadrate	Density	Height (cm)			GBH (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q1	3500	85	175	130	5	9	22	0.52	1	0.76
Q2	2500	100	185	142.5	7	11	22	0.65	1.5	1.075
Q3	2800	110	210	160	8	12.5	26.5	1.1	1.3	1.2
Q4	2000	70	160	115	5	8	16.5	0.3	1.1	0.7
Q5	1800	80	120	100	3	5	20.5	0.6	0.75	0.675
Overall average	**2520.0**	**89.0**	**170.0**	**129.5**	**5.6**	**9.1**	**21.5**	**0.6**	**1.1**	**0.9**

6.2.3 *Avicennia marina* plantation (2018-2019) 50 ha

During the field surveys at this site saplings of both *A. marina* and *R. mucronata* saplings were also noticed (Table 20). An average density of 2480 individuals/ha was recorded for *A. marina*. The plant density varied between of 2100 individuals/ha, to 2800 individuals/ha. The height of the plants ranged from13 cm to 97 cm, with an average of 57.28 cm. The survival and growth of the mangrove plantation at this site (62%) was comparatively high because of continuous water inundation on the extended intertidal mudflats.

Table 20. Evaluation of *A. marina* plantation at Kantiyajal (50 ha) during 2018-2019

Quadrate	Density	Height (cm)		
		Min	Max	Average
Q1	2700	37	52	44.5
Q2	2100	57	93	75
Q3	2200	62	97	79.5
Q4	2600	55	73	64
Q5	2800	13	34	23.4
Average	**2480**	**44.8**	**69.8**	**57.28**

Plate 4. *Avicennia marina* plantation at Kantiyajal coast

Plate 5. *Rhizophora mucronata* plantation at Kantiyajal coast

6.3 Monitoring of mangrove plantation at Sat-Saida Bet

6.3.1 Monitoring of *Avicennia marina* at Sat-Saida Bet (2021-2022) 20 ha

During 2005-2006, the mangrove plantation at Sat Saida Bet was carried out at Dharkadia creek banks in 20 ha. The two sites on both the banks of Dharkadia creek were planted with *A. marina* by Gujarat Institute of Desert Ecology through transplanting nursery-grown seedlings and direct seed sowing for gap filling.

In total, 2 quadrats were laid at this site to assess the survival percentage of the *A. marina.* The results of the growth of these plantations are presented in Table 21. .The *A. marina* plants in the 20 ha area showed tree density varying from 2100/ha to a maximum 2500/ha, and the overall average was 2300 /ha. The overall average plant height of this site was 175cm. and the survival rate was 57.5 %. The GB ranged from 7 cm to 15 cm, with an average of 10.5 cm, while the average canopy cover was 1.89 m^2. The area was moderately dense, with *A. marina* being predominant species (Plate-16).

Additionally, the area being slightly cooler due to frequent tidal exposures and is inhabited by snakes. As the area remains moist due to the tidal influx, assessment of the area becomes

difficult. This area also supports avifauna like Oriental darter (*Anhinga melanogaster*), Painted stork (*Mycteria leucocephala*), crab plovers (*Dromas ardeola*) etc.

Table 21. Evaluation of *A. marina* plantation at Sat Saida Bet (20 ha)

Quadrat	Density	Height (cm)			Girth (cm)				Canopy (m^2)	
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q-1	2100	180	200	190	8	15	11.5	1.14	3.21	2.175
Q-2	2500	110	160	160	7	12	9.5	1.1	2.1	1.6
Average	2300	180	180	175	7.5	13.5	10.5	1.12	2.66	1.89

Plate 6. Sat Saida Bet *Avicennia marina* plantation

6.3.2 Monitoring of *Avicennia marina* plantation at Sat Saida bet (2021-2022) 200 ha.

Mangrove plantation in 200 ha was initiated by Forest Department, Kachchh circle during 2011-2012 on DPA's request. Forest Department (Anjar circle) initiated the plantation activities at Sat Saida Bet during the rainy season of June 2011. The plantation site is opposite to Deendayal port oil jetty and is around 2 km from the bank of Sat Saida bet. A buffer zone of

nearly 2 km was allowed between the waterfront from the banks of Sat Saida bet and the plantation site. The seeds of *A. marina* were used for plantation activities due to the prevailing high salinity in the area. Raised bed method (*Otla*) was followed as the plantation technique, and *A. marina* seeds were collected from Kandla mangroves for plantation work.

In total, 20 quadrats were laid at this site to assess the survival percentage of the *A. marina.* The growth of these plantations was assessed, and the results were presented in Tables 22. The *A. marina* plants in the 200-ha area showed tree density varying from 1800/ha to a maximum 2800/ha, and the overall average was 2250 /ha. The overall average plant height of this site was 117.8 cm and the survival rate was 56.25 %. The GBH ranges from 7 cm to 11 cm with an average of 8.3 cm, while the average canopy cover was 1.1 m^2.

Additionally, the area supported the luxuriant growth of halophytes like *Salicornia brachiata, Sesuvium sp. and Salvadora persica*. The area becomes dry during low tides and gets converted to a hard surface, making it accessible. Interestingly, despite the dryness of the area, snakes were recorded. It was observed that they take shelter under the canopy cover and camouflage themselves by intertwining with the stem of mangroves.

6.3.3 Monitoring of *Avicennia marina* plantation (2021-2022) 300 ha.

The *A. marina* mangrove plantation carried out during 2012-2013 in 300 ha by the Range office of the Forest Department at Anjar. Initially, raised bed method was followed for mangrove plantations but was eventually replaced by direct seed sowing. In a few places, direct seed dibbling was also done.

In total, 30 quadrates were laid at this site to assess the survival percentage of the *A. marina.* The growth of these plantations was assessed, and the results are presented in Table 23. The *A. marina* plants in the 300ha area showed tree density varying from 1300/ha to a maximum 3500/ha, and the overall average was 2247/ha. The overall average plant height of this site was 125.3cm, and the survival rate was 56.17 %. The GB ranges from 0.63 cm to 19 cm with an average of 9.16 cm, while the average canopy cover was 1.44 m^2.

Table 22. Details of mangrove plantation of *A. marina* at Sat Saida Bet (200 Ha)

Quadrate	Density	Height (cm)			Girth (cm)			Canopy cover (m^2)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Q-1	2200	110	140	125	7	10	8.5	0.34	1.24	0.79
Q-2	1800	120	110	115	7	9	8	1	1.57	1.285
Q-3	2500	100	130	115	9	11	10	1	1.34	1.17
Q-4	1800	100	110	105	7	9	8	0.59	1.24	0.915
Q-5	2400	130	140	135	7	11	9	0.89	1.95	1.42
Q-6	2200	110	120	115	7	9	8	0.98	1.4	1.19
Q-7	2400	120	130	125	7	10	8.5	1	1.49	1.245
Q-8	1800	100	120	110	7	10	8.5	0.48	0.67	0.575
Q-9	2200	100	110	105	7	8	7.5	0.34	0.59	0.465
Q-10	1800	130	140	135	7	9	8	1	1.77	1.385
Q-11	2700	120	130	125	7	10	8.5	1	1.8	1.4
Q-12	2200	80	100	90	7	9	8	0.23	1.67	0.95
Q-13	1900	120	150	135	7	8	7.5	1.29	1.78	1.535
Q-14	2800	110	120	115	7	8	7.5	1	1.3	1.15
Q-15	2200	90	110	100	8	9	8.5	1.07	1.29	1.18
Q-16	2400	110	140	125	8	11	9.5	1.2	1.5	1.35
Q-17	2200	120	140	130	8	10	9	1	1.64	1.32
Q-18	2500	80	120	100	5	8	6.5	1.04	1.34	1.19
Q-19	2200	110	130	120	7	8	7.5	0.54	0.76	0.65
Q-20	2800	120	140	130	8	11	9.5	0.72	0.9	0.81
Average	**2250**	**109**	**126.5**	**117.8**	**7.2**	**9.4**	**8.3**	**0.8**	**1.4**	**1.1**

Table 23. Details of mangroves plantation of A. *marina* at Sat Saida Bet (300 Ha)

Quadrat No	Density	Height(cm)			Girth(cm)			Canopy cover (m^2)		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Average
Q-1	2200	120	160	140	9	19	14	1.32	2.7	2.01
Q-2	1500	100	120	110	11	12	11.5	1.56	1.75	1.65
Q-3	2500	90	130	110	0.99	10	5.5	0.96	1.69	1.325
Q-4	1900	120	140	130	9	12	10.5	1	1.39	1.195
Q-5	2600	90	180	135	7	18	12.5	1	1.69	1.345
Q-6	2100	90	140	115	8	9	8.5	1	2.19	1.595
Q-7	2500	100	130	115	7	11	9	1	2.56	1.78
Q-8	2500	90	120	105	0	9	4.5	0.47	1.39	0.93
Q-9	1900	100	120	110	7	12	9.5	1	1.22	1.11
Q-10	2600	110	190	150	10	16	13	1	1.38	1.19
Q-11	2100	110	190	150	12	20	16	1	2.79	1.895
Q-12	2500	120	270	195	9	24	16.5	2	4.46	3.23
Q-13	2200	130	260	195	11	21	16	3	4.39	3.695
Q-14	2200	90	120	105	5	10	7.5	0.39	2.35	1.37
Q-15	2100	130	170	150	11	13	12	0.56	1.67	1.115
Q-16	1800	90	140	115	6	10	8	0.76	1.36	1.06
Q-17	1800	120	130	125	7	9	8	1.2	1.32	1.26
Q-18	2200	80	100	90	5	7	6	0.65	1.02	0.835
Q-19	2200	90	120	105	6	7	6.5	0.89	1.29	1.09
Q-20	1300	130	140	135	7	9	8	0.9	1.34	1.12
Q-21	2200	100	120	110	6	9	7.5	0.79	1.1	0.945
Q-22	1500	80	130	105	6	10	8	0.63	1.35	0.99
Q-23	2200	110	140	125	7	9	8	1	1.45	1.225
Q-24	2800	100	110	105	5	7	6	0.56	1.06	0.81
Q-25	2900	105	130	117.5	7	11	9	1.38	2	1.69
Q-26	3500	120	150	135	9	13	11	1	2	1.5
Q-27	2200	110	130	120	0	9	4.5	1.02	1.89	1.455
Q-28	2400	100	140	120	0	9	4.5	1	1.68	1.34
Q-29	2800	110	150	130	0	10	5	0.64	1.83	1.235
Q-30	2200	70	140	105	0.63	16	8.315	1	1.45	1.225
Average	**2247**	**103.5**	**147**	**125.25**	**6.29**	**12.03**	**9.16**	**1.02**	**1.86**	**1.44**

6.3.4 Monitoring of *Avicennia marina* plantation (2021-2022) 330 ha.

During 2013-14, these sites were planted with *A. marina,* plants with nursery raised saplings and direct dibbling methods, respectively. In total, 33 quadrates were laid at this site to assess the survival percentage of the *A. marina.* The growth of these plantations was assessed, and the results are presented in Table 24. The *A. marina* plants in the 330 ha area showed the tree density varying from 1800/ha to a maximum of 3200/ha, and the overall average was 2509/ha. The overall average plant height of this site was 132.3cm, and the survival rate was 62.7 %. The girth at base ranges from 5 cm to 24 cm with an average of 9.61 cm, while the average canopy cover was 1.35 m^2.

Plate 7. Monitoring of *A. marina* on field

Table 24. Details of mangroves plantation of A. *marina* at Sat Saida Bet (300 ha)

Quadrate	Density	Height (cm)			Girth (cm)				Canopy cover(m^2)	
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	2400	70	90	80	5	6	5.5	0.4	1.2	0.8
2	3200	110	120	115	7	8	7.5	0.28	1.62	0.95
3	2200	90	110	100	7	8	7.5	0.36	1.23	0.795
4	2600	80	100	90	5	6	5.5	1.2	2.2	1.7
5	3200	100	120	110	6	8	7	0.38	1.36	0.87
6	2200	80	90	85	5	7	6	0.7	1.9	1.3
7	3000	100	110	105	4	6	5	0.5	0.9	0.7
8	2500	110	125	117.5	6	9	7.5	0.42	1.23	0.825
9	1900	110	130	120	7	10	8.5	1.08	1.23	1.155
10	2600	110	120	115	7	9	8	0.89	1.26	1.075
11	2100	120	180	150	8	12	10	0.78	1.47	1.125
12	2500	105	150	127.5	7	14	10.5	0.42	1.68	1.05
13	2700	150	190	170	10	16	13	0.8	1.59	1.195
14	2200	110	170	140	7	18	12.5	0.89	2.38	1.635
15	2900	110	180	145	7	17	12	0.54	2.1	1.32
16	3500	110	130	120	6	10	8	0.9	1.2	1.05
17	2200	130	150	140	7	15	11	1.08	2.24	1.66
18	2400	110	140	125	7	12	9.5	0.9	2.36	1.63
19	2200	120	170	145	9	15	12	1.39	2.49	1.94
20	2400	120	140	130	7	12	9.5	1.17	2.35	1.76
21	1800	90	110	100	6	9	7.5	0.89	1.02	0.955
22	2500	100	120	110	9	10	9.5	0.64	0.98	0.81
23	3200	140	170	155	9	13	11	0.9	1.39	1.145
24	2500	80	120	100	6	8	7	0.38	0.76	0.57
25	2500	110	130	120	7	8	7.5	0.34	1.24	0.79
26	1900	110	130	120	7	9	8	0.79	1.1	0.945
27	2600	100	150	125	7	10	8.5	0.88	2.89	1.885
28	2200	100	110	105	7	10	8.5	0.54	1.96	1.25
29	2100	150	250	200	10	22	16	2.34	3.5	2.92
30	2400	160	210	185	1	18	9.5	1.78	2.7	2.24
31	2500	210	260	235	16	24	20	1.98	3.86	2.92
32	2500	150	240	195	11	19	15	2.28	2.46	2.37
33	3200	160	210	185	10	16	13	0.72	1.67	1.195
Average	**2509**	**115**	**149**	**132**	**7.3**	**12**	**9.61**	**0.90**	**1.80**	**1.35**

6.3.5 Monitoring of *Avicennia marina* plantation (2021-2022) 50ha.

During 2018-19, this site was planted with A. marina, plants with nursery raised saplings and direct dibbling methods, respectively by Gujarat Ecology Commission. In total, five quadrates were laid at this site to assess the survival percentage of the A. marina. The growth of these plantations was assessed, and the results are presented in Table 25. The A. marina plants in the 50 ha area showed tree density varying from 1600/ha to a maximum of 2500/ha, and the overall average was 2060/ha. The overall average plant height of this site was 141.6cm, and the survival rate was 51.5 %. The girth ranges from 8 cm to 19 cm with an average of 12.2 cm, while the average canopy cover was 1.45 m^2.

Table 25. Details of mangroves plantation of A. *marina* at Sat Saida Bet (50 Ha)

Quadrat No	Density	Height(cm)			Girth(cm)			Canopy(m^2)		
		Max	Min	Avg	Max	Min	Average	Max	Min	Average
Q-1	1900	180	140	160	18	11	14.5	2.98	0.9	1.94
Q-2	2200	160	136	148	15	12	13.5	2.57	0.48	1.525
Q-3	2500	150	110	130	12	9	10.5	1.82	0.59	1.205
Q-4	2100	190	110	150	19	8	13.5	2.36	1.04	1.7
Q-5	1600	130	110	120	10	8	9	1.34	0.46	0.9
Avg	**2060**	**162**	**121**	**141.6**	**14.8**	**9.6**	**12.2**	**2.214**	**0.69**	**1.45**

7 Regeneration and recruitment class

The regeneration class and recruitment class density were recorded in Sat Saida bet. The overall average density of the regeneration class (saplings with a height of <50 cm) of mangroves in the sampling site recorded was 43,658 plants/ha. The highest regeneration class (62,121 plants/ha) was recorded at 330 ha block, indicating the suitability of the site for germination and survival of young plants (Fig-25, 26). The lowest density of the regeneration class (25,667 plants/ha) was recorded at the 300 Ha block. In the case of recruitment class plants, the overall average density recorded was 5071 plants/ha. The maximum recorded at 330 Ha block (6061 plants/ha), and the minimum at 300 ha block. These results indicate that the 300 Ha block is not conducive for the growth of mangroves.

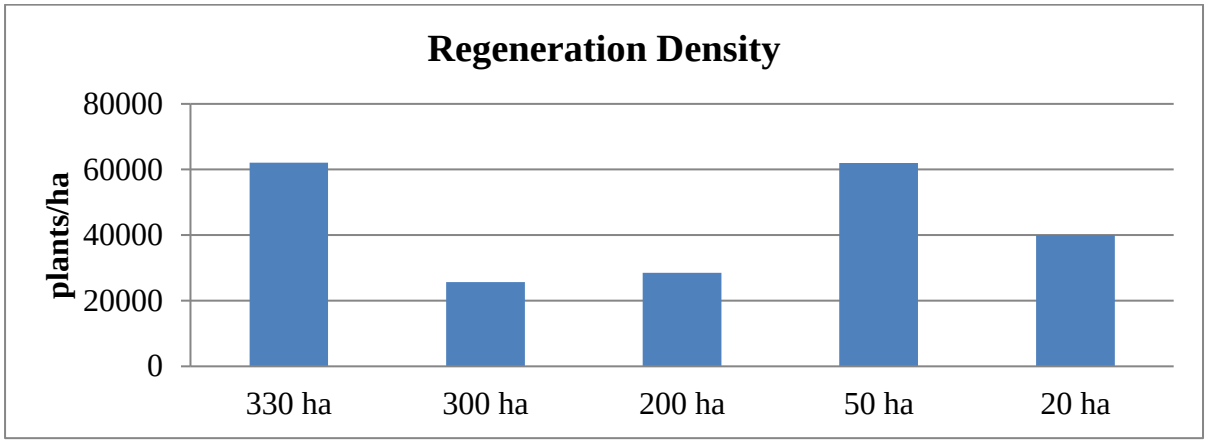

Figure 25. Regeneration class density at Sat Saida Bet

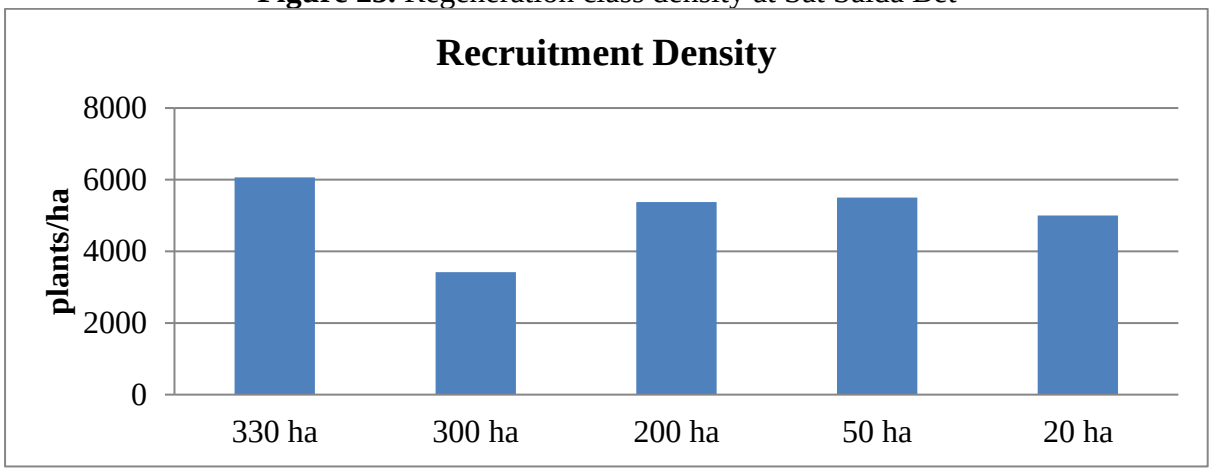

Figure 26. Recruitment class density at Sat Saida Bet

The regeneration class density was highest in 330 ha block followed by 50 ha, 20 ha, 200 ha and lowest in 300 ha. The recruitment class density was highest in 330 ha followed by 50 ha, 200 ha, 20 ha and lowest in 300 ha.

Table 26. Assessment of plant characteristics (Mean) at the plantation sites during 2017-2018

Site	Parameters	150 ha	150ha
Kantiyajal	Plant density (No/ha)	2220 (*A .marina*)	1460 (*A.marina)* 1280 *(R.mucronata)*
	Height(cm)	37	32 (*A.marina*) 30 (*R.mucronata)*
	Survival rate (%)	88.8	58.4 *(A. marina*) 64.0 (*R. mucronata)*
Nakti creek	Plant density (No/ha)	2370	-
	Height (cm)	53 – 84	-
	Survival rate	35.9	-
Sat Saida Bet	Plant density (No/ha)	4133	2031 to 5387
	Height (cm)	89	39 – 113
	Survival rate (%)	62.6%	81.6

8 Soil Biomass Carbon

8.1 Soil biomass carbon stock potential at Nakti creek mangrove site

At Nakti creek, the below ground soil carbon stock of the *A. marina* plantation was 51.76 t/ha and 62.74t/ha at 50 ha and 100ha respectively. At the 100 ha mangrove plantation area, the soil biomass carbon stock ranged from 42.36 to 84.32 t/ha with an average of 62.74 t/ha. Among the two locations, 100 ha plantation site at Nakti creek showed the higher soil Total Biomass Carbon stock (Table 27, 28).

Table 27. Soil Carbon stock in Nakti mangrove plantation site- 100 ha

Sampling Blocks	Depths	TOC (%)	Total carbon (%)	Bulk Density (g/ cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
NC 1	25 cm	0.34	0.18	1.28	5.83	84.315
	50 cm	0.37	0.20	1.30	12.85	
	75 cm	0.43	0.23	1.25	21.56	
	100 cm	0.61	0.33	1.35	44.08	
NC 2	25 cm	0.43	0.23	1.33	7.66	58.63
	50 cm	0.4	0.21	1.25	13.37	
	75 cm	0.34	0.18	1.32	17.94	
	100 cm	0.28	0.15	1.31	19.65	
NC 3	25 cm	0.24	0.13	1.32	4.22	45.27
	50 cm	0.27	0.14	1.27	9.14	
	75 cm	0.21	0.11	1.28	10.80	
	100 cm	0.3	0.16	1.32	21.11	
Average Carbon stock (%)						**62.74**

Table 28. Soil Carbon stock in Nakti mangrove plantation site - 50 ha

Sampling Blocks	Different depths	TOC%	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon in 1 m stock (t/ha)
NC 1	25 cm	0.21	0.11	1.41	3.95	42.364
	50 cm	0.24	0.13	1.25	8.02	
	75 cm	0.24	0.13	1.28	12.34	
	100 cm	0.27	0.14	1.25	18.05	
NC 2	25 cm	0.33	0.18	1.37	6.04	59.12
	50 cm	0.24	0.13	1.33	8.56	
	75 cm	0.3	0.16	1.39	16.71	
	100 cm	0.39	0.21	1.33	27.81	
NC 3	25 cm	0.51	0.27	1.28	8.74	53.79
	50 cm	0.33	0.18	1.32	11.61	
	75 cm	0.27	0.14	1.33	14.44	
	100 cm	0.27	0.14	1.32	19.00	
Average of Carbon stock (%)						**51.6**

Table 29. Average Carbon Stock at Nakti Creek

Plantation (ha)	Avg. Carbon stock 1 m depth (%)
100	62.74
50	51.6
Avg	57.17

8.2 Soil biomass carbon stock potential at Kantiyajal mangrove site

At Kantiyajal creek, the average soil biomass carbon of the *A. marina* plantation was 53.13t/ha (150ha) and it ranged from 46.4 to 59.7 t/ha. Among the three locations, 150 ha *A. marina* plantation site showed the highest soil biomass carbon stock potential at Kantiyajal (Table 30,31,32 & 33). The overall average 1 meter depth soil carbon stock was 53.35t/ha**.**

Table 30. Soil Carbon stock in Kantiyajal mangrove plantation site- 150 ha (*A. marina*)

Sampling Blocks	Different depths	TOC%	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon stock in 1 m(t/ha)
KC-1	25 cm	0.30	0.15	1.27	4.8	**54.7**
	50 cm	0.42	0.21	1.20	12.6	
	75 cm	0.34	0.17	1.19	15.2	
	100 cm	0.52	0.26	1.22	22.2	
KC- 2	25 cm	0.34	0.17	1.21	5.1	**54.0**
	50 cm	0.40	0.20	1.18	11.8	
	75 cm	0.38	0.19	1.20	17.1	
	100 cm	046	0.23	1.24	20.0	
Average Carbon stock (%)						**54.4**

Table 31. Soil Carbon stock in Kantiyajal mangrove plantation site- 150 ha (*R. mucronata)*

Sampling Blocks	Different depths	TOC %	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon stock in 1 m(t/ha)
KC-1	25 cm	0.38	0.19	1.09	5.2	47.7
	50 cm	0.29	0.145	1.22	8.8	
	75 cm	0.39	0.195	1.16	17.0	
	100 cm	0.49	0.145	1.21	20.8	
KC- 2	25 cm	0.36	0.18	1.26	5.7	59.7
	50 cm	0.37	0.185	1.23	11.4	
	75 cm	0.62	0.31	1.19	27.7	
	100 cm	0.37	0.185	1.16	15.0	
Average Carbon stock (%)						**53.69**

Table 32. Soil Carbon stock in Kantiyajal mangrove plantation site- 50 ha *(A.marina*)

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/ m^3)	Carbon stock (%)	Carbon stock in 1 m(t/ha)
KC- 1	25 cm	0.29	0.145	1.24	4.5	57.5
	50 cm	0.36	0.18	1.25	11.3	
	75 cm	0.39	0.195	1.23	18.0	
	100 cm	0.54	0.27	1.26	23.8	
KC- 2	25 cm	0.32	0.16	1.24	5.0	46.4
	50 cm	0.38	0.19	1.09	10.4	
	75 cm	0.37	0.185	1.24	17.2	
	100 cm	0.32	0.16	1.24	13.9	
Average of Carbon stock (%)						**51.97**

Table 33. Average Carbon Stock at Kantiyajal Creek

Plantation (ha)	Avg. Carbon stock 1 m depth (%)
150	54.4
150	53.69
50	51.97
Avg	53.35

8.3 Soil carbon stock potential at Sat Saida bet at mangrove site

At Sat Saida bet the overall average soil biomass carbon of *A. marina* plantation site was 68.17 t/ha. Whereas, at the five blocks of mangrove plantation area, the soil biomass carbon ranged from 54.5 t/ha (50ha) to 79.5 t/ha (200ha). The soil carbon sequestration potential was highest in 200 ha plot followed by 300, 20, 330 and 50 ha plantation blocks (Table 34-39).

Table 34. Soil Carbon stock in Sat Saida bet mangrove plantation site- 300 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.37	0.185	1.30	6	69.3
	50 cm	0.40	0.2	1.29	12.9	
	75 cm	0.37	0.185	1.26	17.5	
	100 cm	0.53	0.265	1.24	32.9	
Sample- 2	25 cm	0.35	0.175	1.23	5.4	73.9
	50 cm	0.48	0.24	1.30	15.6	
	75 cm	0.39	0.195	1.22	17.8	
	100 cm	0.58	0.29	1.21	53.1	
Average of Carbon stock (%)						**71.5**

Table 35. Soil Carbon stock in Sat-Saida bet mangrove plantation site- 200 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.39	0.195	1.23	6.0	78.1
	50 cm	0.36	0.18	1.22	11.0	
	75 cm	0.67	0.335	1.13	28.4	
	100 cm	0.59	0.295	1.24	32.7	
Sample- 2	25 cm	0.42	0.21	1.21	11.6	80.9
	50 cm	0.35	0.175	1.26	11.0	
	75 cm	0.58	0.29	1.27	27.6	
	100 cm	0.52	0.26	1.18	30.7	
Average of Carbon stock (%)						**79.5**

Table 36. Soil Carbon stock in Sat Saida bet mangrove plantation site- 330 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.42	0.21	1.09	5.7	**64.8**
	50 cm	0.32	0.16	1.29	10.3	
	75 cm	0.37	0.185	1.24	17.2	
	100 cm	0.53	0.25	1.23	31.5	
Sample- 2	25 cm	0.48	0.24	1.13	6.8	**55.9**
	50 cm	0.34	0.17	1.24	10.5	
	75 cm	0.30	0.15	1.30	14.6	
	100 cm	0.42	0.21	1.14	23.9	
Average of Carbon stock (%)						**60.3**

Table 37. Soil Carbon stock in Sat Saida bet mangrove plantation site- 50 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.31	0.155	1.26	4.9	**62.8**
	50 cm	0.36	0.18	1.30	11.7	
	75 cm	0.39	0.195	1.06	15.5	
	100 cm	0.50	0.25	1.23	30.8	
Sample- 2	25 cm	0.32	0.16	1.13	5.0	**54.2**
	50 cm	0.33	0.165	1.24	10.8	
	75 cm	0.38	0.19	1.30	17.8	
	100 cm	0.34	0.17	1.14	20.6	
Average of Carbon stock (%)						**58.5**

Table 38 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 20 ha

Sampling Blocks	Different depths	% of TOC	Total carbon (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 1 m (t/ha)
Sample-1	25 cm	0.35	0.175	1.32	5.8	74.5
	50 cm	0.37	0.185	1.18	10.9	
	75 cm	0.39	0.22	1.32	21.8	
	100 cm	0.55	0.275	1.31	36	
Sample- 2	25 cm	0.35	0.175	1.19	5.2	67.6
	50 cm	0.175	0.195	1.34	13.1	
	75 cm	0.29	0.27	1.32	26.7	
	100 cm	0.26	0.19	1.19	22.6	
Average of Carbon stock (%)						**71.0**

Table 39. Average Carbon Stock of all the sites at Sat Saida Bet

Plantation (ha)	**Avg. Carbon stock 1 m depth (%)**
300 ha	71.5
200 ha	79.5
330 ha	60.3
50 ha	58.5
20 ha	71.0
Avg	68.18

8.4 Details of carbon Sequestration at the plantation sites

The above ground biomass varied 113.30 to 210.0gm at Sat Saida Bet while at Kantiyajal it was minimum 121.74 to 164.60 gm/ha. At Nakti creek site it was minimum 133.86 and maximum 161.02 gm/ha during the present investigation (Table 40,41 & 42). The below ground biomass was comparatively less than the above ground values. At Sat Saida Bet it ranged from 22.70 to 62.80gm and that from Kantiyajal were 21.96 to 38.23gm. The below ground biomass at Nakti varied between 29.83 and 42.30gm. The Total Biomass Carbon calculated in the different plantation sites at Sat Saida varied from 112.10kg/ha to 232.74 kg/ha. The values of carbon biomass at Kantiyajal varied from 123.69 to 178.86kg/ha whereas at Nakti it varied between 142.02 and 173.46 kg/ha.

Table 40. Details of Carbon stock at Sat Saida during 2022

Carbon Sequestration - Dry weight basis (gm)										
50ha										
Sample	**Root**	**Leaves**	**Stem**	**Plant Biomass Below ground**	**Plant Biomass Above Ground**	**Total Biomass**	**Total Biomass Carbon**	**Total Biomass Carbon (mg/ha)**	**Total Biomass Carbon (kg/ha)**	**Carbon equivalent (%)**
sample-1	39.80	108.90	48.60	39.80	157.50	197.30	82.87	168325.71	168.33	617.76
sample-2	32.90	80.90	29.60	32.90	110.50	143.40	60.23	122341.14	122.34	448.99
20ha										
sample-1	29.40	80.10	37.70	29.40	117.80	147.20	61.82	125583.09	125.58	460.89
sample-2	24.60	86.40	26.90	24.60	113.30	137.90	57.92	117648.83	117.65	431.77
200ha										
sample-1	22.70	69.30	34.40	22.70	57.10	79.80	33.52	68081.05	68.08	249.86
sample-2	36.10	90.10	43.70	36.10	79.80	115.90	48.68	98879.62	98.88	362.89
300ha										
sample-1	62.80	140.30	69.70	62.80	210.00	272.80	114.58	232738.23	232.74	854.15
sample-2	39.50	93.50	32.90	39.50	126.40	165.90	69.68	141536.92	141.54	519.44
330ha										
sample-1	37.10	64.90	29.40	37.10	94.30	131.40	55.19	112103.38	112.10	411.42
sample-2	34.40	94.60	45.20	34.40	139.80	174.20	73.16	148618.03	148.62	545.43

Table 41. Details of Carbon stock at Kantiyajal during 2022

Dry weight (Gram)				Carbon Sequestration						
150ha										
Sample	**Root**	**leaves**	**stem**	**Plant Biomass Below ground**	**Plant Biomass Above Ground**	**Total Biomass**	**Total Biomass Carbon**	**Total Biomass Carbon (mg/ha)**	**Total Biomass Carbon (mg/ha)**	**Carbon equivalent (%)**
sample-1	34.29	112.30	52.30	34.29	164.60	198.89	83.53	169682.21	169.68	622.73
sample-3	38.23	124.12	47.30	38.23	171.42	209.65	88.05	178862.06	178.86	656.42
150ha										
sample-1	32.86	115.80	43.70	32.86	159.50	192.36	80.79	164111.16	164.11	602.29
sample-2	35.12	108.30	39.42	35.12	147.72	182.84	76.79	155989.21	155.99	572.48
50ha										
sample-1	21.96	84.62	38.40	21.96	123.02	144.98	60.89	123689.11	123.69	453.94
sample-2	24.30	92.14	29.60	24.30	121.74	146.04	61.34	124593.44	124.59	457.26

Table 42. Details of Carbon stock at Nakti creek during 2022

Dry weight (Gram)				Carbon Sequestration						
50 ha										
Sample	Root	leaves	Stem	Below ground	Above Ground Biomass	Total Biomass	Total Biomass Carbon	Total Biomass Carbon (mg/ha)	Total Biomass Carbon (kg/ha)	Carbon equivalent (%)
Sample-1	37.50	112.96	34.60	37.50	147.56	185.06	77.73	157883.20	157.88	579.43
Sample-2	32.90	98.63	36.94	32.90	135.57	168.47	70.76	143729.51	143.73	527.49
Sample-3	35.64	126.23	28.72	35.64	154.95	190.59	80.05	162601.10	162.60	596.75
100 ha										
Sample-1	32.61	94.35	39.51	32.61	133.86	166.47	69.92	142023.21	142.02	521.23
Sample-2	29.83	103.42	34.26	29.83	137.68	167.51	70.35	142910.49	142.91	524.48
Sample-3	42.30	129.18	31.84	42.30	161.02	203.32	85.39	173461.64	173.46	636.60

9 Phyto-sociological observation

9.1 Halophytes

Halophytes are classified based on their growth conditions as obligate halophytes, facultative halophytes, and habitat-indifferent halophytes. In the present study, four major halophytes were recorded within the selected DPA sites during the survey, *viz: Salicornia brachiata, Aeluropus lagopoides, Salvadora persica* and *Sesuvium portulacastrum*. Among the halophyte species, *Salicornia brachiata & Sesuvium portulacastrum* was found to be equally distributed in Sat Saida bet.

At the plantation site, mangroves associated plants such as *Salvadora* spp and *Ipomea* spp, were found at the high tide level; the halophytes, *Suaeda* spp, *Sesuvium* have also occurred in many sites. During the field visit, several mangroves associated fauna such as mudskippers, bivalves, crabs, gastropods and other fishes were found inside the plantation sites.

Plate 8. Mangrove associated Halophytes

10 Discussion

In the present study, the overall percentage survival of the plants on Sat Saida bet in 5 different blocks was observed between 51.5% to 62.7% at different plot size and in different geophysical condition. This indicates that *A marina* species is capable of adapting to a wide range of salinity variations and substratum types. For germination success, matured seeds should be collected and transported with proper moisture content for plantation. (Clarke and Allaway, 1993; McKee, 1995; McGuinness, 1997; Clarke *et. al*., 2001). The recruitment and growth of established mangrove seedlings and their survival to the sapling stage are mainly determined by the availability of light and nutrients (Smith, 1987; Ellison and Farnsworth, 1993) and the influence of physicochemical factors (McKee, 1995, Koch and Snedaker 1997) at Nakti creek, survival rate ranges from 40% to 54% at 100 ha and 50ha, respectively. At Kantiyajal creek, *A. marina* plantation survival rate varies from 62% to 75% within 50 ha and 150ha respectively. The survival rate of *R.mucronata* is 63% at 150 ha plantation site. This clearly indicates that *A. marina* tolerates wide ranges of temperature and salinity to withstand in extreme environmental conditions (Das *et al.*, 2019).

The results of the 1400 ha plantation study at Kantiyajal, shows higher survival rate than the Sat saida bet and Nakti creek, this is because of site to site variations in temperature, salinity and rainfall (Das *et. al*. 2019. In the plantation sites, higher survival was reported for *A. marina*, whereas the high rates of survival, for stilt-rooted *Rhizophora* species were planted as propagules as influenced by plant spacing (Kodikara *et. al*., 2017). The results of the present study are in conformity with the findings that several abiotic and biotic factors, including the local climatic conditions, determine the survival and growth of recruitment classes. It is to be highlighted that the aftercare by the local people and the management is very much important above all for achieving high survival rates of mangrove plantation efforts. The mangrove survival rates are dependent on factors like

• **Biological factors** – mangrove species and infestation of pests (e.g. algae, barnacles, insect larvae)

• **Physical factors** – tidal level and inundation, substrate, waves/typhoons, sedimentation.

• **Human factors** – harvesting of materials for fodder, grazing, fishing gear, management and enforcement.

Well-planned and executed mangrove planting efforts also results in poor survival rate because of a lack of participation by local communities, cultural barriers and adequate after-care (e.g., watering and removal of objects that are entangled with planted individuals) needed for long-term success (Blum and Herr, 2017). In most of the mangrove plantation, poor survival rate, due to restoration projects is often related to the high susceptibility of propagules, seedlings and saplings to wind and wave erosion, flooding and desiccation. The low survival of the recruitment class can be attributed by both the biotic (competition with native and planted vegetation) and abiotic factors (like erratic change in salinity, temperature wave energy and rainfall), site suitability (like high or low inundation, plantation area).

Effective coordination of multiple stakeholders in a given mangrove project was seen to have provided long-term positive impacts for both mangroves and dependent communities. Implementing agencies and community organizers could also contribute to greater success rates if well-trained and equipped by the appropriate environmental specialists (Flint *et al.,* 2018).

Mangrove rehabilitation and restoration are considered one of the most effective management options globally for dealing with lost or damaged mangrove forests (Ellison *et. al*., 2020). Although planting mangroves for restoration and afforestation has been conducted in some regions in Bangladesh (1993) and Vietnam (Hong *et. al.*, 1996) are not always successful. Many biotic and abiotic influences, including predation, seed recruitment, soil characteristics, colonization rates, salinity and temperate, can reduce the survival of the mangroves, in both early (e.g., nursery) and late stages of the planting process (Lewis, 2005). Instead, mangrove restoration projects tend to use specific success criteria; for example, mangrove restoration efforts with an 85-90% survival rate after a defined number of years of monitoring are described as successful projects (Walters *et. al*., 2008; Locatelli *et. al*., 2014).

11 Summary

Mangrove formations in the Kachchh coast are predominated by a single species, *i.e. A. marina*, with the sporadic occurrence of *R. mucronata* and *C. tagal*. The present study was carried out at Sat Saida bet and Nakti creek in Kandla and at the vicinity of Kantiyajal covering ten blocks to evaluate mangrove plantations carried out in 1400 ha during the period between 2005 to 2019. The major goal of this study was to assess the mangrove plantation survival percentage to assess the carbon sequestration potential of planted mangroves, to understand the ecological issues related to plantation success, and suggest conservation measures. The mangrove plantation was carried out in temporally from 2005 onwards. The plantation work in Sat Saida started from 2005-2006 (20 ha), followed by 200 ha in 2011-2012, 300 ha in 2012-2013, and 330 ha during the 2013-2014. The plantation work in Nakti creek was initiated in year 2008-2009 (50 ha) followed by 100 ha during 2010-2011. In Kantiyajal the plantation work initiated from 2015-2016 (150 ha) followed by 150 ha during 2016-2017 and 100 ha during 2018-2019. Due to the prevalence of high salinity in the region, *A. marina* was the preferred species for plantation. Although, *R. mucronata* and *C. tagal* were also planted in small pockets at Nakti creek, and *R. mucronata* was attempted at Kantiyajal along with *A. marina*. Among the different plantation areas, maximum density and height of plants were observed at Kantiyanjal. However, the survival rate was highest (75%) for *A. marina* plantation in 150 ha planted during 2016-2017 followed by *R. mucronata* plantation at 150 ha in Kantiyanjal (2016-2017), 330 ha of *A marina* at Sat Saida bet (62.7%) planted during 2013-2014. The lowest survival rate was observed in Nakti creek (40%) within 100 ha area carried out during 2010-2011. In this site, especially multi species plantation activity was carried out using *R. mucurata, Ceriops tagal and A. marina*. In rest of the blocks, the survival percentage did not reach the minimum expected (67%) despite of the mangrove species planted. Based on the field monitoring and evaluation data, it is advised to prefer nursery bed and direct seed sowing methods to the *Otla* method, since mangrove areas raised through the *Otla* method undergo high mortality rates even when initial survival rates are high.

The soil Total Biomass Carbon of *A. marina* plantation was lowest (42.36t/ha) in Nakti creek 100 ha plot and highest in 200 ha plot of Sat Saida bet (68.17t/ha). Among the three locations, i.e. Sat Saida bet, Nakti creek and Kantiyajal, the highest carbon sequestration potential was recorded at Sat Saida Bet.

12 Suggestions and recommendations

The Global Mangrove Alliance (GMA), a coalition of international nature conservation Organizations, has set the ambitious target of restoring 20% of mangroves over the current extent by 2030 (Quarto, 2013; Bayraktarov *et al.*, 2016; Wylie *et al.*, 2016; Kodikara *et al.*, 2017). Based on the data collected during the present and previous field survey, the following recommendations are suggested for current and future plantation activities.

12.1 Management approach

The present study indicates that ten blocks are the most suitable sites for further promoting mangrove plantation activities in Sat Saida Bet, as they have already shown survival success and there was space available for gap filling. The following conservation measures are suggested for the planted mangroves in order to improve their survival and make them a mature mangrove formation over the period of time:

- Appropriate site selection needs to be done.
- Both field observation and high-resolution mapping need to be used as a part of mangrove monitoring, conservation and management efforts.
- Site specific appropriate plantation techniques to be opted considering the hydro-geological features to avoid high mortality among mangrove plant species.
- Watering the nursery bed at some regular intervals with freshwater is required.
- Regular tidal flushing and inundation are to be ensured at the selected mangrove sites.
- Manual removal of algal entanglement and barnacle infestation on mangrove to be done periodically.
- Monitoring of existing mangrove plantation to control human interventions to avoid grazing by livestock.
- Mangrove plantation to be carried out using seed source from nearest area possible
- Restoration of mangroves, where it already exists, to be done instead of creating new plantation sites.
- Appropriate restoration efforts are needed such as deepening and de-silting and widening of canals.

- Normal tidal hydrology should not be disrupted and the availability of water-borne dispersal of seeds should be allowed.
- Awareness and outreach programmes for DPA staff and other stakeholders would strengthen the plantation efforts.
- Multispecies plantation is to be preferred while planning
- Involvement of stakeholder communities from the nearby villages to be initiated.

The most relevant suggestive measures for successful mangrove restoration efforts are described below:

12.2 Identification of suitable sites

By far, site selection within the broader landscape for a plantation is the most important criterion that determines the plantation' success. For successful plantation, it is essential that the existing bio-physical conditions of the coastal landscape in a broader and general manner are to be thoroughly understood.

12.3Identification of stress factors

It is important that in any conservation efforts, stressors acting on the mangroves are to be identified and removed in order to maintain the ecosystem balance. Mangrove environment will continue to be stable and balanced if there are no external stressors such as change in hydrology, soil, water salinity, pH, soil texture and wave energy. In addition, anthropogenic stress factors such as collection of fodder and other resources, tree felling and other habitat modification activities will severely affect the ecosystem. It would be necessary to find the factors causing stand degradation and scientifically addressing it to remove the stressors allowing mangroves to flourish.

12.4Bio-physical management

Mostly, micro-topography controls the distribution and wellbeing of mangroves, and physical processes play a dominant role in the formation and functioning of mangrove ecosystem. A list of bio-physical parameters such as the gradient of the intertidal belt, soil nature, number of days of tidal flushing, presence/absence of natural mangroves in the vicinity and availability of adequate intertidal extent are to be considered, and grades should be assigned in a scale of 1 to 10. Duration of tidal flushing, which is influenced by the gradient of the intertidal extent is very essential.

12.5Community-based management

Involving local people and fishermen living nearby and use their traditional knowledge will render the site selection easier since they are well versed with the local conditions, especially tidal flushing rate. In addition, short term and small-scale feasibility trials could be conducted in order to ascertain the suitability of the site.

To encourage both motivation and engagement, the needs of the community need to be assessed and addressed towards their socioeconomic development for the direct benefit of community members (Flint *et al.,* 2018). Ideally, mangroves within the DPA jurisdiction should be subjected to intense management regime to protect them. It was proven in many instances that involving the stakeholder communities in the surrounding villagers will yield better results in mangrove plantation and restoration activities. Effective coordination of multiple stakeholders in a given mangrove project or programme has provided long-term positive impacts for both mangroves and dependent communities. Though the population in the port surroundings has different livelihood activities, fishermen community could be targeted to involve them in community-based mangrove restoration and management. The community-based organization *i.e.,* Samithi roles and responsibilities with reference to mangrove conservation in their vicinity should be well defined and that would play a vital role in conserving these mangrove patches.

12.6Physical protection

Physical protection of natural stand is often the best conservation measure that will fetch positive results. Employees of Deendayal port need to be made aware with the environmental and ecological significance of mangroves and other coastal resources within the port limits. Licenses for salt works and other Port allied industries are awarded by port authorities without understanding the ecological and environmental rules and regulations governing them which often lead to legal and environmental bottleneck at a later stage. Short-term awareness programs in a continuous basis to port employees could be conducted by seasoned marine/mangrove ecologists.

13 Future considerations

In all future plantation activities along with *A. marina*, other compatible species like *R. mucronata*, *C. tagal* and *A. corniculatum* which are available at Sat Saida Bet shall be chosen where ever suitable environmental parameters are available during post monsoon season. Further, such efforts would serve to create a seed bank in due course of time which would eventually convert single species stand of *A. marina* into multi-species assemblages. It is suggested that in future plantation activities, nursery raised saplings along with direct dibbling of seeds and propagules should be preferred rather than following the raised bed (*Otla*) method in order to have high survival rate of the plants. Raised bed plantation are to be conducted only on the suitable sites and not everywhere, for which surveys should be conducted before the initiation of plantation activities. Mangrove restoration is possible by enhancing the natural recruitment of propagules and seeds of the species for which the hydrologic manipulation of the mangrove plantation site is to be done so as to retain them in the bottom sediment and germinate. It is necessary to make sure that tidal water inundation is sufficient for the survival of the seedlings. Through appropriate restoration measures, the existing sparse mangroves could be converted into dense patches by regular gap filling and replantation in the already established blocks. The large plants will provide a protective shield for the newly planted or emerging young plants from water currents during the tidal water movements. Thus, it is suggested to carry out restoration activities along with direct plantation to improve mangrove vegetation cover in DPA. Based on the present monitoring results, it is inferred that Sat Saida Bet could be an ideal site for all future mangrove restoration activities with bio-physical amendments such as de-silting existing creeks, joining all the existing minor creeks with one another through modified creek systems. Increased tidal flooding and hydro-period will extend the mangrove formation in this location along with converting sparse mangrove vegetation into dense mangroves over a period of time. Earlier mangrove vegetation analysis studies at Kandla and Tuna mangroves (GUIDE, 2012 and 2015) have clearly indicated that density and addition of younger classes is good enough to become mature trees. To sum up, through sustainable long -term management practices, the mangroves can be made into a fully grown and functional ecosystem with enhanced ecosystem services.

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Annexure -C

Annexure C

CSR Activities at Deendayal Port Trust

Details of CSR

Sr. No	Year	Board Resolution For Budget Provision	Board Approved Budget Provision	Board Resolution for approval of the CSR activities	Board Approved Amount For CSR Activities	Actual Exp. Upto Nov'20 (Rs. In Lakhs)	Net balance (Rs. In Lakhs)	Remarks
1	2	3	4	5	6	7	6-7	
1	2011-2012	369 of 28.03.2012	3.00 Cr					
2	2012-2013	17 of 31.05.2012	4.00 Cr					
				61 of 30.08.2012	564.00 Lakh	564.00	Nil	Works completed
3	2013 -2014	99 of 30.09.2013	6.43 Cr					
4	2014-2015	322 of 21.11.2014	1.07 Cr	20 of 16.04.2015	236.22 Lakh	188.18	8.04	Works in progress
5	2015-2016	151 of 12.02.2016	1.50 Cr	48 of 12.08.2016	28.00 Lakh	5.00	23.00	Works in progress
6	2016-2017	138 of 06.01.2017	2.60 Cr	52 of 2.8.2017	140.30 Lakh	146.00	-5.70	Works completed
7	2017-2018	41 of 2.08.2017	7.02 Cr	15 of 04.05.2018	155.10 Lakh	115.37	39.73	Works in progress
8	2018-19	51 of 07.08.2019	6.70 Cr	111 of 4.12.2018	154.90 Lakh	50.50	104.40	Works in progress
					1278.52 Lakh	**1069.05**	**209.47**	
9	2019-20	58 of 10.10.2019	5.49 Cr	92 of 06.12.2019	1838.57 Lakh	Nil		MoS approval is awaited
		Total	**37.81 Cr**		**3117.09 Lakh**			
						Spent in PM Fund for COVID-19=800 Lakhs		

Year-wise details of CSR works undertaken by DPT during 2012 – 13 to 2019 – 20 are given in **Tables 7.3a, 7.3b, 7.3c, 7.3d, 7.3e, 7.3f** and **7.3g**.

Table 7.3a: CSR Works Undertaken by DPT during 2011-12 and 2012 – 13

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Repair of road from Dr. Baba Saheb Ambedkar Circle to NH 8A (via Ganesh Nagar)	518
2	Repair of road from S.T. Bus Stand to Sunderpuri Cross Road via Collector Road	
3	Repair of road from NH 8A Railway Crossing to Maninagar (along railway track)	
4	Repair of road from Khanna Market Road (Collector Road) to Green Palace Hotel	
5	Construction of internal roads at "Shri Ram" Harijan Co-operative Housing Society (near Kidana)	
6	Construction of cremation ground and graveyard with other facilities at Vadinar	19.44
7	Providing cement concrete internal roads in Village Vadinar Stage - I	16.16
8	Approach road provided for developing tourism at Village Veera near Harsidhi Mata Temple	4.65
9	Water tank along with R.O. provided near developing tourism area	0.30
10	Creating facilities of flooring and steps surrounding lake to stop soil erosion and attract tourists at Village Veera.	4.80
	TOTAL	563.35

Table 7.3b: CSR Works Undertaken by DPT during 2014-15

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Construction of community hall – cum – school at Maheshwari Nagar, Gandhidham	51.90
2	Renovation of "Muktidham" (cremation ground) at Kandla	10.65
3	Sunderpuri – 1 Valmiki Community Hall	5.00
4	Sunderpuri – 2 Valmiki Community Hall	5.00
5	Ganeshnagar Community Hall	10.00
6	Jagjivan Maheshwari Community Hall	10.00
7	Various works of road at Sapnanagar	99.19
8	Construction of compound wall in the dam of Jogninar Village	14.48
	TOTAL	206.22

Table 7.3c: CSR Works Undertaken by DPT during 2015-16

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	Construction of Bus Stand at Vadinar Village	10.00
2	Providing drainage system at Vadinar Village	6.00
3	Providing and laying of water supply lines in Vadinar Village	6.00
4	Road from Gandhidham Post Office to Merchantile Marine Department Office along with toilet facilities	60.00
5	Construction of toilets for girls / women at Khari Rohar, Village	3.00
6	Construction of toilets for girls at Mathak Primary School, Mathak, Village	3.00
	TOTAL	**88.00**

Table 7.3d: CSR Works Approved by DPT Board for 2016-17

Sl. No.	Name of Work	Cost (Rs. In lakhs)
1	RCC community hall at Harsidhi Mata Temple, Village Veera, Anjar Taluka	19.00
2	Fabricated Community Hall at Sanghad Village, Anjar Taluka	21.00
3	CSR Works for Shri Maheshwari Meghvad Samaj, Gandhidham at graveyard behind Redison Hotel	8.00
4	CSR Works for Shri Dhanraj Matiyadev Mukti Dham, Sector 14, Rotary Nagar, Gandhidham	30.50
5	CSR Works for Nirvasit Harijan Co-operative Housing Society, Gandhidham Health Cum Education Centre	41.00
6	CSR Works for Shri Rotary Nagar Primary School, Gandhidham	2.80
7	CSR Works at NU-4, NU-10(B) Sapnanagar & Saktinagar, Golden Jubilee Park at Gandhidham	18.00
	TOTAL	**140.30**

Table 7.3e: CSR Works Approved for 2017-18

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR Works at Shri Ganesh Nagar High School, Gandhidham	Principal, Shri Ganesh Nagar Govt High School, Gandhidham	38.30 Lakhs
2	CSR Works for MOLANA AZAD Primary School, Kandla	Shri M L Bellani, Trustee, DPT, Shri Kandla Port Education Society, New Kandla	7.00 Lakhs
3	Grant financial contribution for facility of Army Cantonment for 50 nos. air coolers at Kutch Border Area	Shri Vinod L Chavda, MP	15 Lakhs
4	40% of the estimated cost of providing drainage lines at Tuna and Vandi villages under Swachh Bharat Abhiyan.	Shri Sarpanch, Tuna Village & Vandi village & Shri M L Bellani, Trustee, DPT	**Rs. 39.80 Lakhs** *Approx. estimated Cost Rs.99.50 Lakhs, of which 40% to be contributed by DPT.*
5	CSR works for S.H.N. Academy English School (managed by Indian Inst. Of Sindhology – Bharati Sindhu Vidyapeeth), Adipur	Director, S.H.N Academy English School	**40 Lakhs**
6	Construction of internal roads at Bhaktinagar Society, Kidana	Smt Maltiben Maheshwari, MLA	**15 Lakh**
		TOTAL	**155.10**

Table 7.3f: CSR Works Approved for 2018-19

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR work to Donate 100 Nos of Computers to Daughters of Martyred Soldiers in the country under the "BETI BACHAO BETI PADHAO" program by Atharva Foundation, Mumbai	Chairman, Atharva Foundation, Mumbai	**24.00**
2	CSR work to Donate ONE (40 Seater) School Bus for Deaf Children Students for the Institute of Mata Lachmi Rotary Society, Adipur	Mata Lachmi Rotary Society, Adipur	**18.00**
3	CSR work to Providing One R.O Plant with Cooler at PanchyatPrathmikSala, Gadpadar Village for the ANARDE Foundation, Kandla&Gandhidham Center.	Dist. Rural Development Officer, Annarde Foundation-Kandla & Gandhidham	**1.50**
4	CSR work for Providing Drainage Line at MeghparBorichi village, AnjarTaluka	Shri Vasanbhai Ahir, MLA, Gujarat Govt	**25.00**
5	CSR work for Construction of Health Centre at Kidana Village	Shri Vinod L Chavda, MP	**13.00**
6	CSR work to provide 4 Nos. of Big Dust Bin for MithiRoharJuth Gram Panchayat.	Shri Sarapanch, Mithi RoharJuth Gram Panchayat	**3.40**

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
7	CSR work for Renovation & construction of shed at CharanSamaj, Gandhidham –Adipur.	Shri Vinod L Chavda, MP	**10.00**
8	CSR Work for Renovation/Repairing of Ceiling of School Building at A. P Vidhyalay, Kandla.	Smt Maltiben K. Maheshwary, MP, Gandhidham.	**10.00**
9	CSR work for Construction of Over Head Tank & Providing 10 Nos of Computers (for students) of NavjivanViklangSevashray, Bhachau, Kutch	Shri Jitendra Joshi, Founder Secretary, Shri Navjivan Viklang Sevashray, Bhachau, Kutch	**9.50**
10	CSR work to Provide Books & Tuition fees for Educational facilities to weaker section children of ValmikiSamaj, Kutch.	Shri Manohar Jala, Chairman of "National Commission of Safai Karamcharis"	**2.00**
11	CSR work to provide Water Purifier & Cooler for the ST. Joseph's Hospital, Gandhidham	Smt. Maltiben K Mahewari, MLA ,Gandhidham	**1.50**
12	CSR work for Construction of Second Floor (Phase – I) for Training Centre of "GarbhSanskran Kendra" "Samarth Bharat Abhiyan" of Kutch Kalyan Sangh, Gandhidham	Shri Vinod L Chavda, MP, Kutch	**37.00**
		TOTAL	**154.90**

Table 7.3g: CSR works approved for the year 2019-20 (approval from Ministry of Shipping still awaited)

Sl. No.	Name of Work	Proposal Received from / / Name of Organization / N.G.O	Cost (Rs. In lakhs)
1	CSR activities for Providing Drainage line at Nani Nagalpar village.	Sarpanch of Village:-Nani Nagalpar, Taluk: Anjar.	**3.00**
2	CSR activities for Development of ANGANWADI Building at School no- 12 at Ward no 3 & 6 at Anjar.	Shri Vasanbhai Ahir, MLA	**7.00**
3	CSR activities for Improving the facilities of Garden at Sapna Nagar(NU-4)& (NU-10 B),Gandhidham.	Shri K P Maheshwari, Resident Sapnanagar, Gandhidham	**18.00**
4	CSR activities for Providing of Plastic Shredding Machine to Mirror Charitable Trust, Gandhidham.	Mirror Charitable Trust ,Gandhidham	**4.75**
5	CSR activities for development of School premises of Shri Guru Nanak Edu. Society, Gim.	Shri Guru Nanak Education Society, Gandhidham.	**30.00**
6	CSR activities for the improvement of the facilities at St. Joseph Hospital & Shantisadan at Gandhidham	St. Joseph Hospital Trust, Gandhidham	**20.00**
7	CSR activities for the improvement of the facilities at SVP (SardarValabhbhai Patel) Multipurpose Hall at Gandhidham	Request from MarwadiYuva Munch & UNION Gandhidham	**500.00**
8	Consideration of Expenditure for running of St Ann's High School at Vadinar of last 5 years 2014 to 2019 under CSR.	Proposal from COM, OOT Vadinar, DPT	**825.00**
9	CSR activities for development of school premises of Shri Adipur Group Kanya Sala no-1 at Adipur	Principal, Shri Adipur Group KanyaSala, Adipur	**6.50**
10	CSR activities for development of school premises of Shri Jagjivan Nagar Panchyat Prathmiksala, Gandhidham.	Principal, Shri Jagjivan Nagar Panchyat Prathmiksala, Gandhidham.	**16.50**
11	CSR activities for development of school premises of Ganeshnagar Government high school, Gandhidham.	Shri Vinod L Chavda, MP, Kutch	**9.00**
12	CSR activities for improving greenery, increase carbon sequestration and beat Pollution at Kandla, DPT reg.	Work awarded to Forest Department , Bhuj	**352.32**
13	CSR activities for providing infrastructures facilities at "Bhiratna Sarmas Kanya Chhatralaya" under the Trust of Samaj Nav- Nirman at Mirjapur highway, Ta Bhuj.	SamajNav- Nirman at Mirjapur highway, Ta Bhuj.	**46.50**
		TOTAL	**1838.57**

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
1	CSR activities for the development of gardening at Sector -5 , Gim	Shri Sarvodaya Co-Operative Housing Society Ltd	**Appx Cost – Rs 25.00 Lakhs** **Cost for** – Comp wall, Benches, Plantation, walkway, other facilities (Land is reserved for Garden development only since from 50 years)
2	CSR activities for providing various facilities in SHRI GANESHNAGAR GOVT HIGHSCHOOL, GANDHIDHAM	Principal of School	**Appx cost –Rs 20.00 Lakhs** (Two times CSR works carried out at school by DPT)
3	CSR activities for the VadhiyarVankarSamajvaadi, NaviSunderpuriGim	SmtMaltiben K Maheswari, MLA	**Appx Cost Rs 6.00 Lakhs** Cost for Const. of Comp Wall
4	CSR activities for Construction work of Cabin at Oslo Area- Gim	SmtMaltiben& Shri VinadChavda	Cost not mentioned.
5	CSR activities & Land requirement forAkhil Kutch SamastaMeghvanshiGurjarmeghwal Charitable Trust ,Gim.	Shri Akhil Kutch SamastaMeghvanshiGurjarmeghwal Charitable Trust. Shri Dharmendra R Gohil	Cost Not mentioned. (demand of Land for development of SAMAJ VADI in Gandhidham)
6	CSR Activities for providing Water supply pipe line, Play ground and sports equipment, electric facilities, drinking water facilities for poor people & Fishermen at VANDI Village.	Shri R RKhambhra, PRO , Collector Office, Bhuj.	**Appx Cost Rs 51.00 Lakhs** (Last year also applied by village Sarpanch) & Recommended by Shri VASANBHAI AHIR, MLA, Shri V L Chavda, MP)
7	CSR activities for the Tuna village,	Sarpanch, Tuna village	**Appx Cost Rs. 25 Lakhs** **Cost for :-**

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	Ta -Gim		2 No Fab shed 20'x20'x1250= 10 Lakh 2 Nos of Agnawadi =10 Lakh Fab shed for school=5 Lakh
8	CSR activities for the Global Vision India Foundation, Gim	Global vision India Foundation, G'dham	Requirement of Land –OR- Old building at Gandhidham for foundation of welfare activities.
9	CSR activities for the UNITED ORPHANAGE FOR THE DISABLED, TAMIL NADU	UNITED ORPHANAGE FOR THE DISABLED, TAMIL NADU	**Cost Rs 25,000.00** (Winter sweaters for children)
10	CSR activities for the Garden Development on already bounded area with Compound wall near Plot no 448 Sector-1/A, Gandhidham.	Residents, near Plot no 448, Sector-1/A, Gim.	**AppxCost Rs 20.00 Lakhs** (Requirement to provide benches, drinking water facility, plantation, lightings & walkways in side bounded area)
11	CSR activities for donation of Land for the Shri SUNDARPUI Govt Primary School, Gim	SmtMalti ben Maheshwari, MLA	(request for Land Requirement)
12	CSR activities for Extension of Adarsh Primary School building, Adipur	GandhidhamMatri Mandal, English Medium School, Adipur	**Appx Cost Rs. 40.00 Lakhs** (Construction for 4 Rooms extension) (Trust registered under Societies Registration Act XXI -1860, Reg No F-42 dtd 23.9.1965. Land belong to Trust)
13	CSR Activities for providing HD projector for KANYA MAHA VIDYALAYA, Adipur	Principal, KANYA MAHA VIDYALAYA, Adipur	**Cost Rs 1.50 Lakhs** (School Managed by G'dhamMaitry Mandal, Adipur)

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
14	CSR activities for DONATION various Medical Equipment for the Hospital of Gandhidham Jain SevaSamiti, Adipur	Gandhidham Jain SevaSamiti, Adipur	**Cost for** :- 1) Fresenius Haemodialysis Machine Rs 38.00 Lakh 2) Maltislice Helical CT Scanner- Rs 52.00 Lakhs 3) Others Rs 54.00 Lakhs (**Total Appx Cost Rs 144 Lakhs**)
15	CSR activities for SHRI VIDI JUTH GRAM PANCHAYAT, Vidi, Anjar	Sarpanch, Vidi Gram	**Appx Cost Rs 30.00 Lakhs** Cost for- Drainage , Garbage vehicle, and Cattle shed (Already applied earlier at Sr-5/12)
16	CSR activities for SOS CHILDRESN'S VILLAGES INDIA, Madhapar, Bhuj	Director, SOS Children's Village of India-Bhuj	**Appx Cost Rs 31.00 Lakhs** (request for Financial support towards parentless and abandoned Children Education support located at Bhuj) & support to women working in SOS.
17	Gujarat Biodiversity Board, Gandhinagar invites to involved National & Global endeavour of conservation of biodiversity by creating financial partnership with GBB under CSR programme of expenditure to be incurred 187 Lakh.	GUJARAT BIODIVERSITY BOAD, GANDHINAGAR	**Requirement-** Financial Support from DPT for **AppxRs 1.88 Cr.** (Cost for various meetings, collection of primary data from villagers , processing of documentation, printing , TA DA of Technical support &Miscexp for 150 Peoples Biodiversity Register (PBR).

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
18	CSR activities for providing furniture & Home appliances for ROJAVANAM TRUST at Madurai.	Shri Arul Kannan, Director	**Appx Cost Rs 30 Lakhs** (seeking help to provide facilities to Aged & Homeless people living in Trust and Purchasing of New Ambulance)
19	CSR activities for providing Dialysis Machine for treatment of Kidney patients at "ST JOSEPH'S HOSPITAL TRUST" at Gandhidham.	Sr. Franciline, Administrator of Hospital.	**Appx Cost Rs 31.36 Lakhs** (Cost of 5 Nos of Dialysis Machines for treatment of kidney patients)
20	CSR activities for providing facilities in Girls Hostel of Gasturba Gandhi BalikaVidhyalay, Gandhidham.	Shri Vinod L Chavda, MP	**Appx cost Rs 30 Lakhs.** (Cost of Comp Wall, Entrance gate, Girls toilets etc)
21	CSR works for providing Oxygen Generator Plant and 45 KV Silent Generator for COVID HOSPITAL at Swami LilashahKutia, Adipur.	Secretary, BHARAT VIKAS PARISHAD, Gandhidham	**Appx Cost Rs 80.00 Lakhs** (Facilities for 100 Beds of COVID patient which it to be extend upto 240 Beds)
22	CSR works for providing Two Numbers of Oxygen Concentrator and others medical equipment for the Trust ,Antarjal, Gim.	President SHRI SARV JEEV KALYAN TRUST, ANTARJAL, Gandhidham	**Appx Cost Rs21.50 Lakhs** (Facilities to be provided for the treatment of CORONA PATIENTS at their trust.)
23	CSR works for providing Fabricated Shed , Construction of Compound Wall and Land levelling for the Cattle of **GauSevaSamiti-Tappar** at Gram-Tappar, Ta Anjar.	Shri Vinod Chavda, MP &Presedent , GauSevaSamiti, village Tappar, Ta-Anjar	**Appx Cost Rs84 Lakhs** (Facilities to be provided for Cattle shelters at Village.) (Land belongs to Gram-panchayat)
24	CSR works for Construction of Auditorium Hall at RSETI (Rural Self Employment Training Institute) at	Shri Vinod Chavda, MP & Director of RSETI, Bhuj	**Cost not mentioned.** (Facilities to be provided

List of CSR applications received from various NGOs , Organizations , Village Sharpanchs etc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	Bhujodi-Bhuj.		for the people needs Self-employment activities.)
25	CSR works for Providing of Furniture for the School "SHRI GALPADAR PANCHAYAT PRATHMIC KUMAR GROUP SALA " atGalpadar Village Ta Gim.	Principal, SHRI GALPADAR PANCHAYAT PRATHMIC KUMAR GROUP SALA " atGalpadar Village Ta Gim.	**Cost not mentioned.** (Facilities to be provided for the Students of Workers & poor village people who study in the school.)
26	Construction of Shed, hall and Gate for the DADA Bhagwandas Charitable Trust, Adipur. (Sr no -4)	Shri Vinod Chavda, MP & DADA BHAGWANDAS CharitableTrust, Gandhidham	<u>As per CSR Guideline-</u> ➢ Promoting gender equality and empowering women ➢ Eradicating extreme hunger and poverty (Considered shed and hall) Fab Shelter Shed - 30'x100' x 1250=37.00 Lakh & RCC Hall – 20'x100'x1500=30.00 Lakh (**Appx Cost Rs67.00 Lakhs**) Land authority belongs to Trust given by GDA and NOC given by SRC.Doc submitted.
27	CSR work for reconstruction of the Internal Roads of the Sector-9B-C and Sector-10 area in Gandhidham.	President, Shri TejaKangad, The Gandhidham Chamber of Commerce and Industry, Gandhidham.	Cost not mentioned.

List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
	CSR Applications kept pending in last year Agenda:-		
27	CSR Activities for providing Water supply pipe line, Play ground and sports equipment, electric facilities, drinking water facilities for poor people & Fishermen at VANDI Village. (Sr no-3)	Sarpanch ,Village-VANDI , Ta- Anjar (Recommd. By Shri VASANBHAI AHIR, MLA, Shri V L Chavda, MP)	As per CSR Guideline- ➢ Env Sustainability ➢ Eradicating extreme hunger and poverty (to be Consider for health Center ,Drainage line, Water sump etc activities) **(Appx Cost - 51.00 Lakhs)** (Land authorization of Gram Panchayat)
28	Construction of Shed, hall and Gate for the DADA Bhagwandas Charitable Trust, Adipur. (Sr no -4)	DADA BHAGWANDAS CharitableTrust, Gandhidham (Recommd. By Shri V L Chavda, MP)	As per CSR Guideline- ➢ Promoting gender equality and empowering women ➢ Eradicating extreme hunger and poverty (Considered shed and hall) Fab Shed - 30'x100' x 1250=37.00 Lakh & RCC Hall – 20'x100'x1500=30.00 Lakh (**Appx Cost Rs 67.00 Lakhs**) Land authority belongs to Trust given by GDA and NOC given by SRC. Doc submitted.
29	10 Nos of Computers required for ShirMaheswarinagar Panchayat Girls Primary School, Gandhidham& Boys Group School, Gandhidham. (Sr no-8)	Maheswarinagar Panchayat Primary Kanya Sala, Gandhidham (Contact no 9913903686)	**AppxRs 5.00 Lakhs** As per CSR Guideline- ➢ Promotion of Education (to be consider for 20 Computers)

List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
			Visited the site. Land belongs to MahewariMeghwadSamaj given by SRC for school purpose, doc are awaited.
30	Construction of Shed and Roof at JeparMatiyadev, shamsanbhumi at Kidana village &Maheswari Community Hall at JuniSundarpuri ,Gandhidham. (Sr no-10)	Shri VINOD CHAVDA, MP	**AppxRs 15.00 Lakhs** (Land authorization not mentioned)
31	Drainage, road, Dust bins, & shed for Cattle shelters at VIDI Village, Ta –Anjar. (Sr no- 12)	Village- VIDI, Ta: Anjar	**AppxRs 30.00 Lakhs** As per CSR Guideline- ➢ Env Sustainability ➢ Eradicating extreme hunger and poverty (Consider for Garbage vehicle & Drainage Cost)
32	Education, Women empowerment and Primary health care services at Kutch area. (Sr no-13)	Light of Life Trust, **Mumbai.**	Cost not mentioned.
33	Request for Help Divyang persons to employment by providing machineries. (Sr no-14)	Kutch DivyangSangthan, Gandhidham.	Cost not mentioned
34	Construction of 2nd Floor of Shri MaheswariMeghwadSamaj, Gandhidham. (Sr no-20)	Shri MaheswariMeghwadSamaj, Gandhidham	**AppxRs. 15.00 Lakhs** (Visited the site and Land ownership documents awaited) (Name plate of DPT fixed at the Asset)

List of CSR applications received from various NGOs , Organizations , Village Sharpanchsetc for the FY 2021-22 .

Sr.No	Name of Scheme	Proposal Received from / Name of Organization / N.G.O	Brief Details
35	Installation of Mini Science Center at Anjar and Gandhidham. (Sr no-21)	STEM Learning Pvt Ltd, Mumbai.	Cost not mentioned.
36	CSR work for Shri Rampar Gram Panchayat. ➢ Wall Plastering for Cattles -7 Lakhs ➢ Shed for Cattel's-15 Lakhs (Sr no-25)	Shri Sarpanch, Rampar Village.	**AppxRs 22.00 Lakhs** (Land authorization of Gram Panchayat and under taking submitted by applicant)
37	CSR activities for the 45,000 Patients over the period of 3 years by "SMILE FOUNDATION", Mumbai. 1. Concept for Nutrition covering 3 years 2. Concept for Mobile Health Unit reaching beneficiaries for 3 years 3. Concept for Vocational Training with NGO (Sr no-29)	Proposal from "SMILE FOUNDATION " Mumbai.	Appx Cost- **Rs 539 Lakhs** for 3 years
38	Development of Park in Public utility plot in between Block "C" & "D" of Sapna Nagar (NU-4) , Gandhidham (Sr no -31)	Shri RAVI MAHESHWARI, DPT	Land belongs to DPT earmarked for recreational purpose. (Total Cost –Rs**88.75 Lakhs**)
39	CSR works for NariJanshsktiVikas Foundation at Gandhidham near Shakti Nagar. (Sr no-33)	NariJanshsktiVikas Foundation, Ahmedabad	➢ Promoting gender equality and empowering women ➢ Env Sustainability ➢ Under promotion of education (Consider for Computers with printers, Sewing machine & RO plant**Cost Rs 48 Lakhs**)

Annexure -D

ENVIRONMENT MONITORING REPORT OF DEENDAYAL PORT AUTHORITY

(Annual Report)

(March 2021 to February 2022)

(Report No-DCPL/DPA (19-22)/AMR/21-22/02)

Submitted to

Deendayal Port Authority

Prepared by
Detox Corporation Pvt. Ltd.
Detox House, Udhna Darwaja, RingRoad
Surat - 395002

TABLE OF CONTENTS

1. Introduction

The environmental Monitoring plan is the key document in the environmental management system and sets out the detailed targets, objectives and procedures that will be adopted in order to achieve the goals set out in the environmental policy. EMP document is a collation of background information relevant to the Kandla Port Environmental Management and Monitoring Plan (EMMP).

1.1 The Environment (Protection) Act, 1986

The EPA 1986 came into force in all of India in November of 1986, under an official notification. The Act contains 26 sections divided into 4 chapters. The Act has its genesis in Indian Constitution's Article 48(A) and Article 51 (A)g. The Act is a part of Article 253 of the Indian Constitution.

The rules of Environment protection came into force on 19th November1986 and these rules provide for the following:

- The standards of quality of air, soil and water for various areas and purposes of environment.
- The standard set up to know about the limits of the environmental pollutants.
- Rules include the procedure and safeguards needed to handle the hazardous substance.
- Restrictions and some prohibitions on handling the hazardous substances in different areas and premise
- The procedures and safeguards required for the prevention of accidents which may cause environmental pollution and also the remedies for it.
- The prohibition and restrictions possessed on the location of industries in different areas.

1.2 EIA and CRZ Notification

The Ministry of Environment, Forests & Climate Change (MoEF & CC), Government of India, exercising the powers conferred upon it under the provisions of the Environment (Protection) Act, 1986, issued the Environment Impact Assessment Notification, 2006 and its sub sequent amendments.

1.2.1 EIA Notification

The basic objective of the Environment Impact Assessment is to identify, predict, mitigate and communicate the possible impacts due the proposed project to the Government authority and people likely to be affected and incorporate the conditions for construction, operation, maintenance and waste disposal phases of the project to mitigate the negative (adverse) impacts and enhance the positive impacts for the sustainable development of the region.

Environmental Impact NotificationS.O.1533 (E), dtd.14th September2006as amended 2009, issued under Environment (Protection) Act 1986, has made it mandatory to obtain prior environmental clearance (EC)for scheduled development projects. The notification has classified projects under two categories A & B. Category A projects (including expansion and modernization of existing projects) require clearance from The Ministry of Environment, Forests & Climate Change (MoEF & CC), Govt. of India (GoI) and for category B from State Environmental Impact Assessment Authority(SEIAA),constituted by Govt. of India.

Some important features of the said Notification are:

I. Prior Environmental Clearance (EC) is required by all new projects or activities listed in the Schedule of the EIA Notification2006 and subsequent amendments thereafter.EC are required before Commencement of any construction work or preparation of land by the project management.

II. Prior EC is also required by the existing projects or activities if its capacity is likely to exceed the threshold limit mentioned in the said Schedule.

III. All category B projects where general condition does not apply, the project proponents are required to apply to the SEAC who will hear the case according to the procedure laid down in the EIA notification and

based on whose recommendation, EC may be granted or rejected by the SEIAA.

IV. For all category A projects and also category B projects where general condition applies, the project proponents are required to apply directly to The Ministry of Environment, Forests & Climate Change (MoEF & CC), Government of India, who would consider the project for grant or rejection of the EC based on the recommendation of the Expert Appraisal Committee at the central level.

V. If projects attract CRZ clearance, then clearance under CRZ rules is also required.

1.2.2. Coastal Regulation Zone (CRZ)

The Union Cabinet approved the Coastal Regulation Zone (CRZ) Notification,2018 which were last reviewed and issued in 2011. The notification was released after a series of representations received by the Ministry of Environment, Forest & Climate Change (MoEF&CC) from various Coastal States/UTs for a comprehensive review of the provisions of the CRZ Notification, 2011.

1.2.2.1. Classification of CRZ

For the purpose of conserving and protecting the coastal areas and marine waters, the CRZ area shall be classified as follows, namely:-

CRZ-I A

CRZ-I A shall constitute the ecologically sensitive areas (ESAs) and the geomorphologic features which play a role in maintaining the integrity of the coast viz.: Mangroves, corals, biologically active mudflats, Marine national parks, turtle nesting grounds etc.

CRZ-I B

The intertidal zone i.e. the area between Low Tide Line and High Tide Line shall constitute the CRZ-IB.

CRZ-II

CRZ-II shall constitute the developed land areas up to or close to the shoreline, within the existing municipal limits or in other existing legally designated urban areas, which are substantially built-up with a ratio of built-up plots to that of total plots being more than 50 per cent and have been provided with drainage and approach roads and other infrastructural facilities, such as water supply, sewerage mains, etc.

CRZ-III

Land areas that are relatively undisturbed (viz. rural areas, etc.) and those which do not fall under CRZ-II, shall constitute CRZ-III, and CRZ-III shall be further classified into following categories:-

CRZ-III A

Such densely populated CRZ-III areas, where the population density is more than 2161 per square kilometer as per 2011 census base, shall be designated as CRZ-III A and in CRZ-III A, area up to 50 meters from the HTL on the landward side shall be earmarked as the "No Development Zone (NDZ)", provided the CZMP as per this notification, framed with due consultative process, have been approved, failing which, a NDZ of200meters shall continue to apply.

CRZ-III B

All other CRZ-III areas with population density of less than 2161 per square kilometer, as per 2011 census base, shall be designated as CRZ-III B and in CRZ-III B, the area up to 200 meters from the HTL on the landward side shall be earmarked as the " No Development Zone(NDZ)".

Land area up to 50meters from the HTL, or width of the creek whichever is less, along the tidal influenced water bodies in the CRZ III, shall also be earmarked as the NDZ in CRZ III.

CRZ-IV

The CRZ-IV shall constitute the water area and shall be further classified as under:

CRZ-IV A

The water area and the sea bed area between the Low Tide Line up to twelve nautical miles on the seaward side shall constitute CRZ-IV A.

CRZ-IV B

CRZ-IV B areas shall include the water area and the bed area between LTL at the bank of the tidal influenced water body to the LTL on the opposite side of the bank, extending from the mouth of the water body at the sea up to the influence of tide, i.e., salinity of five parts per thousand (ppt) during the driest season of the year.

1.2.3. EMMP Plan

As per the guidelines of Ministry of Environment Forests and Climate Change and also as per the environment management plans submitted by various agencies during their EIA studies, DPA has appointed M/s. Detox Corporation Pvt. Ltd. For the work of "Preparing and Monitoring of Environmental Management Plan for Deendayal Port Authority at Kandla vide Work Order No.EG/WK/EMC/11023/2011/IV/213Dated-07/12/2019.

As part of this assignment, M/s. Detox Corporation Pvt. Ltd. prepared an Environmental Management and Monitoring Plan (EMMP) and submitted this EMMP prior to commencement of the Environment Monitoring of Deendayal Port in February2020.The EMMP summarized the background information as are source to develop Environment Monitoring Plan, based on the results of the EIA studies carried out at Deendayal Port by several agencies.
This environmental Management and Monitoring Plan (EMMP) plan submitted in February2020 was the key document in the environmental management system and set out the detailed targets, objectives and procedures that are adopted in order to achieve the goals to efficiently manage the environmental policy of Deendayal Port Authority.

2. DEENDAYAL PORT Authority

Deendayal Port is one of the most important ports of India. This port is situated at Latitude23º01‟N and Longitude70º13‟E on the shores of the Kandla Creek. The Deendayal Port came into existence in the year 1931 with a single Pier construction. Later on with the loss of Karachi port to Pakistan during partition, after independence the Government of India chose Kandla as an ideal sea outlet. Thus the Deendayal Port was developed and since then Deendayal Port has played a pivotal role in enhancing country`s maritime trade.

The Port of Kandla was declared a major port in 1955. The Deendayal Port Authority was created by law in 1963 to manage the new port. In 1978, The Deendayal Port had commissioned the off-shore Oil Terminal facilities at Vadinar jointly with Indian Oil Corporation, by providing Single Buoy Mooring (SBM) system, having a capacity of 54 MMTPA, which was first of its kind in India. Further, significant quantum of infrastructure up-gradation has been effected, excellent maritime infrastructure has been created having capacity of 32 MMTPA by M/s Essar Oil Refinery in Jamnagar district.

The port governed by Deendayal Port Authority (DPA) is a gateway port to the hinterland in western and northern states of Jammu & Kashmir, Delhi, Punjab, Himachal Pradesh, Haryana, Rajasthan, Gujarat and parts of Madhya Pradesh, Uttaranchal and Uttar Pradesh. It is in the district of Kutch and is located on the west bank of Kandla creek which runs into the Gulf of Kutch at a distance of 90 nautical miles from the Arabian Sea. The Port is well connected by the network of rail and road and is a gateway port for export and import of goods for northern states (Map1). The width of the channel varies from 200 meters to 1,000 meters. The contour depth along the shipping channel is around 10 meters. The total length of the Deendayal Port approach Channel is around 23kms. Presently, the Port has sixteen cargo berths for handling dry cargo traffic,

six oil jetties for handling Petroleum Oil products and other liquid cargo traffic at Kandla Creek and 3 Single Buoy Mooring (SBM) at Vadinar for handling crude oil and two product jetties for handling petroleum products.

2.1. Environment Management Policy of Deendayal Port Authority

In 2013, the DPA achieved certification of its Environmental Management System to ISO 14001. In 2019, DPA obtained ISO 14001:2015 certifications. One of the key requirements of the ISO 14001 series is that the systems, plans and controls are under the operational control of the entity committed to managing the activity. The DPA also manages environmental risk to land and marine areas under its control arising from third party industrial activities. While these parties and the associated risks are covered in the risk register, the controls are managed by standalone EMP,s of the third party in accordance with the DPA development Approval Process and /or through direct state or central Government requirements as part of an:

- Environmental Clearance, CRZ Clearance, in the case of a new project; and
- Consent to Establish /NOC for an establishment, and Consent to Operate/NOC for operation of the projects.

2.1.1 The Key Objectives of Deendayal Port Authority

- To provide our Clientele, efficient and economical Port services. To render value for money and value added services to our Customers to their utmost satisfaction.
- To create facilities of international standards, and facilitate quicker turnaround of vessels.To maintain peaceful industrial relations by recognizing our work force as an asset and develop them to adopt to the changing Port scenario.
- To participate in social development by contributing our mite to the society at large.
- To be Environment friendly.

2.2. QHSE Policy of Deendayal Port

Quality, Occupational health, Safety and Environmental Policy (QHSE) of Deendayal Port Authority is the statement of its intentions, principles & commitment in relation to its overall QHSE performance, which provides a frame work for the action and for the setting of QHSE objectives & targets. QHSE policy has been developed through initial status review of quality, Occupational health, Safety and Environment Management comprising of following key areas namely;

- Legislative, regulatory and other requirements
- Identification of equipment and services supporting quality of final services.
- Identification of significant OH&S risks and Environmental aspects.
- Examination of all existing environmental & Occupational health and safety management practices and procedures.
- Evaluation and feedback from the investigation of previous incidents and accidents.

The QHSE policy of Deendayal Port Authority has been communicated at all levels through display in all the relevant places. The policy has also been communicated to external parties by way of displaying it at the main gate of Deendayal Port Authority in Hindi/English/local (vernacular) language.

Management representative of Deendayal Port Authority has established, implemented and maintaining the QHSE management system and continually improves its effectiveness by regular monitoring in accordance with the requirements of this international standard. MR has identified the various processes needed for the QHSE management system and their application throughout the organization.

The sequence and interrelation of these processes are determined to control the effectiveness of these processes & operations. The criteria & methods are determined necessary resources & information/details are made available at the point of use so that operations & processes can be monitored. (Ref: Department Operational Manual and their Process Flow Chart).

Measurement of these processes are timely analyzed and the relevant actions are implemented to achieve planned results & for continual improvement.

2.3. The Physical Environment

Deendayal Port ($23^0$02‟29.92”N, $70^0$13‟08.99”E) is located at the tail end of Gulf of Kachchh (GoK), an east west oriented Gulf system in the western part of Gujarat. It is about 90 nautical miles from the open waters of Arabian Sea. Kandla creek harboring the Deendayal Port is one of the major creeks of the inner Gulf of Kachchh. Gulf of Kachchh (GoK) is 75 km wide at its mouth and after running about 170 km away from the Arabian sea towards east, narrows down into a constriction at 70^0 20‟ E at *Sat Saida*Bet and then bifurcates into many creek systems (Map1).The Little Ran at the tail end of GoK has a network of many small and large creeks, intermingling with marshy tidal flats rich in fine clays. Kandla creek is one of the major tributaries of this creek system, which empties into the inner GoK. All these creeks bring water from the Little Ran into Kandla creek, which has a fairly good depth and stable banks.

Coastal and inland environmental setting of Kandla, similar to other parts of Kachchh, has marked climatological peculiarities like aridity, geomorphology and coastal and terrestrial ecosystems. Annual rainfall in Kachchh district was 458 mm during 2001- 10 whereas it was 443 mm at Gandhidham taluka during the same period which is often irregular. Rain during monsoon is confined to only 15-20 days and occurs as an instant downpour. The mean rainfall in year 2019 was 194mm.

On the terrestrial side there are no major rivers or rivulets or fresh water streams. Winter and summer temperatures range from 7°- 47°C with a yearly average humidity of 60% which increases to 80% during southwest monsoon and decreases to 50% during November-December. Average wind speed is 4.65 m/s with a maximum of 10.61 m/s during June. Drought is a common phenomenon in Kachchh with 2 drought year in a cycle of 5years. Annual temperature fluctuation in the district is extreme, rangingfrom4°Cto 47.5°C.

2.4. Biophysical Environment

a. Creek system

The creek system consists of 3 main creeks the Nakti, the Kandla and the Hansthal, and the Little Gulf of Kutch interconnecting through many other big and small creeks, all along the coast. Very few rivers drain into the Gulf and they carry only a small quantity of freshwater, except during the brief monsoon. They are broad-valleyed and their river bed is mostly composed of coarse sand and gravel. The Gulf is uniquely characterized by numerous hydrographic features like pinnacles, as much as 10 m high. The southern shore has numerous is lands and inlets covered with mangroves and surrounded by coral reefs. The northern shore is predominantly sandy or muddy confronted by numerous shoals.

The Marine water of Gulf of Kutch and its creeks like Kandla creek, Nakti creek and Khori creek are providing the suitable habitat for marine vegetation. The Gulf abounds in marine wealth and is considered as one of the biologically rich marine habitat along the west coast of India. The marine vegetation is highly varied, which includes sand dune vegetation, mangroves, sea grasses, macrophytes and phytoplankton. The dominant species of sand dune flora are *Euphorbia caudicifolia, E. nerifolia, Aloeverasp, Ephedrafoliata, Urochodrasetulosa, Sporobolus maderaspatenus, Eragrostis unioloides, Calotropis procera, Fimbristylis* sp, *Indigofera* sp and*Ipomoea pescaprae*. The common sea grasses found growing on the mud flats are *Halophila*

ovate and *H.beccarii*.

b. Mangroves

Deendayal Port Authority (DPA) is one of the largest ports of India in terms of volume of cargo handled. Among Indian ports, this port also has the largest coastal habitats such as mangroves (193.1km2)and mudflats(312.9 km2). DPA has implemented mangrove plantation in 1500 Ha during2005 - 2017 through various implementing agencies at Sat Saida Bet, Nakti creek and Kantiyajal. The Deendayal Port Authority has enauthorityed the task of evaluating 1500 ha of mangrove plantation in these three locations to Gujarat Institute of Desert Ecology (GUIDE), Bhuj.

Coastal belt in and around Kandla region is characterized by a network of creek systems and mudflats which are covered by sparse halophytic vegetation like scrubby to dense mangroves, creek water and salt encrusted land mass which forms the major land component. The surrounding environment in a radius of 10 km from the Port is mostly built up areas consisting salt works, human habitations and Port related structures on west and north, creek system, mangrove formations and mudflats in the east and south. Deendayal Port and its surroundings have mangroves, mud flats and creek systems as major ecological entities.

Mangrove plantation activity by DPA was initiated in 2005 as mandated by the Ministry of Environment, Forests & Climate Change (MoEF&CC). Subsequently, 1300 ha of mangrove plantation has been completed till the end of 2017 in different years in order to meet the legal mandate of Ministry of Environment, Forests and Climate Change (MoEF & CC). The mangrove plantation activities were carried out at Sat Saida Bet, Nakti creek and Kantiyajal of Bharuch district in South Gujarat. At Sat Saida Bet, Plantation activities were carried out in phased out manner i.e.20 ha during2005-2006, 200 ha during 2011-2012, 300 ha during 2012-2013, and 330 ha during 2013-2014 (Plate1). At Nakti creek plantation was carried out during 2008-2009 and 2010-2011 in 50 ha and 100 ha,respectively(GUIDE,2018).In 2015-17 300 ha by GEC at Kantiyajal, Bharuch District and 2018- 20 by GEC (At Satsaida bet : 50 Ha. And 300 ha at Kantiyajal 50 Ha Taluka : Hansot, District : Bharuch). In 2020-2021 -100 ha GEC, Gandhinagar.

A. marina was the preferred species for plantation activities in all the three locations due to prevailing high salinity and high success rate of this species. At Nakti creek *Rhizophora mucronata* and *Ceriops tagal* were also planted in small numbers along with*A. marina*. Likewise, at Kantiyajal attempts were made for planting *R.mucronata*a long with *A.marina*.

c. Marine Fauna

In the marine environment of Deendayal Port, there are eleven species of mollusca, seven species of shrimps (Prawn) and seven species of annelids. Besides these, there are twelve groups of phytoplankton, 7 groups of zooplanktons. The density of meio-fauna ranged from 382 to 670 nos/10cm^2. The density of benthic macro fauna ranged from 952 to 1092 no/m^2.Thedominant macro-faunal group was porifera (Mantec, 2014).

d. Terrestrial Biodiversity

Sensitive ecological habitats like forest, grassland, agricultural land, wetlands are absent within and in the proximity of the Deendayal Port due to its highly built-up nature. The species richness and abundance of aquatic birds and terrestrial fauna (reptiles, mammals) in the port environ and its surrounding was low with least conservation significance.

There are 11 species of herpetofauna (reptiles and amphibians), 53 species of terrestrial birds, 49 species of aquatic birds in the Port Environs. Due to absence of forest habitat in the immediate vicinity of Deendayal Port, only nine species of mammals were recorded with very low abundance.

3.0 Environment Management Plan

Port activities can often affect the quality of air, noise and marine water in the surrounding areas due to the wide range of port operation activities. For the determination of environment quality, need for identification of sources, control and disposal of waste from various point and non-point sources and for prediction of various parameters of sound environmental quality, regular monitoring and assessment are required.

The Environment management plan is the key document in the environmental management system and sets out the detailed targets, objectives and procedures that will be adopted in order to achieve the goals set out in the environmental policy.

It is extremely essential that port and harbour projects should have an environmental management plan (EMP), which also incorporates monitoring of air, noise, soil and marine water quality along with the collection of meteorological data.

Deendayal Port Authority targets the achievement of high environmental standards and strives to ensure that activities within the Port are environmentally and ecologically sustainable and have minimal impact on the natural environment.

Several developmental projects have been initiated and EIAs have been carried out for the said projects. These EIA studies have also submitted the suggestions on the environmental management of the project area and Deendayal Port in general. These suggestions and mitigation measures have also been considered in framing the current environment management plan.

The present Environment Management Plan summarizes the suggestions of the ECs received from the Ministry of Environment, Forests & Climate Change (MoEF & CC), and consents granted by Gujarat Pollution Control Board(GPCB).

The projects for which ECs were granted and which formed the frame work of the present EMP are as below;

- EC and CRZ Clearance for Construction of 13th to 16th Cargo berth at Kandla in year 2008
- EC & CRZ clearance for development of plots for construction of liquid storage tank farms at Kandla, district Kutchinyear2009
- Environmental and CRZ Clearance to DPA for development of plots for construction of warehouses/Godowns (stage II) in year2012.
- Environmental and CRZ clearance for Single Point Mooring (SPM) and Allied facilities off Veera in the Gulf of Kachchh for handling Crude Oil on BOT basis in year 2013.
- Developing seven integrated facilities within the Existing Kandla port at Kandla, Gujarat–December2016
- Proposed Smart Industrial Port City (SIPC) at green Field Site 1 (Adipur side– Northeast of Antarjaal, South of Tagore Road, 580Acres),Gandhidham, Kutch-Gujarat"-October2017
- Proposed Smart Industrial Port City (SIPC) at Green Field Site 2 (DPA Complex, 849.96Acres), Gandhidham, Kutch –Gujarat.–October2017.
- Construction of Interchange cum road over bridged (SIA/GJ/NCP/19832/2017)
- Creation of water front facilities of oil jetties of 8,9,10 & 11 & development of land (1432 areas) (IA/GI/MIS/61679/2017)
- Development of plots for constructing of warehouse/ godowns ad measuring 11,50,000 m2 area at outside west gate no 1 on national highway no 8A at Kandla (SIA/GJ/MIS/122861/2019)

- Up gradation of Barge handling facility at Sunder Basin at Kandla
- Multipurpose Cargo Terminal at Tekra off Tuna on BOT basis
- Construction of Rail Over Bridge at NH-8A near Nakti Bridge (crossing of NH 8A)
- Strengthening of oil jetty no. 1
- Modification and strengthening of Cargo Berth no. 6 at Kandla Port Trust
- Container terminal Tuna Tekra (Capacity 2.19 Million TEUs)
- Railway line (NH 8A to Tuna 11 km)
- Construction of port craft jetty & SNA section
- Development of integrated facility stage II (IA/GJ/MIS/27227/2015)
- Setting up 7th oil jetty at old Kandla
- Setting up Barge jetty at Veera
- Setting up Barge jetty at JafraWadi
- One administrative building at Tuna Tekra
- Construction of 15.5 km long road from Veera Barge Jetty to Tuna Gate
- Single point Mooring and allied facilities off Veera in Gulf of Kutch for handling crude oil on BOT basis in the state of Gujarat (IA/GJ/MIS/178779/2020)

Table: 1 Yearly Monitoring schedule

Yearly Monitoring schedule				
Sr. No	**Sampling Activity Description**	**Locations**	**Monthly Monitoring**	**Yearly Monitoring**
1	Ambient Air	6 locations (Kandla)	8	96
		2 locations (Vadinar)	8	96
2	Drinking Water	18 locations (Kandla)	1	12
		2 locations (Vadinar)	1	12
3	Waste water	2 locations (Gopalpuri Township & Kandla)	4	48
		1 location (Vadinar)	4	48
4	Soil	4 locations (Kandla)	1	12
		2 locations (Vadinar)	1	12
5	Noise	10 locations (Kandla)	1	12
		2 locations (Vadinar)	1	12
6	Marine Water sampling for Physico - Chemical Parameters, Biological parameters and sediments (Twice a month)	8 Locations (6- Kandla & 2- Vadinar)	2	24

4. Environment Monitoring Plan

Environment Monitoring Plan is very important for monitoring the environmental status of the port for sustainable development. The EMP mainly consists of monitoring of the Air quality, Marine water quality, Ecological and Biological quality and Noise quality of the Deendayal Port area. The monitoring program is also required to suggest suitable mitigation measures for the deviation found in the results of the monitoring, so as to keep the pollution level with in control.

The list of main elements for which Environmental monitoring is carried out is mentioned below.

- Air Quality Monitoring
- Drinking Water Monitoring
- Noise Monitoring
- Marine Water Monitoring
- Soil Monitoring
- Sewage Treatment Plant Monitoring
- Meteorological Monitoring

M/s Detox Corporation Pvt. Ltd. appointed by Deendayal Port Authority will carry out monitoring of the various environmental aspects of the port with following objectives;

- To review the locations of ambient air and marine water quality monitoring stations within the impacted region in and around DPA establishment, in view of the developmental projects.
- To assess the ambient air quality and marine water quality at selected stations in terms of gases and particulate matter, physical, chemical and biological parameters for the assignment period.
- To assess the marine water quality in terms of aquatic flora and fauna and sediment quality in terms of benthic flora and fauna.
- To assess the trends of air and water quality by comparing the data collected over a specified time period.
- To assess the trends of water quality in terms of marine ecology by comparing the data collected over a specified time period.
- To review the results and to check compliance with environmental quality standards.
- To suggest mitigation measures, if necessary, based on the findings of this study.
- To recommend future action plans on air and marine water quality monitoring programmed based on the findings of this study.
- Drinking Water samples at twenty stations will also be monitored for various physical, chemical and biological parameters viz., color, odor, turbidity, conductivity, pH, EC, total dissolved solids, chlorides, total hardness, iron, sulfate, NH3N, PO4, Turbidity, salinity, BOD, Hardness, Calcium, Magnesium, Sodium, Potassium, metals and bacterial count on a monthly basis.
- Every week a sample (inlet and outlet) of the Sewage Treatment Plant (STP) shall be analyzed to see the water quality being discharged by DPA. However, the results will be submitted every month. If in a particular month any deviation is observed, the same shall be submitted immediately to the Employer.
- Noise monitoring will be carried out twice a day at the representative stations for a period of 24 hours. A report of the same will be submitted to DPA.
- Meteorological parameters are very important from air pollution point of view and precise and continuous

data collection is of utmost importance. The data collected is analyzed as per the standards. Meteorological data on wind speed, wind direction, temperature, relative humidity, solar radiation and rainfall will be collected from one permanent station at DPA and one permanent station at Vadinar.

- All Locations & Monitoring parameters are tentative and subject to change as per GPCB/CPCB/MoEF &CC Guideline.

4.1 Selection of Sampling Locations

Sampling locations have been selected by Deendayal Port Authority considering various activities of Deendayal Port Authority and its environs and various Environment Impact Assessment Studies carried out in Deendayal Port. The sampling locations of various air, water and marine water surveys will be reviewed periodically and may be altered if required as per the suggestions/discussions with the Deendayal Port Authority and Environmental consultants engaged by the Deendayal Port Authority.

The major components of the monitoring are:

4.1.1. Air Quality Monitoring

Air Monitoring is done at eight fixed locations in port area. The description of stations is depicted in Table1. The monitoring cycle at all eight monitoring stations is twice in a week.

Method of Monitoring

Sampling and analysis will be carried out as per CPCB guidelines for Ambient Air Quality monitoring. The monitoring is carried-out for air quality parameters mentioned in the National Ambient Air Quality Standards (NAAQS), CPCB Notification published in 2019. Sampling for Particulate Matter PM_{10}, $PM_{2.5}$ and Total Suspended Particulate Matter (TSPM) is done for a twenty four hour period.

Frequency of AAQ Monitoring

The monitoring cycle at all eight monitoring Stations is twice in a week. Sampling for Particulate matter (PM_{10}, $PM_{2.5}$) and total suspended particulate matter is done for a twenty four hour period. Sampling for gaseous samples like SO_x, NOx will be done for a twenty four hour period with sample collection at every eight hour. Table 2 gives description of Ambient Air Monitoring Stations.

Table 2: Ambient Air Monitoring Stations

Sr. No.	Location	Station Description	Location Codes
1	6 Stations at Kandla	Marine Bhavan	AL-1
2		Oil Jetty	AL-2
3		Kandla Port Colony	AL-3
4		Gopalpuri Hospital	AL-4
5		Coal Storage Area	AL-5
6		Tuna Port	AL-6
7	2 Stations at Vadinar	Signal Building	AL-7
8		Vadinar Colony	AL-8

4.1.2. Monitoring of Drinking Water Quality Method of monitoring

The sampling and analysis will be done as per standard methods IS 10500:2012. The water samples will be analyzed for various parameters via; Color, Odor, Turbidity, Conductivity, pH, Chlorides, TDS, Total hardness, Iron, Sulphate, Salinity, Biological Oxygen Demand (BOD), Chlorides, Sodium(Na), Potassium(asK+), Calcium(asCa), Magnesium(Mg), Fluorides (F), Nitrate (NO_3), Nitrite (NO_2), Manganese (Mn), Iron (Fe), Chromium(Cr_6+), Copper(asCu), Cadmium(Cd), Arsenic(As), Mercury(Hg), Lead (Pb), Zinc (Zn), CFU, & bacterial count. The method will be manual at all monitoring stations.

- **Frequency of Drinking Water Monitoring:**

  The monitoring at all twenty drinking water stations will be done monthly once.

- **Drinking Water Monitoring Stations**

  A list of locations for collecting the drinking water samples is depicted in Table 3.

Table 3: Monitoring locations for Drinking Water

Sr. No	Monitoring Locations	Location Code		Sr. No	Monitoring Locations	Location Code
Location at Kandla				11	Hospital Kandla	DW-11
1	Nirman Building1	DW-1		12	A.O. Building	DW-12
2	P& C Building	DW-2		13	School Gopalpuri	DW-13
3	Main Gate(North)	DW-3		14	Guest House	DW-14
4	Canteen	DW-4		15	E-Type quarter	DW-15
5	West gatel	DW-5		16	F-type quarter	DW-16
6	Wharf area	DW-6		17	Hospital Gopalpuri	DW-17
7	Sewasadan-3	DW-7		18	Tuna Port	DW-18
8	Workshop	DW-8		**Locations at Vadinar**		
9	Custom building	DW-9		19	Nr. Vadinar Jetty	DW-19
10	Port Colony Kandla	DW-10		20	Port colony	DW-20

4.1.3. Monitoring of Marine Water Quality and Biological Parameters Methodology for Physico-chemical Monitoring

Water samples will be collected for analyzing physico-chemical and biochemical parameters viz. pH, Temperature, Colour, Odour, Salinity, Turbidity, SS, TDS, TS, DO, COD, BOD, Silicate, PO_4, SO_4, NO_3, NO_2, Ca, Mg, Na, K, Iron (as Fe), Chromium (as Cr), Copper (As Cu), Arsenic (as As),Cadmium (as Cd), Mercury (Hg), Lead (as Pb), Zinc (as Zn), petroleum hydro carbons, trace metals total coliform & fecal coliform.

Methodology for Biological Monitoring

Sampling will be conducted from sub surface layer in high tide period and low tide period of the tide from all sampling stations during consecutive spring tide and neap tide.

Net sampling for qualitative evaluation of mixed plankton will be conducted only once during between maximum high water and slack water and maximum low water and Slack water.

Sediment sampling for qualitative and quantitative evaluation of benthic organisms will be conducted only once during one tidal cycle during maximum low water and slack water.

The collected samples will be first collected in a clean bucket to reduce the heterogeneity. From the collected water sample 1 liter of water sample will be taken in an opaque plastic bottle for chlorophyll estimation. Quantitative plankton samples will be collected by filtering rest of the water sample using plankton net of 20µm mesh size.

Methodology adopted for Plankton sampling

Mixed plankton sample for qualitative evaluation will be obtained from the sub surface layer, at each sampling locations by towing the net horizontally with the weight during highest high tide and slack period and lowest low tide and slack period. After the tow of about 15-20 minutes at speed of 1- 1.5 m/s. For quantitative evaluation 50 L sample will be collected from the sub surface during high tide and low tide period will be filtered through 20 µm mesh size net assembly.

Methodology adopted for benthic fauna sampling

Van veen sampler (0.1 m^2) will be used for sampling bottom sediments during lowest low tide. The fixation of benthic fauna will be normally done by bulk fixation of the sediment sample. The bulk fixation will be done by using 10% formalin (buffered with borate) with Rose Bengal as stain. The organisms will be preserved with sea water as diluting agent.

Frequency

Phytoplankton (Qualitative & Quantitative) Zooplankton (Qualitative & Quantitative) & Benthos (Qualitative & Quantitative) samples will be collected during high tide and low tide during each spring and neap tides of the month.

Sampling Stations

The monitoring of marine environment for the study of biological and ecological parameters will be carried out in harbour regions of DPA (Table3) during Spring tide period of full moon phase of Lunar Cycle.

Table 4: Sampling Locations for Marine Monitoring

Sr.No	Monitoring locations	Location Code
Locations at Kandla		
1	Near passenger Jetty One	ML-1
2	Near Berth No.8&9	ML-2
3	Kandla Creek Near KPT colony	ML-3
4	Near13th&14thBerth	ML-4
5	Nakti Creek Near Tuna Port	ML-5
6	Nakti Creek Near NH-8A Bridge	ML-6
Locations at Vadinar		
7	Nr.SBM 2	ML-7
8	Nr. Vadinar Jetty	ML-8

4.1.4. Noise Monitoring

Noise sources in port operations include cargo handling, vehicular traffic, and loading / unloading of cargo to/from ships. Noise Monitoring will be done at 10 stationsat Kandla, and three locations in Vadinar.

Method and Frequency of monitoring

Sampling will be done at all stations for 24 hour period once in month. Data will be recorded using automated sound level meter. The intensity of sound will be measured in sound pressure level (SPL) and common unit of measurement is decibel (dB).

Sampling Stations

The sampling locations for noise monitoring as listed in table 5.

Table 5: Locations for Noise Monitoring

Sr. No	Name of locations	Location Code		Sr. No	Name of locations	Location Code
Locations at Kandla				8	Nirman Building 1	NL-8
1	West Gate no 1	NL-1		9	Tuna Port	NL-9
2	Main gate(North)	NL-2		10	Port & customs office	NL-10
3	Wharf area/Jetty Area	NL-3		**Location at Vadinar**		
4	Main road/Central Road	NL-4		11	Nr. Port Gate-Vadinar	NL-11
5	Canteen Area	NL-5		12	Nr. Vadinar Jetty	NL-12
6	ATM building	NL-6		13	Port colony Vadinar	NL-13
7	Marine Bhavan	NL-7				

4.1.5. Soil Quality Monitoring

Soil quality monitoring is important for evaluating the effects of environment management practices of a region/area.

Method of Monitoring

The soil samples will be collected from four locations in Kandla and two locations in Vadinar Port. The soil samples will be filled in polythene bags, labeled in the field with number and site name and taken to the laboratory for analysis (as per IS 2720). Physical and chemical properties of soil at selected locations will be studied.

Frequency of monitoring

Sampling will be done at all stations in Kandla and Vadinar once in a month.

Soil Quality Monitoring Stations

List of the locations for collecting the soil samples are as per Table 6.

Table 6: List of sampling locations for Soil Quality Monitoring

Sr. No	Name of locations	Location Code
Locations at Kandla		
1	Tuna Port	SL-1
2	IFFCO Plant	SL-2
3	Khori Creek	SL-3
4	Nakti creek bridge at NH-8A	SL-4
Location at Vadinar		
5	Nr. Vadinar Port Office	SL-5
6	Nr. Vadinar Colony	SL-6

4.1.6. Monitoring of performance of the Sewage Treatment Plant (STP) at Gopalpuri Township, Deendayal Port & Vadinar

The principal objective of waste water treatment is generally to allow human and industrial effluents to be disposed off without danger to human health or unacceptable damage to the natural environment.

Method of Monitoring

The parameters monitored will be pH, BOD, COD, residual chlorine, MLSS, MLVSS and TSS. The data collected will be analyzed as per the standards. The performance of the Sewage Treatment plant will be studied by collecting samples of the aeration tank and effluent tank.

Frequency of monitoring

Sampling will be done at all stations from inlet, aeration tank and outlet of an STP once in week.

Monitoring Stations:

Lists of the location for collecting the STP samples are as per table 7.

Table 7: List of sampling locations for STP

Sr. No	Sampling location
1	STP at Kandla
2	STP at Gopalpuri
3	STP at Vadinar

5. Monitoring Results

Based on the EMMP submitted, M/s Detox Corporation Pvt. Ltd. carried out monitoring of the following environmental aspects of the port for the period of March 2021 to February 2022.

5.1 Ambient Air

The monitoring was carried out twice a week. The results obtained from the sampling and analysis is submitted to Deendayal Port authority on monthly basis. The monthly averaged and annual results for the ambient air monitoring are given in the sections followed.

I. Total Suspended Particulate Matter (TSPM)

The frequency of sampling was twice a week for every sampling station.

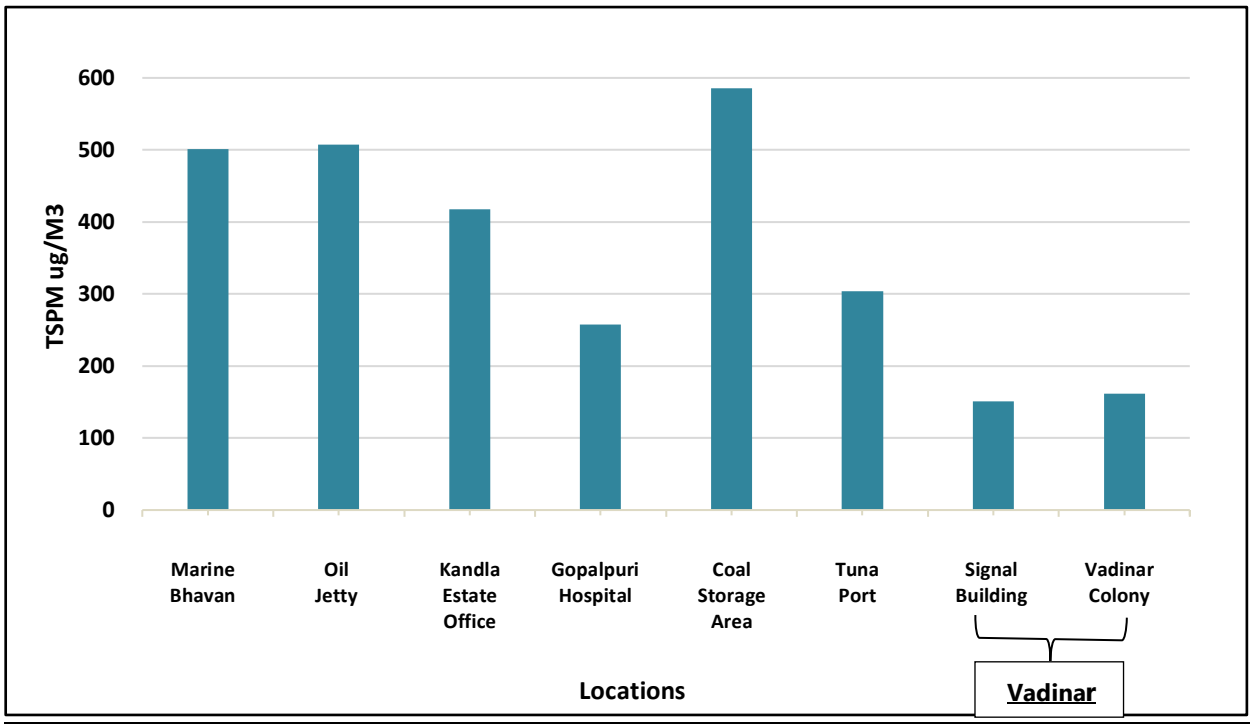
Table 8. TSPM (in µg/m^3) values at monitoring locations in Kandla and Vadinar Port

Months	Marine Bhavan	Oil Jetty	Kandla Estate Office	Gopalpuri Hospital	Coal Storage Area	Tuna Port	Signal Building	Vadinar colony
Mar-21	530	447	328	266	435	165	147	157
Apr-21	642	617	449	198	779	385	152	171
May-21	966	752	570	352	1341	273	134	161
Jun-21	374	312	267	173	596	125	59	60
Jul-21	467	578	463	307	354	372	105	146
Aug-21	495	520	488	229	548	347	155	138
Sep-21	449	554	341	194	324	238	164	169
Oct-21	364	465	402	274	527	362	157	211
Nov-21	460	489	487	357	598	387	219	205
Dec-21	442	480	427	251	518	362	176	183
Jan-22	417	480	417	251	484	348	164	164
Feb-22	412	393	371	243	523	284	171	186
Annual Mean	**502**	**507**	**418**	**258**	**586**	**304**	**150**	**163**

The mean TSPM values were highest at Coal Storage location and Marine Bhavan, followed by Oil Jetty. TSPM values were least at both the locations of Vadinar Port. The major cause of TSPM values at Coal Storage and Marine Bhavan is large amount of coal is handled at Berth No. 6, 7, 8and use of grabs for unloading of coal directly in the truck cause coal to spread in air as well as coal dust to fall on ground. This settled coal dust again mixes with the air during trucks movement through hit.

Also, the coal laden trucks are not always covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers during its transit from vessel to yard or storage site.

Fig 1. Observed values (annual mean) of TSPM at all eight monitoring stations



Interpretation of Results

- Maximum TSPM of 1341.0 µg/m^3 was recorded in the month of May"21 at Coal storage site and the minimum value was recorded in the month of June„21at Tuna Port 125.0µg/m$^{3.}$
- At Vadinar, maximum TSPM of 219 µg/m^3 was recorded in the month of November at Vadinar Signal Building site and the minimum value was recorded in the month of June "21 at Vadinar Signal Building (59µg/m^3).

II. Particulate Matter (PM_{10})

PM_{10} is particulate matters which are 10 micrometers or less in diameter. The frequency of sampling was twice a week for every sampling station.

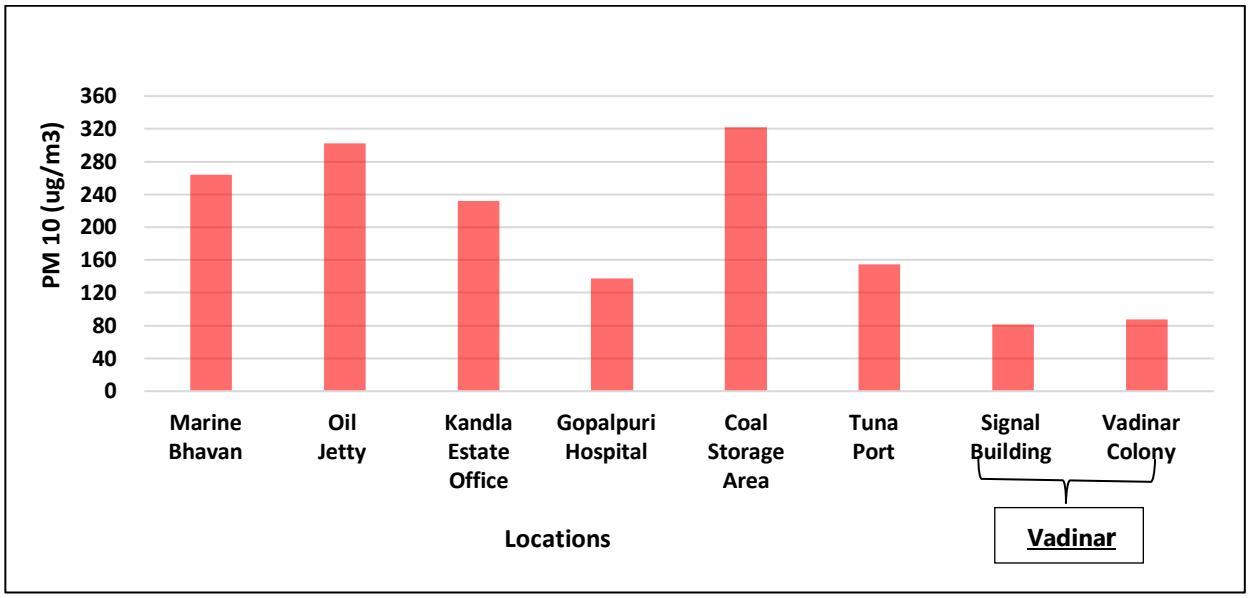
Table 9. PM_{10} (in µg/m^3) values at monitoring locations in Kandla and Vadinar Port

Months	Marine Bhavan	Oil Jetty	Kandla Estate Office	Gopalpuri Hospital	Coal Storage Area	Tuna Port	Signal Building	Vadinar colony
Mar-21	130	103	90	98	163	68	73	79
Apr-21	239	225	99	89	327	76	53	66
May-21	607	611	559	176	1149	160	73	99
Jun-21	130	82	69	52	140	59	33	33
Jul-21	373	496	366	230	206	250	75	81
Aug-21	262	322	276	133	327	217	98	77
Sep-21	333	442	211	123	200	126	97	95
Oct-21	190	246	219	140	203	163	82	116
Nov-21	193	190	217	187	292	195	115	108
Dec-21	245	263	243	142	295	194	88	98
Jan-22	227	437	217	142	264	184	93	97
Feb-22	237	213	215	139	300	161	98	104
Annual Mean	**264**	**303**	**232**	**138**	**322**	**154**	**82**	**88**

The mean PM_{10} Values were highest at Coal Storage location and Marine Bhavan, followed by Oil Jetty. PM_{10} values were least at both the locations of Vadinar Port. Higher PM_{10} values at Coal Storage and Marine Bhavan is a result of large amount of coal handling and its inappropriate transportation methods.

Coal laden trucks are seldom covered with tarpaulin sheets and these results in spillage of coal from trucks/dumpers resulting into higher PM_{10}values.

Fig 2. Observed values (annual mean) of PM_{10}at all eight monitoring stations



Interpretation of Results

- Maximum value of PM_{10} of 1149 µg/m^3 was recorded in the month ofMay"21 at Coal storage site and the minimum value was recorded in the month of June 2021 at Tuna Port 59.0µg/m^3.
- In Vadinar, maximum value of PM_{10} of 116 µg/m3 was recorded in the month of October 2021 at Vadinar Colony and the minimum value was recorded in the month of june- 2021atVadinarColony & Signal Building (33.0 µg/m3).

III. Particulate Matter ($PM_{2.5}$)

$PM_{2.5}$ particles are air pollutants with a diameter of 2.5 micrometers or less, small enough to invade even the smallest airways. $PM_{2.5}$ was also monitored twice a week for every sampling station.

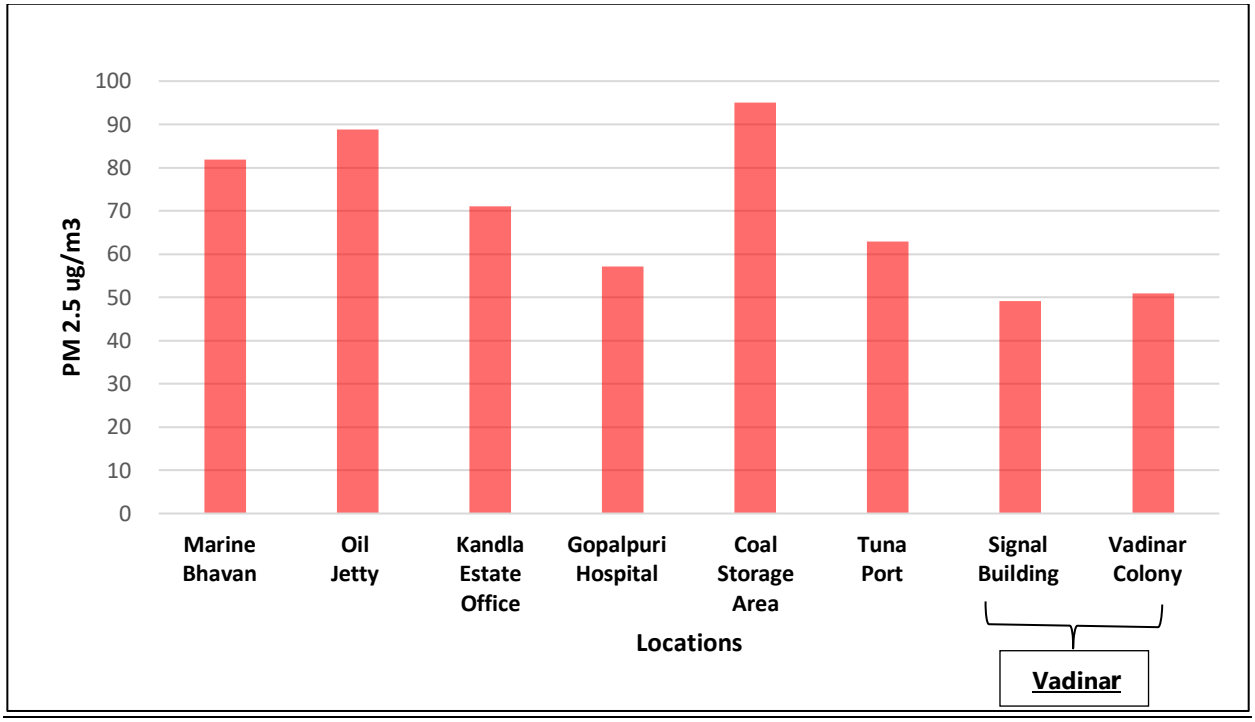
Table 10. $PM_{2.5}$ (in µg/m^3) values at monitoring locations in Kandla and Vadinar Port

Months	Marine Bhavan	Oil Jetty	Kandla Estate Office	Gopalpuri Hospital	Coal Storage Area	Tuna Port	Signal Building	Vadinar colony
Mar-21	56	50	34	29	67	24	21	41
Apr-21	73	52	44	15	101	18	35	17
May-21	41	37	40	27	102	23	33	36
Jun-21	108	113	61	33	138	33	38	22
Jul-21	89	47	56	63	40	58	40	44
Aug-21	71	73	71	51	80	63	39	45
Sep-21	81	83	60	46	80	55	44	42
Oct-21	82	89	90	79	105	96	49	70
Nov-21	90	97	97	87	104	98	84	82
Dec-21	104	102	98	87	101	93	71	75
Jan-22	95	232	99	87	111	79	66	60
Feb-22	92	90	102	82	112	114	69	76
Annual Mean	**82**	**89**	**71**	**57**	**95**	**63**	**49**	**51**

Average $PM_{2.5}$ values were highest at Oil Jetty location (mean=232.0 µg/m^3) followed by Coal Storage Area

(mean =138.0 µg/m^3) and Gopalpuri Hospital (mean=57.0 µg/m^3). $PM_{2.5}$ values At Vadinar Port the $PM_{2.5}$ values were significantly lower.

Fig 3. Observed values (annual mean) of $PM_{2.5}$ at all eight monitoring stations

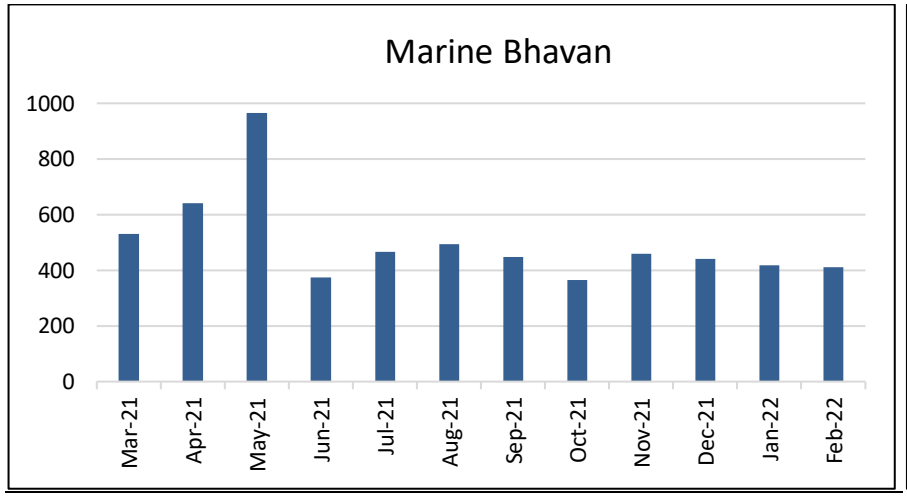


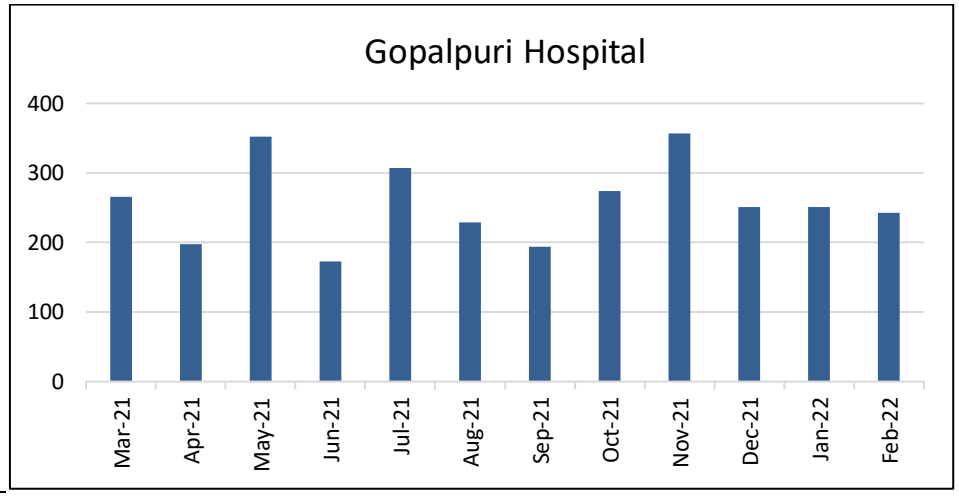
Interpretation of Results

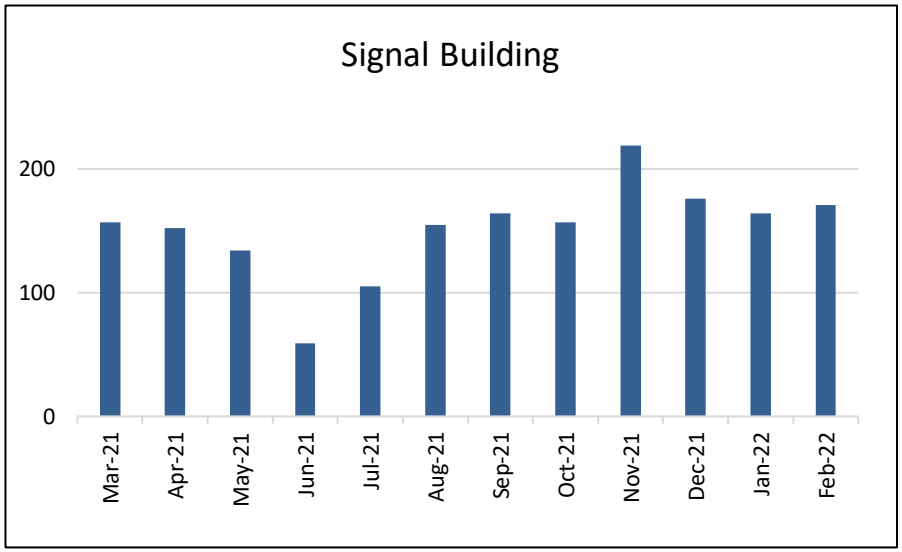
- Maximum value of $PM_{2.5}$232.0 µg/m^3) was recorded in the month of January 2022 at Oil Jetty site and the minimum value was recorded in the month of May 2021 at Gopalpuri Hospital (27.0µg/m^3).
- Annual mean values of $PM_{2.5}$ were highest at Coal Storage Area (95.0µg/m^3).
- In Vadinar, maximum value of $PM_{2.5}$ of 84.0 µg/m^3 was recorded in the month of November‟ 21 at Signal building site and the minimum value was recorded inthe month of April at Vadinar Port colony (17.0µg/m^3).

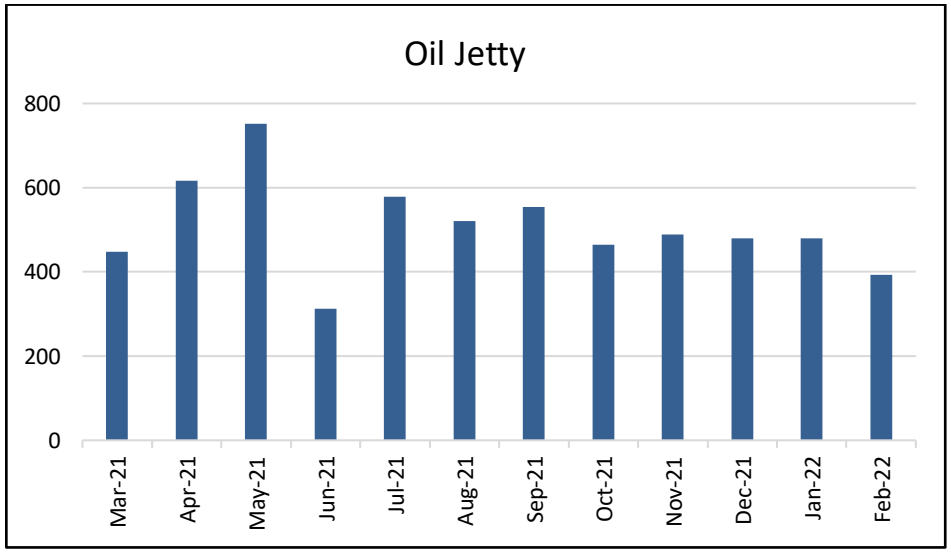
  Location wise graphs depicting trends in TSPM, PM_{10} and $PM_{2.5}$ in all locations of Kandla and Vadinar Port are depicted in 1 to 3.

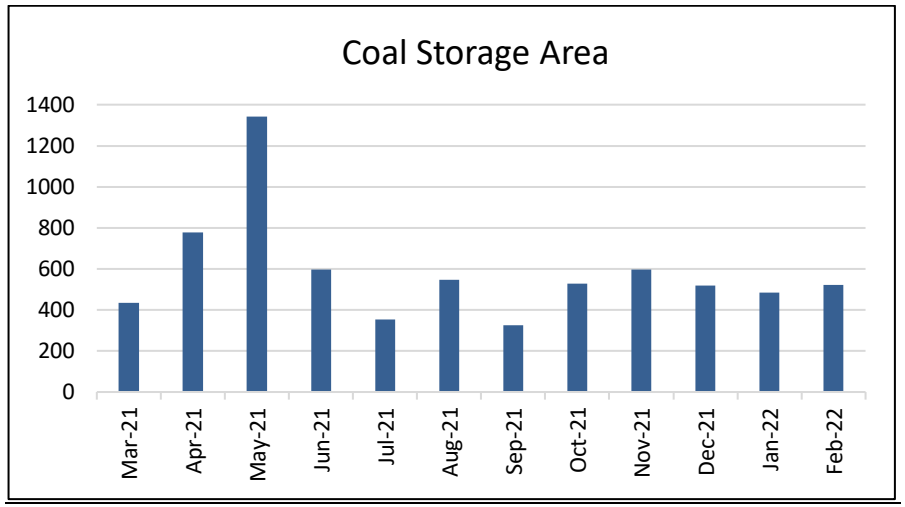
Fig 4. Trend in TSPM values of various AAQ Monitoring Locations

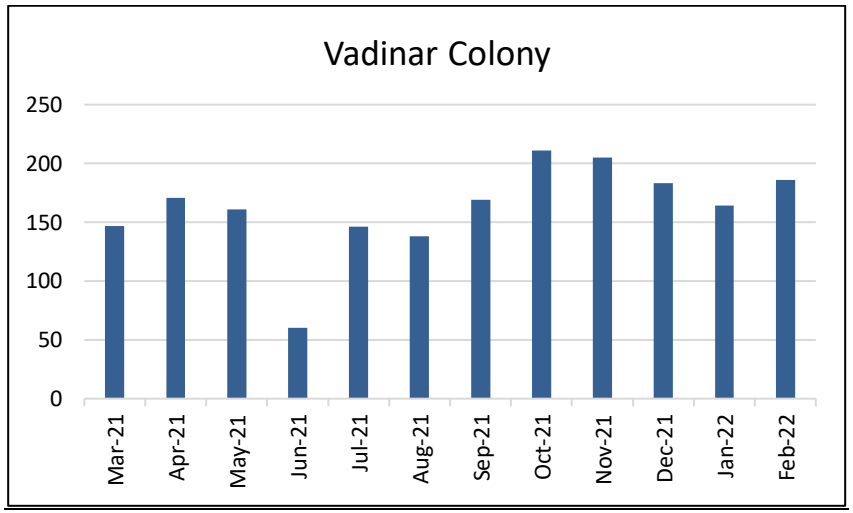


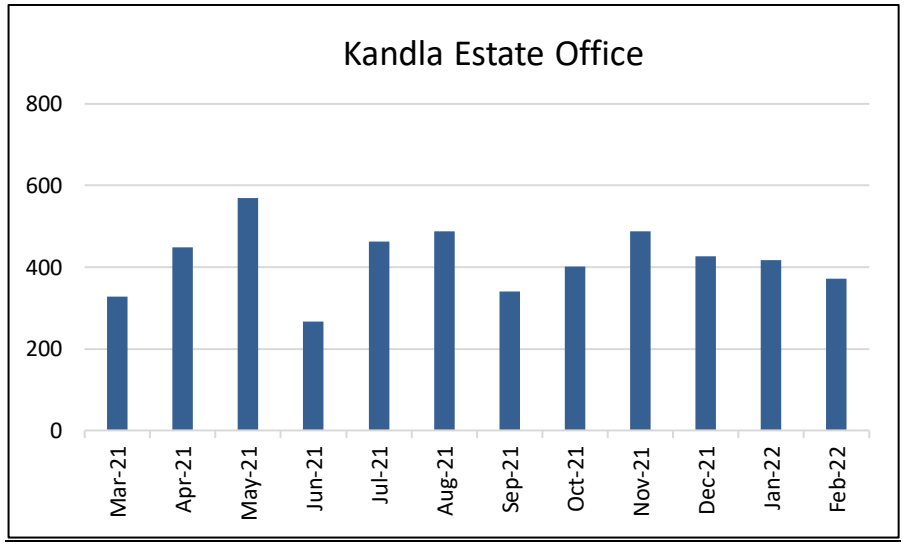







Coal Storage Area
1400
1200
1000
800
600
400
200
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22


Vadinar Colony
250
200
150
100
50
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22


Kandla Estate Office
800
600
400
200
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
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Dec-21
Jan-22
Feb-22

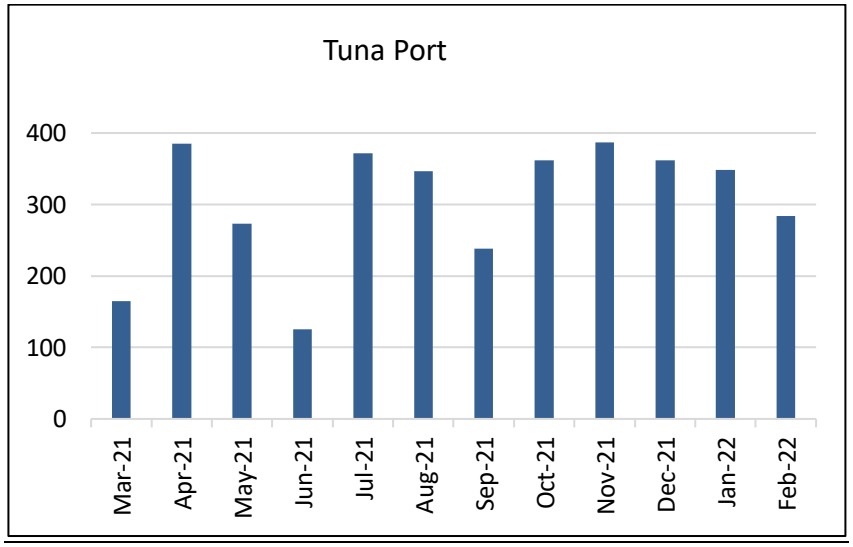
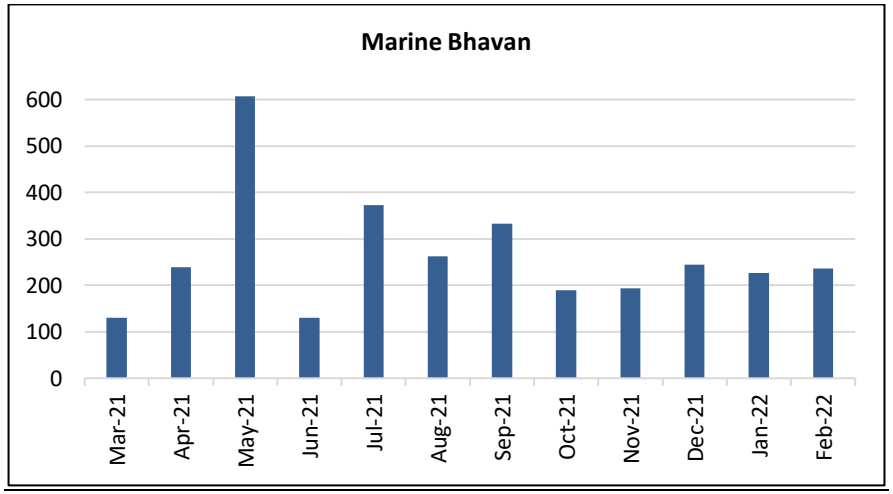
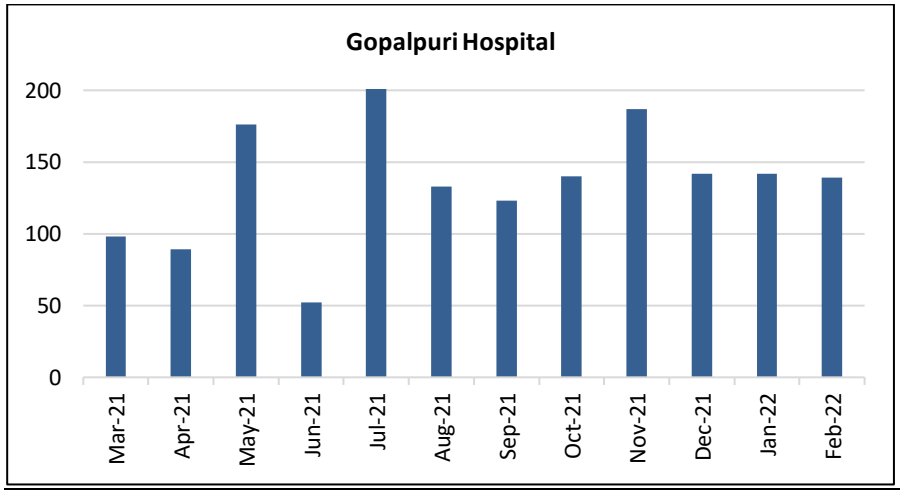
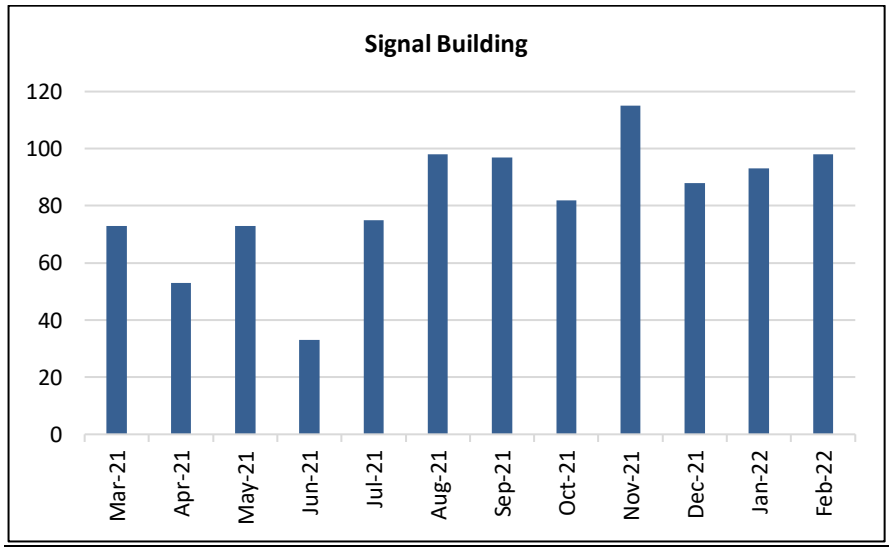
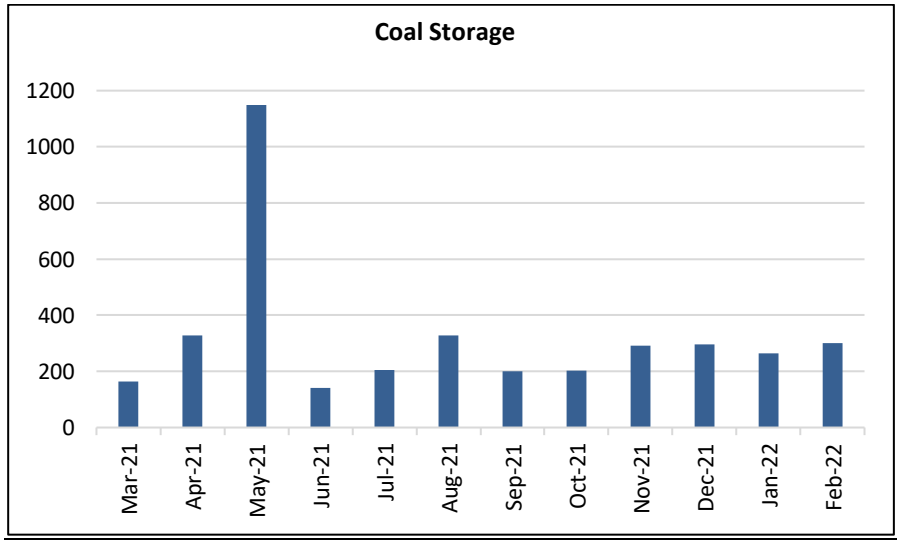

Tuna Port
400
300
200
100
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22

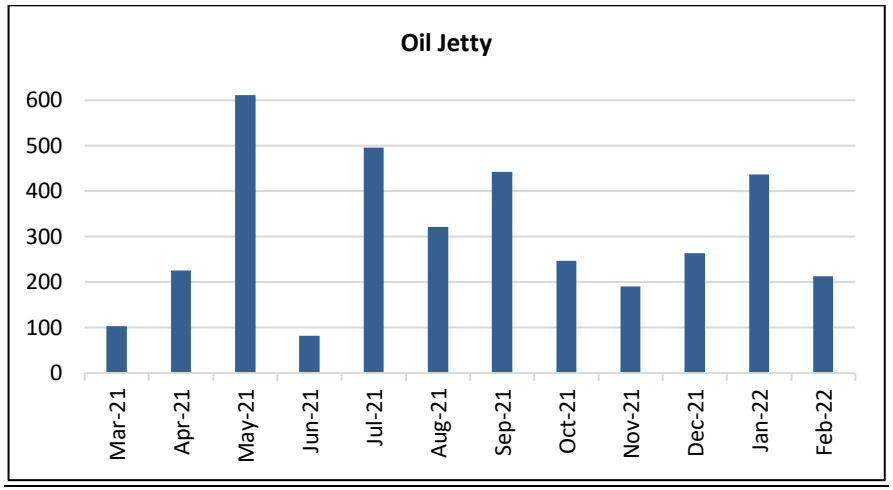
Fig 5. Trend in PM10 values of various AAQ Monitoring Locations










Oil Jetty
600
500
400
300
200
100
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
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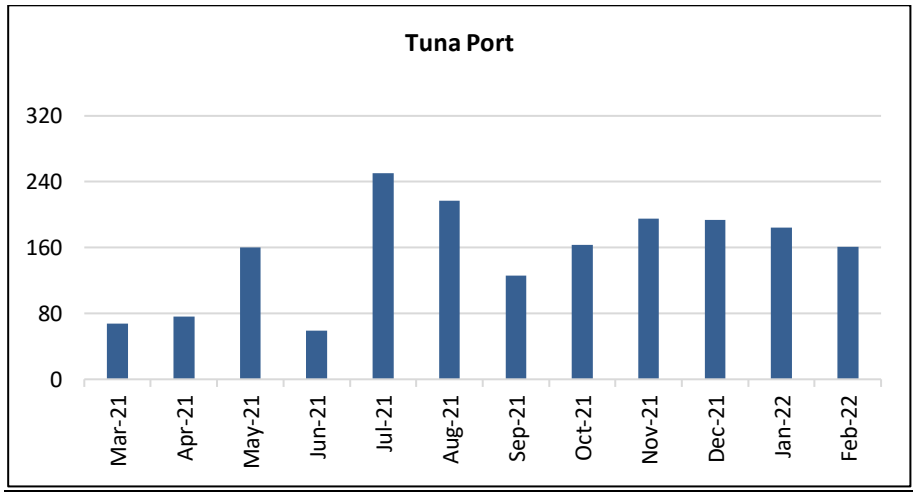
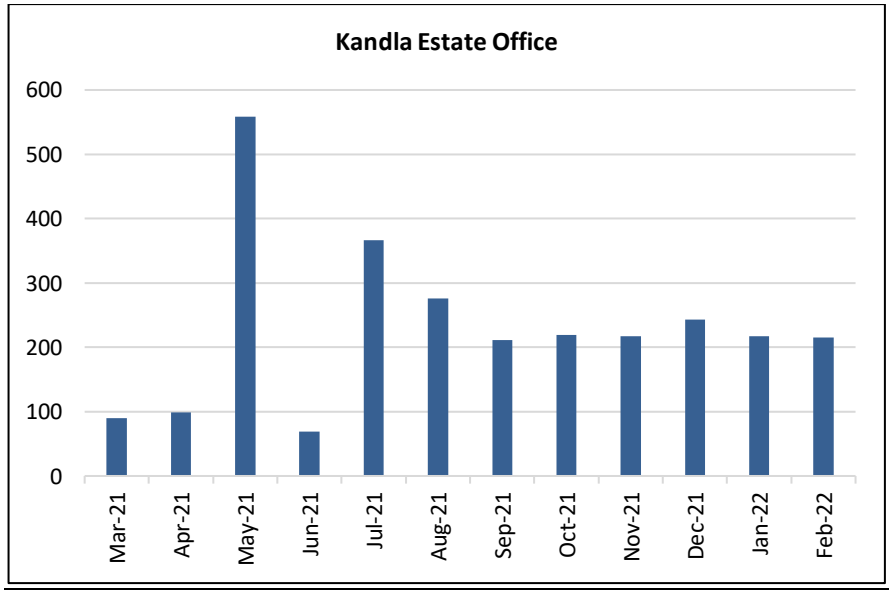
Dec-21
Jan-22
Feb-22


Tuna Port
320
240
160
80
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22


Kandla Estate Office
600
500
400
300
200
100
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
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Dec-21
Jan-22
Feb-22

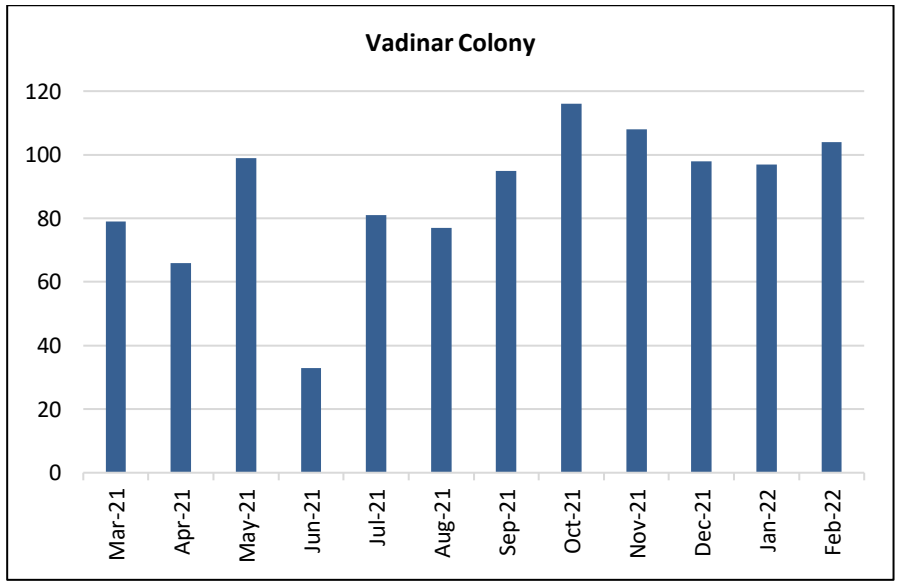
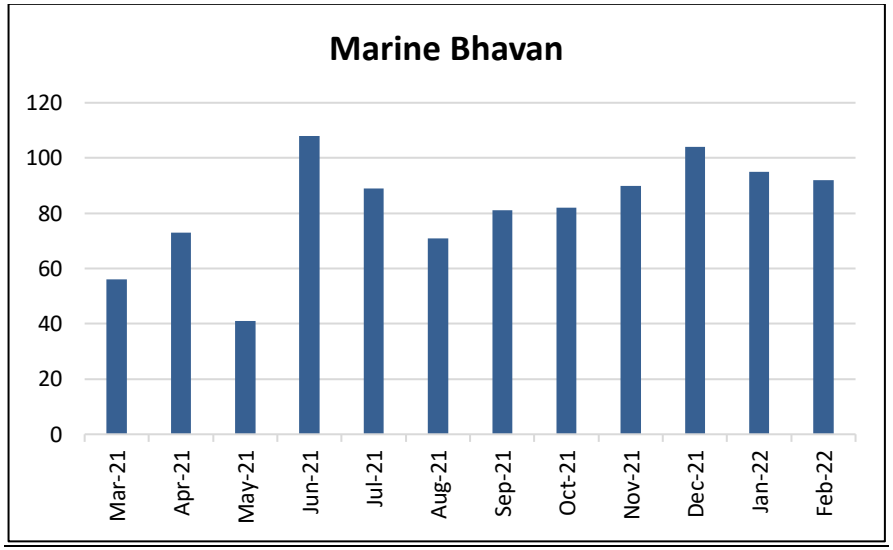
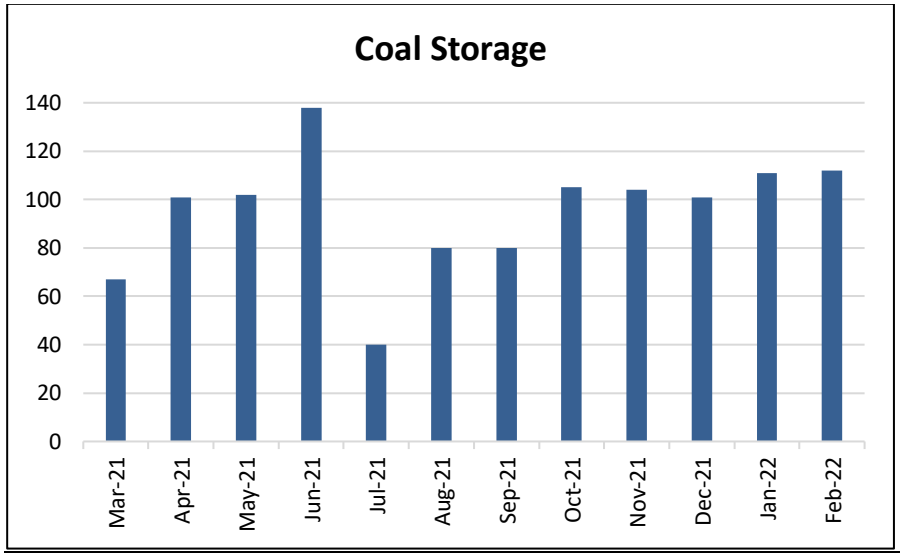
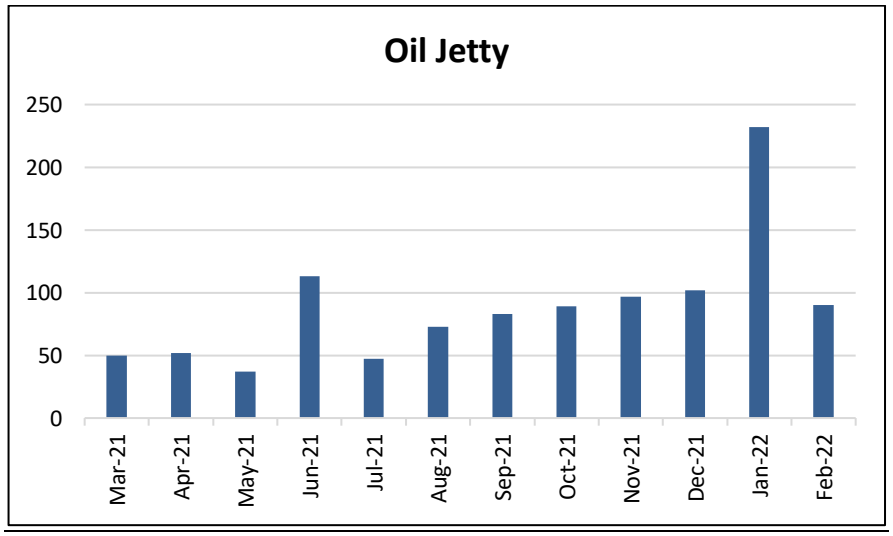
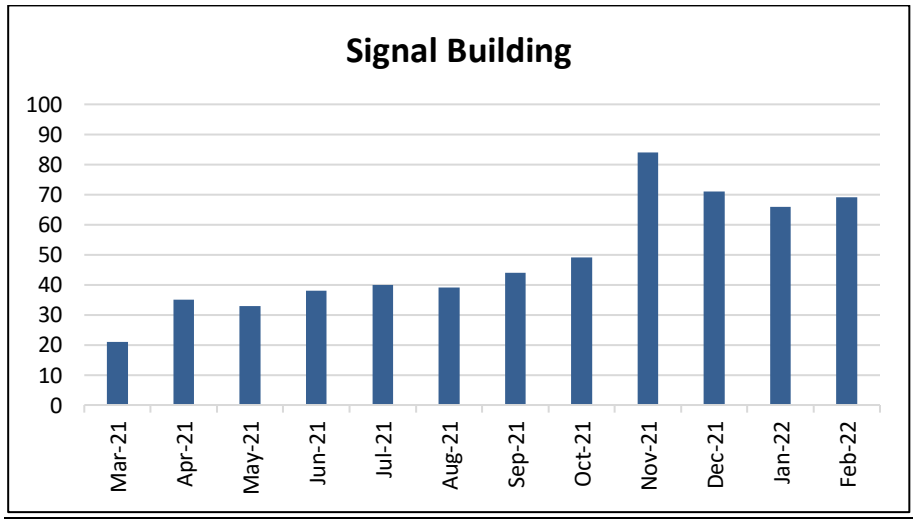

Vadinar Colony
120
100
80
60
40
20
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22

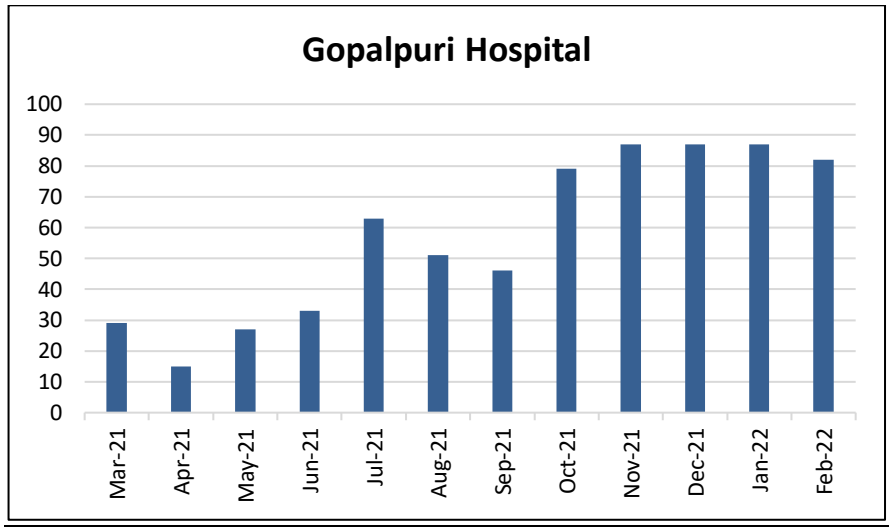
Fig 6. Trend in PM2.5 values of various AAQ Monitoring Locations

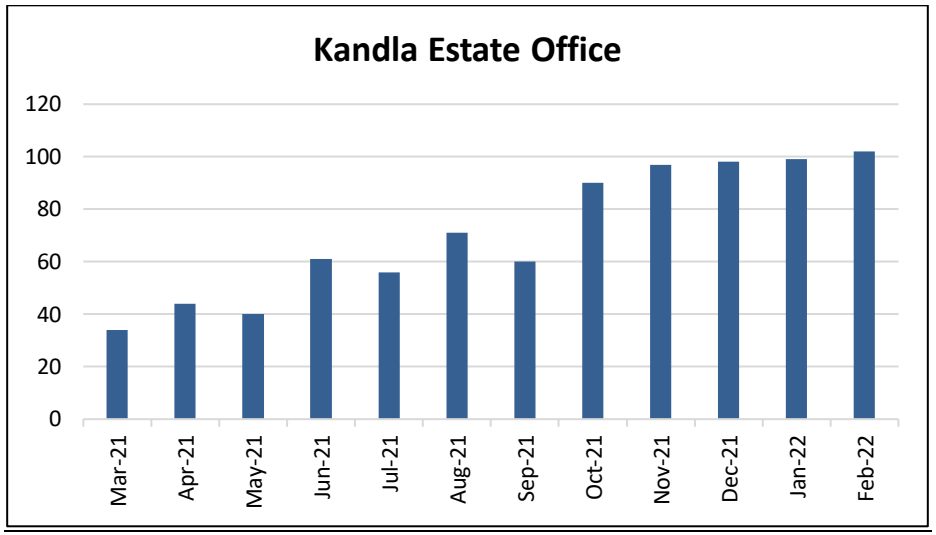









Gopalpuri Hospital
100
90
80
70
60
50
40
30
20
10
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22


Kandla Estate Office
120
100
80
60
40
20
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
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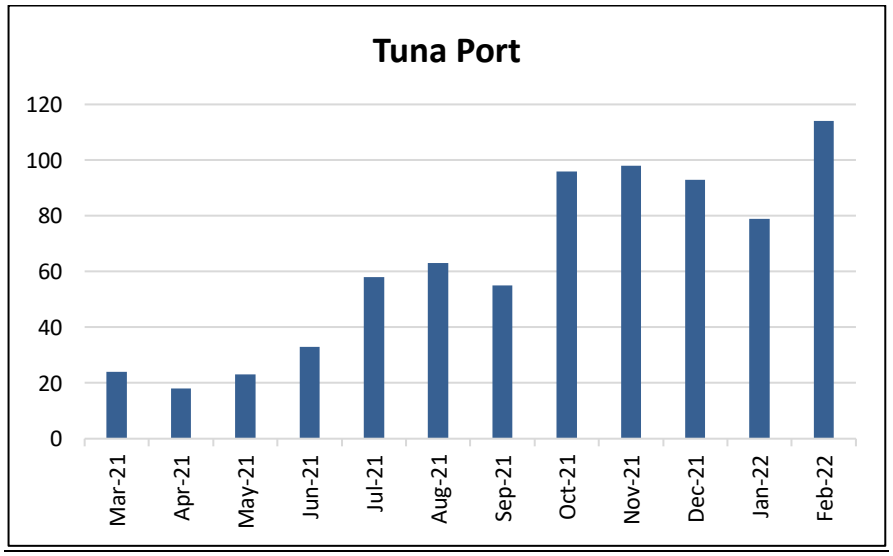
Nov-21
Dec-21
Jan-22
Feb-22


Tuna Port
120
100
80
60
40
20
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
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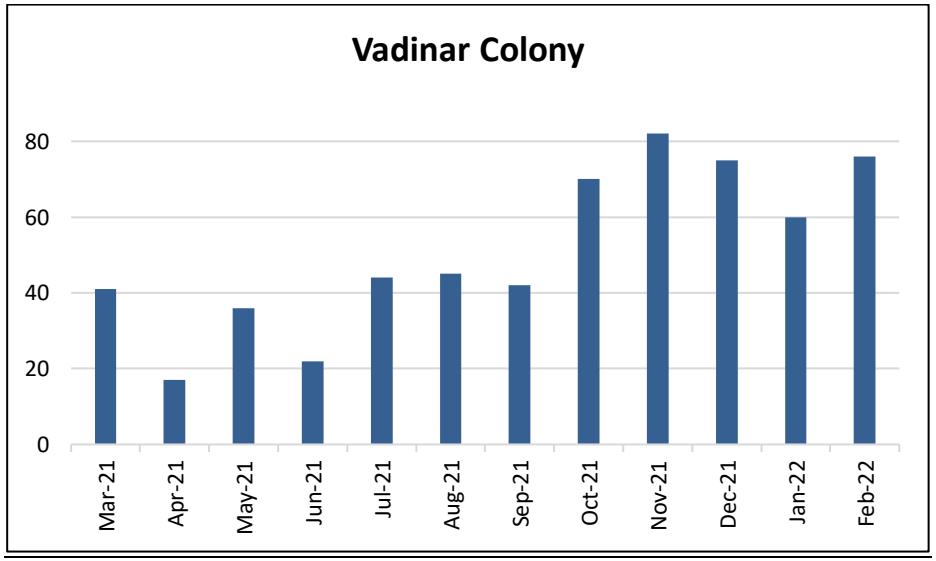
Dec-21
Jan-22
Feb-22


Vadinar Colony
80
60
40
20
0
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22

5.2 Drinking Water Quality Monitoring

Drinking Water Quality Monitoring was carried out at twenty stations at Kandla, Vadinar & Town ship Area of Deendayal Port.

Drinking water samples are collected from 20 locations (18 locations in Kandla and 2 locations in Vadinar). Samples for physico-chemical analysis are collected and analysed in laboratory for various parameters, viz. Color, Odor, Turbidity, Conductivity, pH, Chlorides, TDS, Total Hardness, Iron, Sulphate, Salinity, DO, BOD, Na, K, Ca, Mg, F, NO3, NO2, Mn, Cu, Cd, As, Hg, Pb, Zn, Bacterial Count (CFU).

Monitoring Results

Mean values of drinking water of Deendayal Port Locations are given in table 6.4. The values shown are the annual average of all the locations of Deendayal Port Colony, Port and Harbor area as well as Deendayal Port Authority office buildings.

Table 11 : Annual average values of Drinking water at Deendayal Port Authority

Sr. No.	Parameter		1st	2nd	3rd	4th	Value	Acceptable Limits	Permissible Limits
		Unit	Quarter Mean	Quarter Mean	Quarter Mean	Quarter Mean	(Annual Avg.)		
1	pH	pH Unit	7.38	7.41	7.46	7.38	7.41	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/L	1114.30	1083.67	1265.93	1155.75	1154.91	500	2000
3	Turbidity	NTU	0.53	0.48	0.47	0.45	0.48	1	5
4	Odor	-	Odorless	Odorless	Odorless	Odorless	Odorless	Agreeable	Agreeable
5	Color	Hazen Units	Colorless	Colorless	Colorless	Colorless	Colorless	5	15
6	Conductivity	µs/cm	2253.97	2064.35	2448.83	2108.38	2218.88	NS*	NS*
7	Bio.Oxygen Demand	mg/L	<2	<2	<2	<2	<2	NS*	NS*
8	Chloride as Cl	mg/L	651.10	579.99	484.50	539.53	563.78	250	1000
9	Ca as Ca	mg/L	74.21	59.34	62.83	61.72	64.53	75	200
10	Mg as Mg	mg/L	62.90	68.23	71.90	65.22	67.07	30	100
11	Total Hardness	mg/L	443.03	415.20	403.03	436.67	424.48	200	600
12	Iron as Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	0.3	1
13	Fluorides as F	mg/L	0.45	0.69	0.55	0.64	0.58	1	1.5
14	Sulphate as SO_4	mg/L	211.96	193.41	229.75	220.67	213.95	200	400
15	Nitrite as NO2	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	NS*	NS*
16	Nitrate as NO3	mg/L	5.29	10.23	9.92	10.04	8.87	45	100
17	Salinity	%	1.26	1.05	0.88	0.97	1.04	NS*	NS*
18	Sodium as Na	mg/L	329.18	228.77	219.20	268.63	261.45	NS*	NS*
19	Potassium as K	mg/L	4.13	2.94	3.80	4.43	3.82	NS*	NS*
20	Manganese	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	0.1	0.3
21	Hexavalent Chromium	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	NS*	NS*
22	Copper	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	0.05	1.5
23	Cadmium	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	0.003	0.003
24	Arsenic	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	0.01	0.05
25	Mercury	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	0.001	0.001
26	Lead	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	0.01	0.01
27	Zinc	mg/L	<0.04	<0.04	<0.04	<0.04	<0.04	5	15
28	Bacterial Count	CFU/100 ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent

NS= Not specified, ND=Not detected

Discussion

The colour of all drinking water samples was colourless unit and odour of the samples was also agreeable. The values of turbidity, Iron as Fe and Ammonia as NH_3-N were observed to be below detection limits of measurement i.e. <0.1NT, <0.03mg/L and <0.1mg/L respectively. Apparently these parameters were not at alarming levels. Some important parameters for drinking water are discussed below in detail;

pH

pH value in the studied area varied from 7.37 to 7.47 pH unit during the first year of monitoring. The limit of pH value for drinking water is specified as 6.5 to 8.5. All the sampling points showed pH values within the prescribed limit by Indian Standards.

Total Dissolved Solids (TDS)

TDS values in the studied area varied between 1073.73-1201.26 mg/L. The mean TDS value was 1154.9 mg/L. None of the sampling points showed higher TDS values than the prescribed limit by Indian standards which are 500-2000mg/L.

Conductivity

Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The conductivity in the samples collected during the month of June ranged from 2149.36-2320.63 µs/cm. Electrical conductivity standards do not appear in BIS standards for drinking water.

Chlorides

Chloride values in drinking water for the present year varied between 507.6 -647.63 mg/L. Excessive chloride concentration increase rates of corrosion of metals in the distribution system. This can lead to increased concentration of metals in the supply.

Calcium

Calcium value in drinking water for the present year the studied area varied between 62.32 – 68.91 mg/L. The mean Ca was observed to be 64.52 mg/L. If calcium is present beyond the maximum acceptable limit, it causes incrustation of pipes.

Magnesium

Magnesium value in the studied area for the present year varied from 65.80mg/L to 68.26 mg/L. All the locations had Magnesium within the prescribed limits of 30-100mg/L.

Total Hardness

Total Hardness value in the studied area for the present year varied between 389.03-447.43 mg/L. The prescribed limit by Indian Standards is 200-600mg/L.

Fluoride

Fluoride value in the studied area varied between 0.48 – 0.65 mg/L. The permissible limit as per Indian Standards is 1.0-1.5mg/L. Moderate amount of fluoride in water lead to dental effects, but long-term ingestion of large amounts can lead to potentially severe skeletal problems.

Sulphates

Sulphate value in the studied area varied between 195.75–225.46 mg/L. All the sampling points showed Sulphates values within the prescribed limits by Indian Standards (200-400 mg/L). Sulphate occurs naturally in water as are sult of leaching from gypsum and other common minerals. Sulphate content in drinking water exceeding the 400 mg/L imparts bitter taste.

Nitrites (NO_2)

Nitrite values in all the water samples were observed to be <0.01 mg/L. There are no specified standard values for Nitrites in drinking water. Ground water contains nitrate due to leaching of nitrate with the percolating water and by sewage and other wastes rich in nitrates.

Salinity

Salinity in drinking water in the present samples collected ranged from 0.92to 1.23 %. There are no prescribed Indian standards for salinity in Drinking water.

Heavy Metals in Drinking Water

In the present study period drinking water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals were well below/ the permissible limits of the Indian Standards for drinking water.

Bacteriological Study

Analysis of the bacteriological parameter at all location shows that total Coliform values is observed to be 0.1 to cfu/100 ml. total Coliform and E-Coli values showed that all the drinking water samples were safe from any bacteriological contamination.

Conclusion

The results are compared with acceptable limits as well as Permissible Limits as prescribed in IS10500:2012 – Drinking Water Specification. It was observed from the data analysis that during the Third year (March 2021 to February 2022) the drinking water was safe for human consumption as per tested parameters only at all drinking water monitoring stations.

5.3 Marine Water Monitoring

Marine Water Monitoring was carried out at six stations at Deendayal Port and two locations at Vadinar Port.

Water samples were analyzed for physico-chemical and Biochemical parameters. Besides these, Phytoplankton (Qualitative & Quantitative) Zooplankton (Qualitative & Quantitative) & Benthos (Qualitative & Quantitative) samples were collected during spring tide and neap tide from all the eight fixed monitoring stations.

Results

The annual average values of monitored parameters for marine waters of DPA are given as per table 12.

Table 12. Annual average values of various physico-chemical parameters at Deendayal Port during neap tide. (Marine Sampling Station at Gulf of Kutch).

Sr. No.	Parameters	Unit	1st	2nd	3rd	4th
			Quarter Mean	Quarter Mean	Quarter Mean	Quarter Mean
1	pH	-	7.30	7.35	7.36	7.39
2	Color	-	Colorless	Colorless	Colorless	Colorless
3	Odor	-	Odourless	Odourless	Odourless	Odourless
4	Salinity	ppt	32.51	32.24	31.82	31.80
5	Turbidity	NTU	26.56	35.05	36.78	35.71
6	Total Dissolved Solids	mg/L	40307.26	39446.10	39151.25	34126.11
7	Total Suspended Solids	mg/L	468.54	393.35	503.95	630.73
8	Total Solids	mg/L	43192.33	41383.94	39672.71	34818.14
9	DO	mg/L	5.11	4.57	4.82	4.45
10	COD	mg/L	79.05	83.13	84.56	85.60
11	BOD	mg/L	0.00	0.00	0.00	0.00
12	Silica	mg/L	0.57	0.56	0.67	0.78
13	Phosphate	mg/L	0.29	0.25	0.19	0.20
14	Sulphate	mg/L	3499.62	2586.77	2451.53	2493.91
15	Nitrate	mg/L	4.15	3.23	3.80	3.97
16	Nitrite	mg/L	0.01	0.00	0.00	0.00
17	Calcium	mg/L	518.97	557.01	522.61	578.93
18	Magnesium	mg/L	1588.81	1739.01	1150.32	1680.46
19	Sodium	mg/L	9976.72	10571.44	10635.22	10265.40
20	Potassium	mg/L	314.39	367.85	324.11	343.54
21	Iron	mg/L	1.81	1.67	1.61	0.81
22	Chromium	mg/L	0.14	0.15	0.13	0.04
23	Copper	mg/L	0.07	0.10	0.04	0.00
24	Arsenic	mg/L	0.00	0.00	0.00	0.00
25	Cadmium	mg/L	0.06	0.07	0.06	0.02
26	Mercury	mg/L	0.00	0.00	0.00	0.00
27	Lead	mg/L	0.16	0.17	0.12	0.02
28	Zinc	mg/L	0.06	0.06	0.04	0.11

Discussion

Coastal ecosystems are characterized by daily fluctuations, driven by tidal amplitude, wind direction and also on the anthropogenic activities carried out on the coasts. Marine water parameters at Kandla Harbor and creek waters also showed an high array of fluctuations in several of its parameters such as TDS, TSS, salinity and salts. Some of the important parameters are explained below;

pH

The pH of all marine water samples collected from Deendayal Port variedfrom7.3to 7.39. The mean pH of all samples was 7.64pH unit.

Salinity

Salinity in the DPA marine water ranged from 31.8ppt to 32.51ppt. The mean salinity at was recorded to be 32.09 ppt.

Turbidity

Turbidity in the DPA marine water ranged from 26.56 – 36.78 NTU. The mean turbidity of all the locations of Deendayal Port was 33.52 NTU. Turbidity at Vadinar port was<1.0NTU.

Total Dissolved Solids (TDS)

TDS values varied from 34126.11 to 40307.26 mg/L at all locations of Deendayal Port. Mean TDS values at Deendayal Port was 38257.68mg/L.

Dissolved Oxygen (DO)

DO value in the studied area varied between 4.45-5.11 mg/L. The mean DO values of Kandla Marine waters were 4.7mg/L.

Nitrates (NO3)

The mean Nitrate values in all the marine water samples were of Deendayal Port was 3.78 mg/L at DPA waters. Nitrite was rarely detected from marine waters of Vadinar.

Sodium (Na)

Sodium value in the Deendayal Port marine waters varied between 9976.72-10635.22 mg/L. The mean Na recorded at DPA waters was 11448.78 mg/L.

Trace Metals

In the present study period water samples were analyzed for Mn, Cr, Cu, Cd, As, Hg, Pb and Zn. All these heavy metals reported below trace levels.

Bacteriological Study

Analysis of the bacteriological parameter at all location shows that total Coli form values is observed to be 0.1to cfu/100ml.

5.4 Productivity Study

Chlorophyll-A

Water Samples for the chlorophyll estimation collected from sub surface layer during high tide and low tide period of the tidal cycle for each sampling locations and analysed for Chlorophyll -a and after acidification for Pheophytin –a.

In the sub surface water chlorophyll-a was varying from 0.204 to 1.923 mg/m^3 in harbour region of DPA during sampling done in from March 2021 to February 2022. In the nearby creeks chlorophyll-a was varying from 0.153.93 to 1.923mg/m^3.

In the sub surface water chlorophyll-a was varying from 0.392 – 1.356mg/m3 at Vadinar jetty and 0.392 mg/m3 to 1.365 mg/m3near SPM during sampling done spring tide period and during Neap tide.

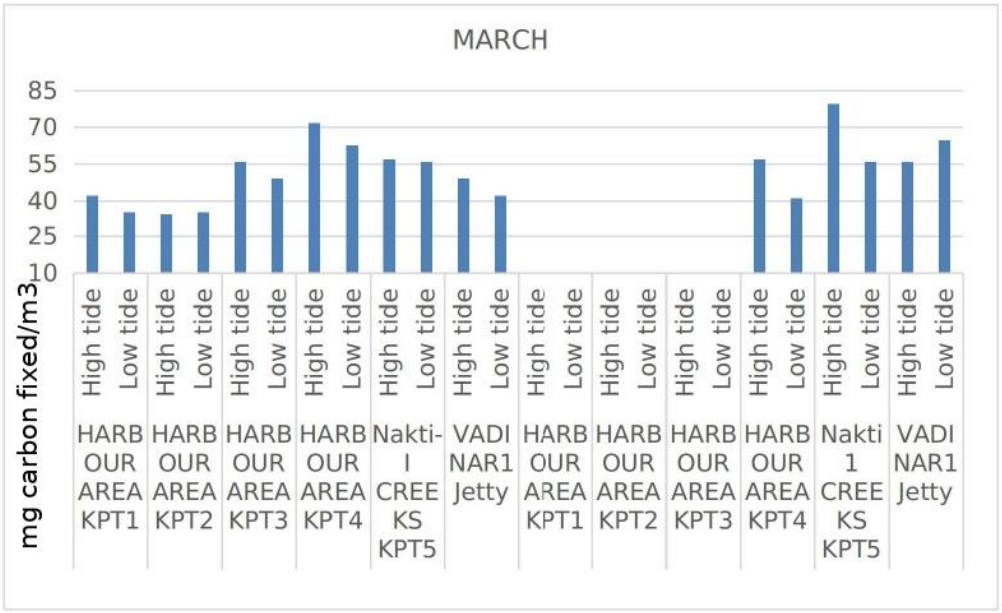
Algal Biomass

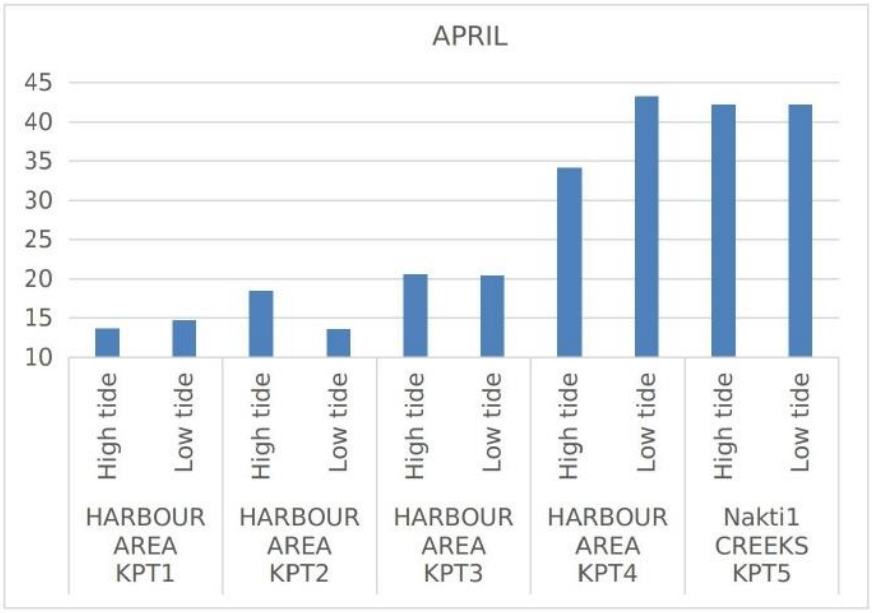
Chlorophyll-a value was used as algal biomass indicator (APHA 23rd Edition). Algal biomass was estimated by converting Chlorophyll value.

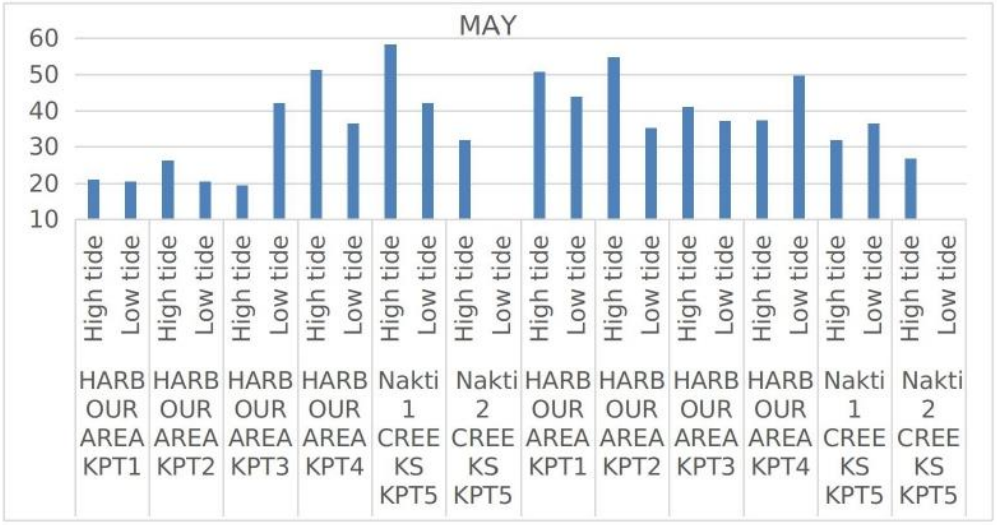
In the sub surface water algal biomass was varying from13.66to 128.84mg/m^3 in harbour region of DPA during sampling done in fromMarch2021 to February 2022. In the nearby creeks Algal Biomass was varyingfrom10.24to 128.84mg/m^3.

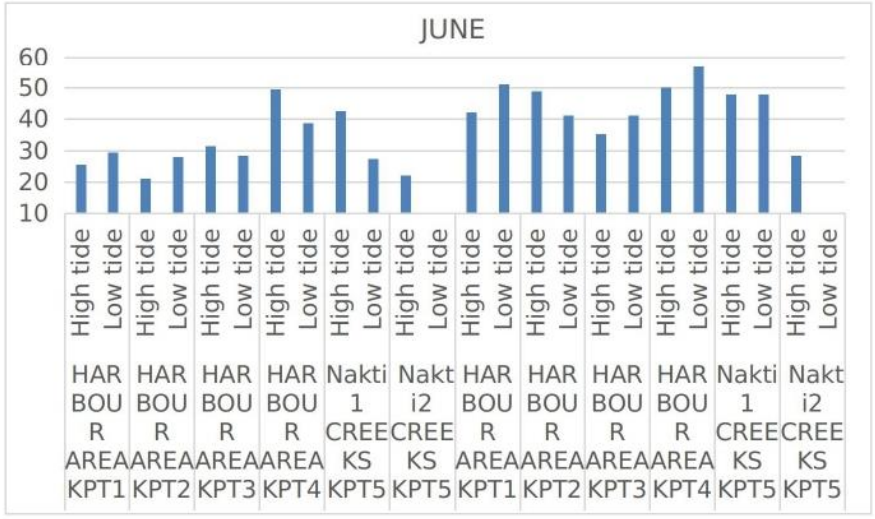
In the sub surface water algal biomass was varying from 26.26 – 90.85mg/m3 at Vadinar jetty and SPM during sampling done spring tide period and during Neap tide.

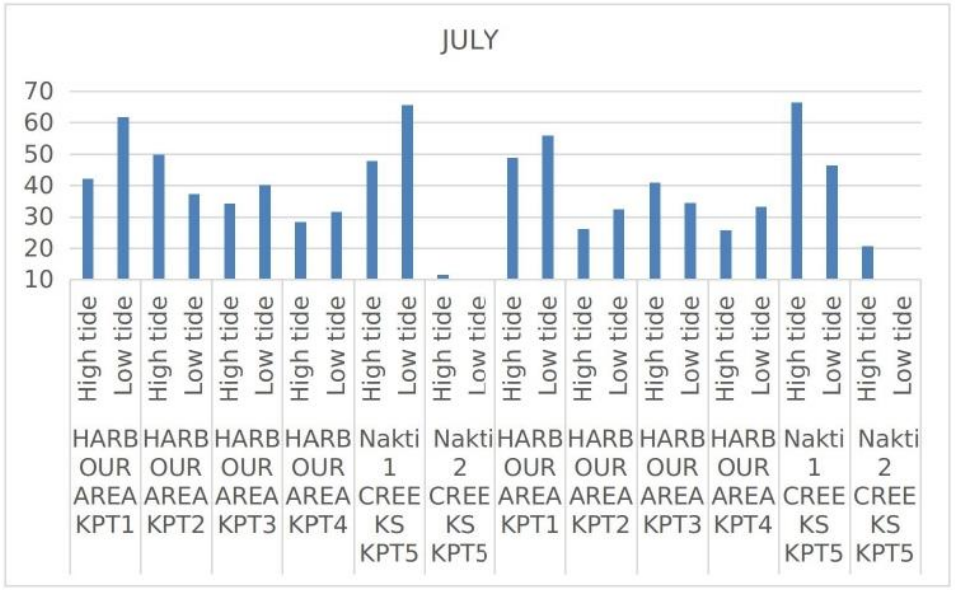
Fig 7. Monthly values of Algal Biomass in harbor waters of DPA

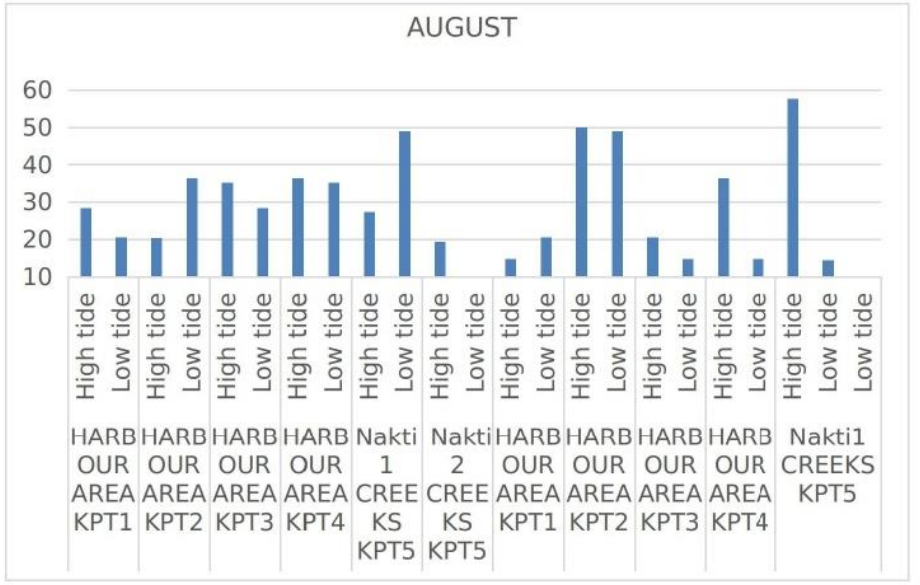


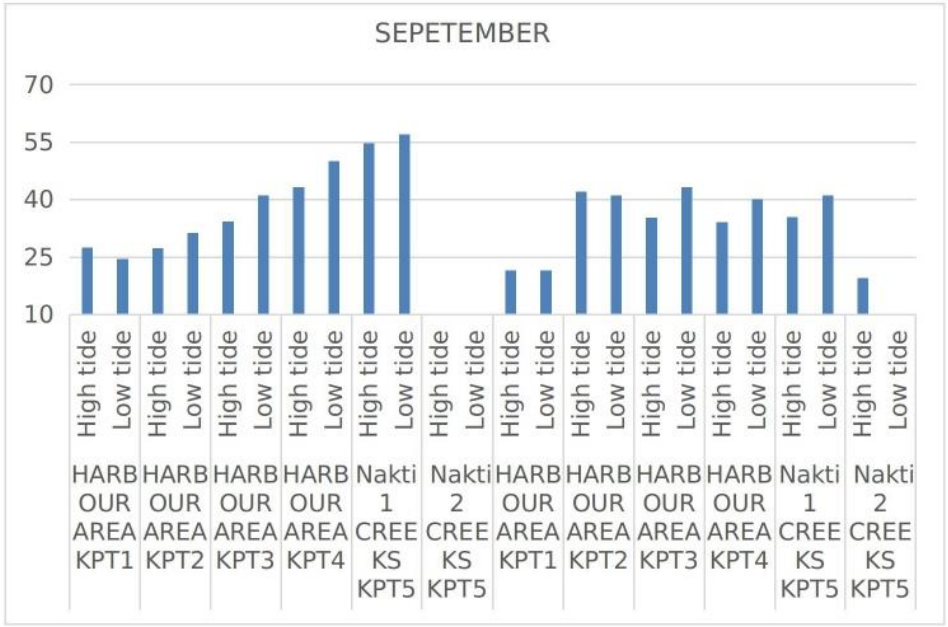


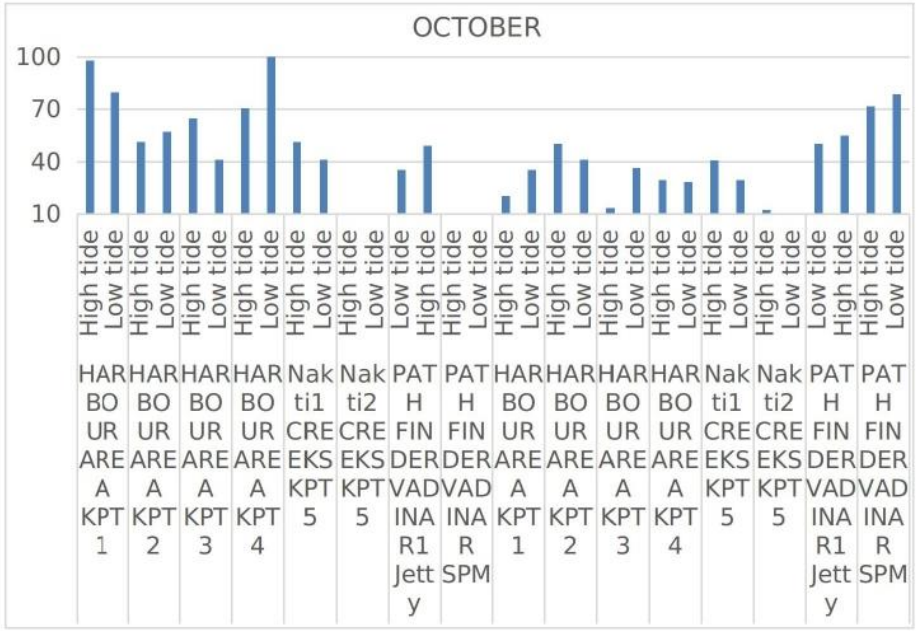


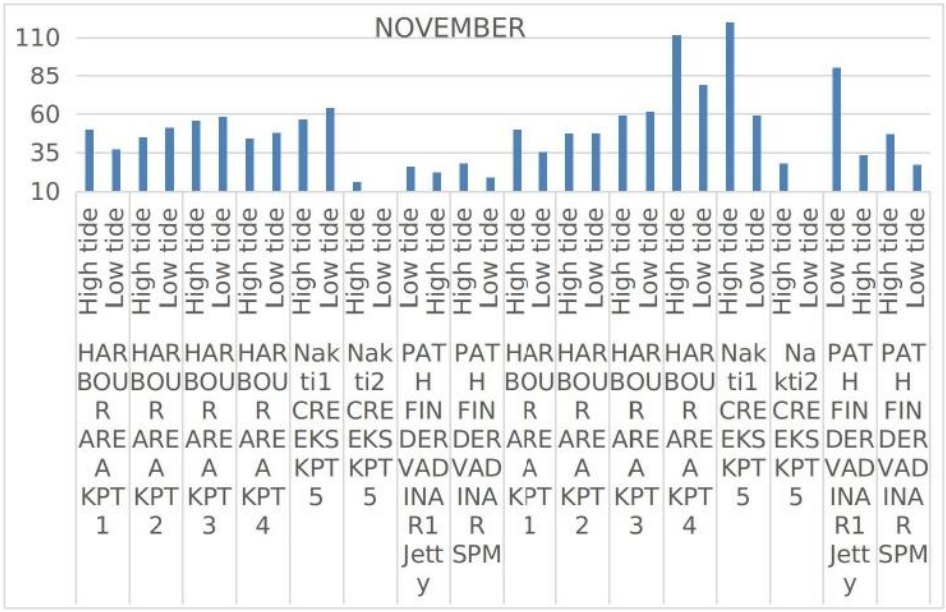


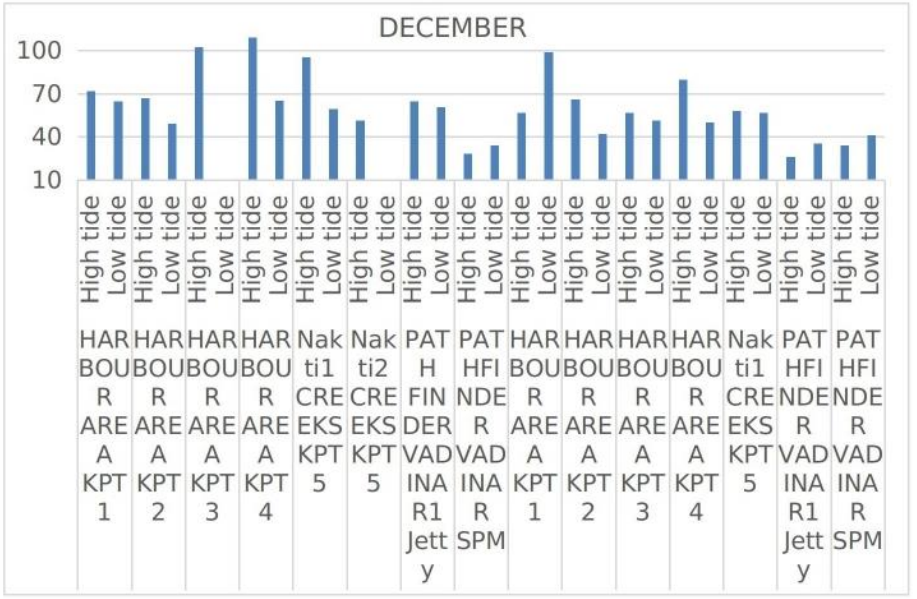

JULY
70
60
50
40
30
20
10
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
Nakti 2 CREEKS KPT5

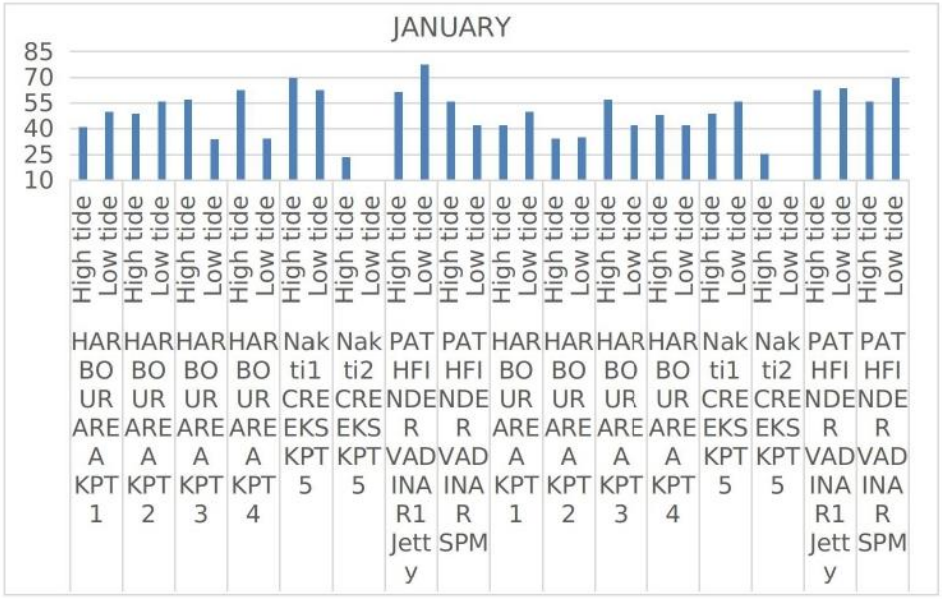

AUGUST
60
50
40
30
20
10
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
Nakti 2 CREEKS KPT5
Nakti1 CREEKS KPT5


SEPETEMBER
70
55
40
25
10
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
Nakti 2 CREEKS KPT5


OCTOBER
100
70
40
10
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti1 CREEKS KPT5
Nakti2 CREEKS KPT5
PATH FINDER VADINAR1 Jetty
PATH FINDER VADINAR SPM


NOVEMBER
110
85
60
35
10
High tide
Low tide
HARBOUR AREA KPT 1
HARBOUR AREA KPT 2
HARBOUR AREA KPT 3
HARBOUR AREA KPT 4
Nakti1 CREEKS KPT 5
Nakti2 CREEKS KPT 5
PATH FINDER VADINAR1 Jetty
PATH FINDER VADINAR SPM


DECEMBER
100
70
40
10
High tide
Low tide
HARBOUR AREA KPT 1
HARBOUR AREA KPT 2
HARBOUR AREA KPT 3
HARBOUR AREA KPT 4
Nakti1 CREEKS KPT 5
Nakti2 CREEKS KPT 5
PATH FINDER VADINAR1 Jetty
PATH FINDER VADINAR SPM


JANUARY
85
70
55
40
25
10
High tide
Low tide
HARBOUR AREA KPT 1
HARBOUR AREA KPT 2
HARBOUR AREA KPT 3
HARBOUR AREA KPT 4
Nakti1 CREEKS KPT 5
Nakti2 CREEKS KPT 5
PATHFINDER VADINAR1 Jetty
PATHFINDER VADINAR SPM

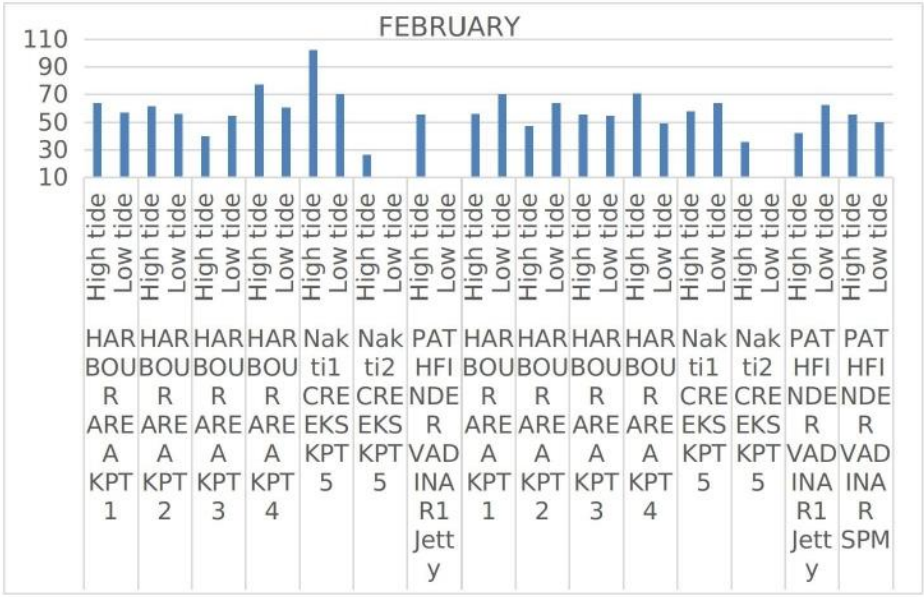
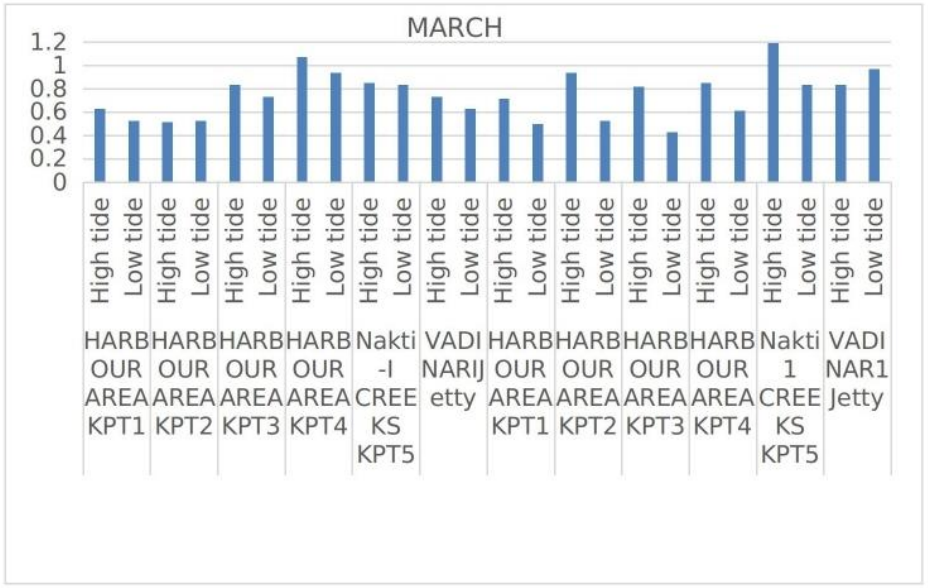
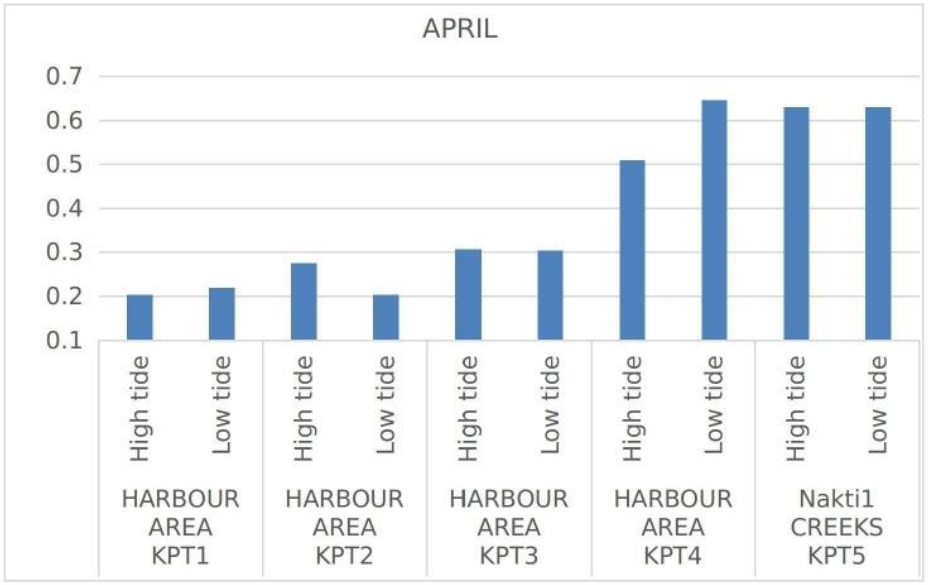
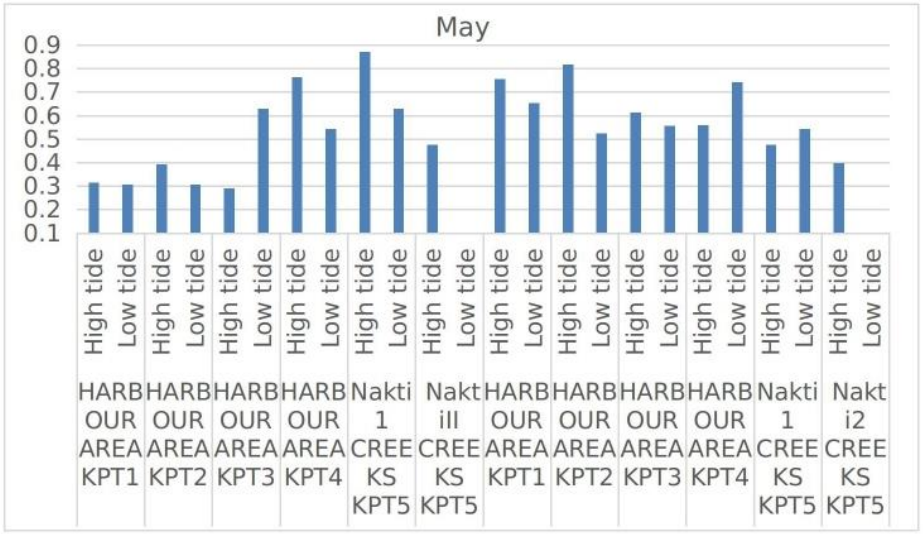
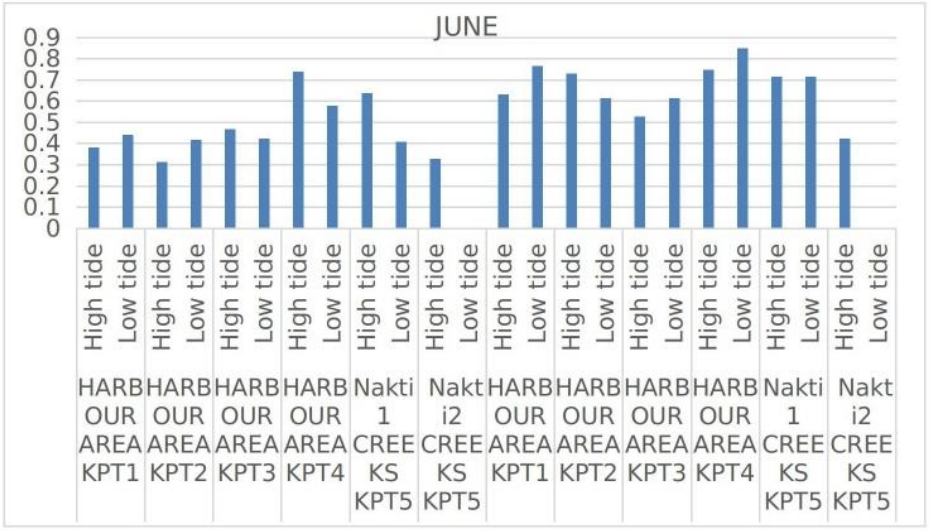

FEBRUARY
110
90
70
50
30
10
High tide
Low tide
HARBOUR AREA KPT 1
HARBOUR AREA KPT 2
HARBOUR AREA KPT 3
HARBOUR AREA KPT 4
Nakti1 CREEKS KPT 5
Nakti2 CREEKS KPT 5
PATHFINDER VADINAR1 Jetty
PATHFINDER VADINAR SPM

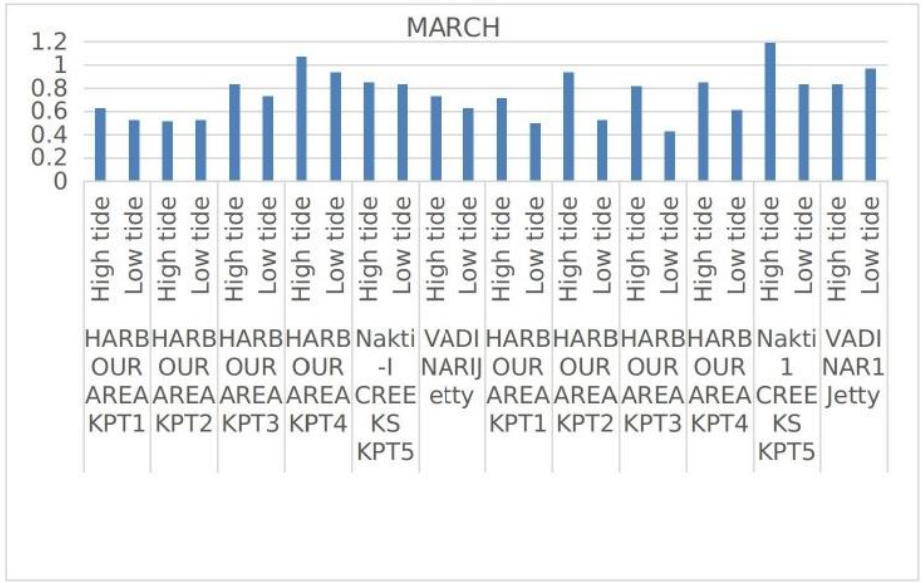
Fig 8. Annual average values of Chlorophyll-a in harbor waters of DPA

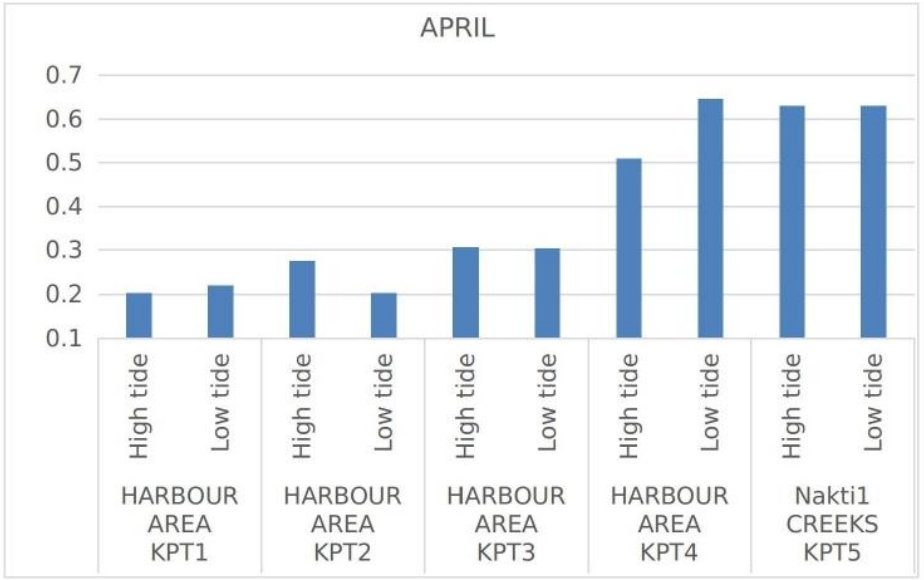


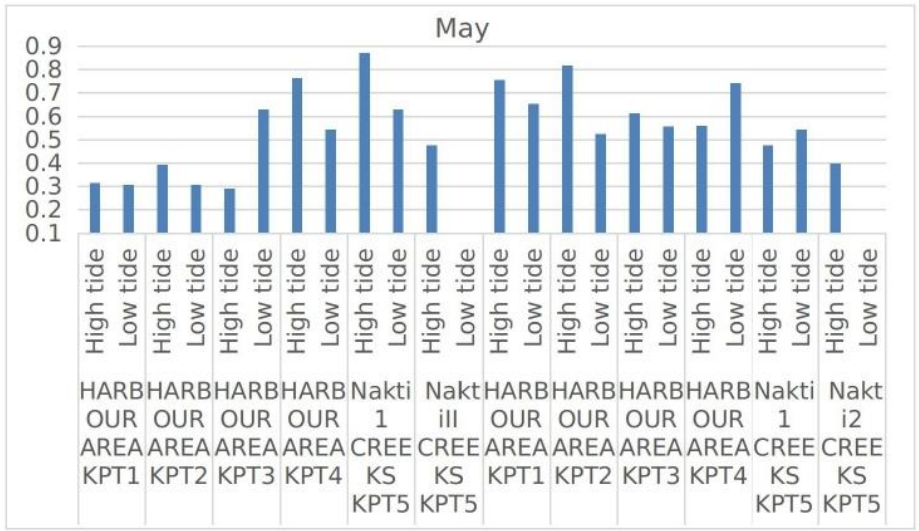


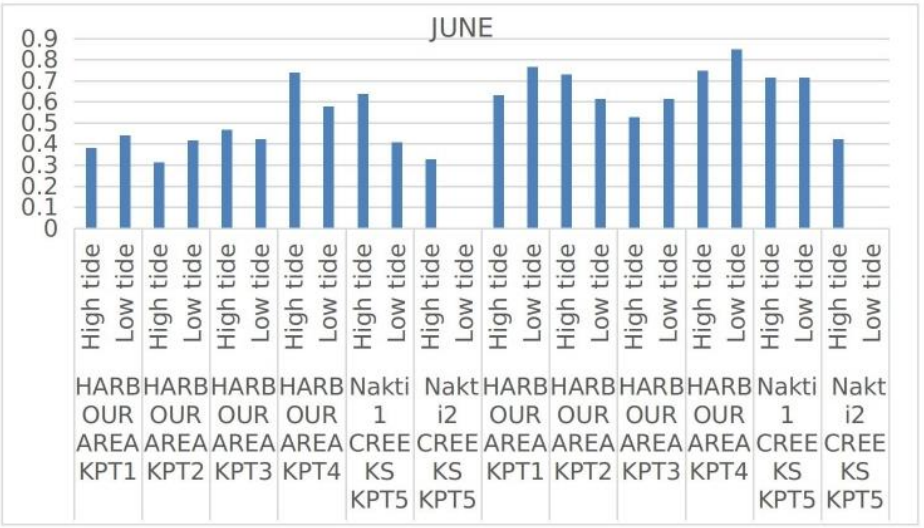


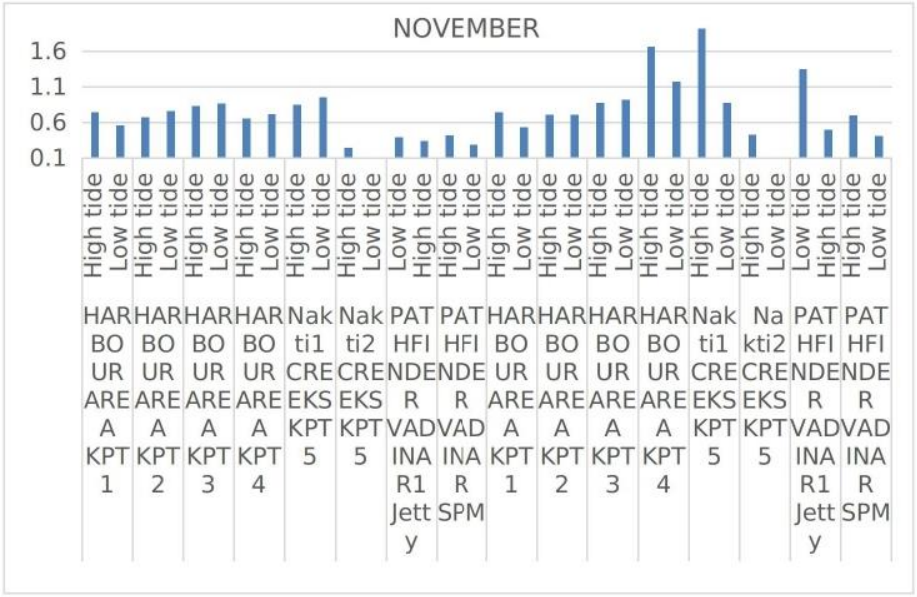


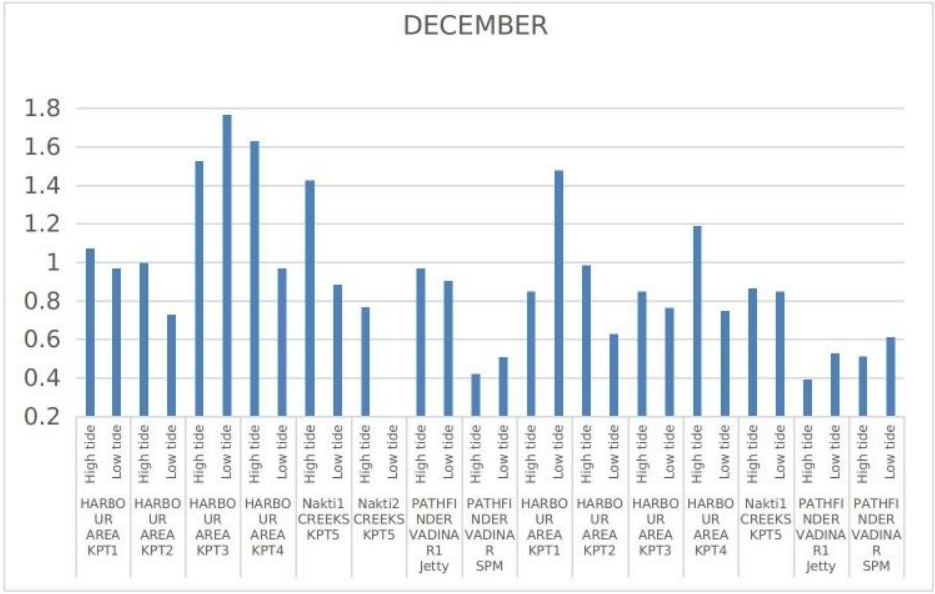

MARCH
1.2
1
0.8
0.6
0.4
0.2
0
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti -I CREEKS KPT5
VADINARIJetty
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
VADINAR1 Jetty

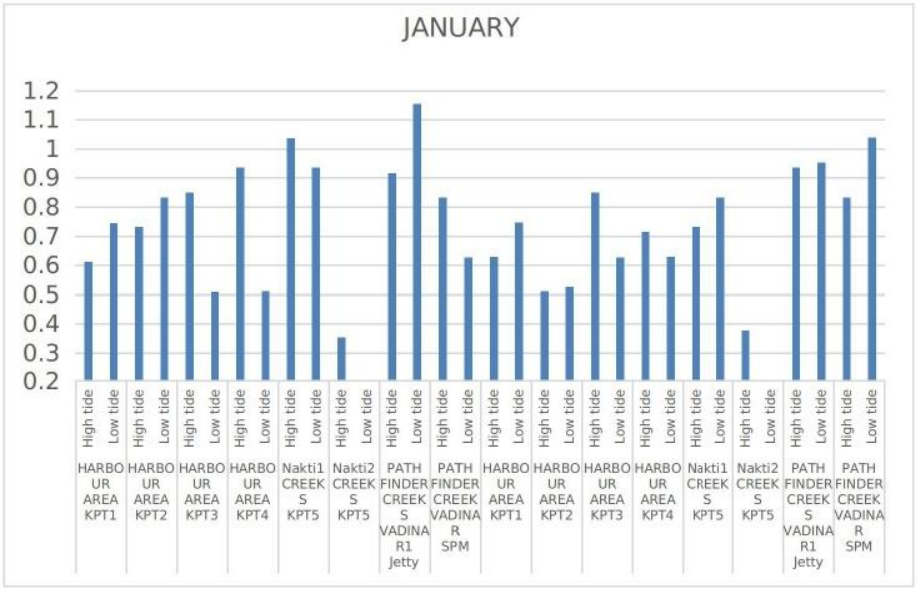

APRIL
0.7
0.6
0.5
0.4
0.3
0.2
0.1
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti1 CREEKS KPT5

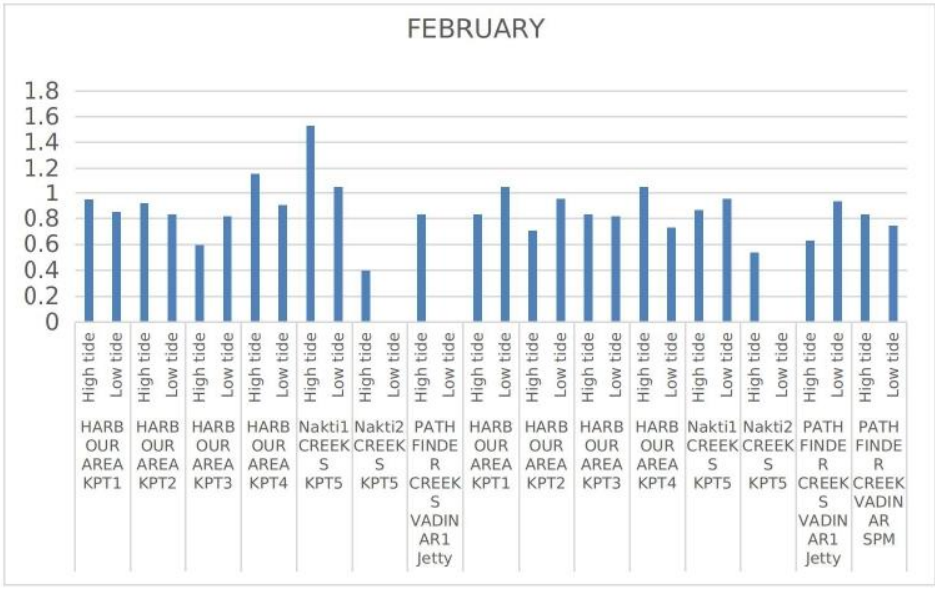

May
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
Nakti II CREEKS KPT5
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
Nakti i2 CREEKS KPT5


JUNE
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
Nakti i2 CREEKS KPT5
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti 1 CREEKS KPT5
Nakti i2 CREEKS KPT5


NOVEMBER
1.6
1.1
0.6
0.1
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti1 CREEKS KPT5
Nakti2 CREEKS KPT5
PATHFINDER VADINAR1 Jetty
PATHFINDER VADINAR SPM


DECEMBER
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti1 CREEKS KPT5
Nakti2 CREEKS KPT5
PATHFINDER VADINAR1 Jetty
PATHFINDER VADINAR SPM


JANUARY
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti1 CREEKS KPT5
Nakti2 CREEKS KPT5
PATHFINDER CREEKS VADINAR1 Jetty
PATHFINDER CREEK VADINAR SPM


FEBRUARY
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
High tide
Low tide
HARBOUR AREA KPT1
HARBOUR AREA KPT2
HARBOUR AREA KPT3
HARBOUR AREA KPT4
Nakti1 CREEKS KPT5
Nakti2 CREEKS KPT5
PATHFINDER CREEKS VADINAR1 Jetty
PATHFINDER CREEK VADINAR SPM

5.5 Phytoplankton and Zooplankton

The phytoplankton community of the sub surface water in the harbour and nearby creeks was represented by Blue green algae and diatoms during spring tide period and neap tide period. Diatoms were represented by 13 genera belonging to 3 classes, 9 orders and 12 families.

The Zooplankton community of the sub surface water in the harbour and nearby creeks is comparatively low and represented by mainly four groups Tintinids, Copepods, Foramiferans, and larval forms of Crustaceans.

However, Vadinar waters were observed to be rich in terms of diversity and abundance of phytoplankton and zooplanktons.

5.6 Noise Monitoring

Noise monitoring is carried out as per "Noise Pollution" (Regulation and Control) Rules, 2000. The results of noise monitoring results are annual mean of each location of Kandla and Vadinar Port (Table 13).

Table 13. Annual avg. of noise level at locations of Kandla (10 locations) and Vadinar (3locations) Port

Sr. No.	Locations	Day Time Average Noise Level(SPL) in dB(A)	Night Time Average Noise Level(SPL) in dB(A)
	Time	6 A.M.. And 10 P.M.	10 P.M. To 6 A.M.
1	Marine Bhavan	62.35	55.14
2	Nirman Building 1	58.41	53.72
3	Tuna Port	55.51	48.87
4	Main Gate North	62.58	57.54
5	West Gate I	66.68	60.97
6	Canteen Area	59.64	51.94
7	Main Road	65.06	56.39
8	ATM Building	67.37	58.00
9	Wharf /Jetty Area	69.50	64.12
10	Port & Custom Office	58.51	48.77
	Vadinar Port		
11	Nr. Vadinar Port Gate	59.25	52.99
12	Port Colony Vadinar	57.42	54.11
13	Nr. Vadinar Jetty	63.58	59.08

Observations:

- The Day Time Average Noise Level in all ten locations at Deendayal Port ranged from 55.51dB to 69.50dB
- The noise levels were within the day time limits (75 dB (A)) of industrial area.
- The Night Time Average Noise Level in all ten locations of Deendayal Port ranged from 48.77 dB to 64.12 dB and it was within the permissible limits of 70 dB A for the industrial area for the night time.
- The mean day time noise levels at Vadinar were 60.08dB and the mean noise levels at night hours was 55.39dB.

5.7 Soil Monitoring

Sampling and analysis of soil samples was under taken at six locations with in the study area (Deendayal Port and Vadinar Port). The soil monitoring locations are coastal soils and exhibits saline soil characteristics, typical of a muddy shore.

The texture of soil of all locations was Sandy Loam. The soil at all the locations is saline in nature. The mean pH of the soil at all the locations of Kandla was 8.08 pH unit suggesting it to be slightly to medium alkaline.

Electrical conductivity of the soil was high with low moisture and organic carbon indicating less productivity of the soil and its unsuitability for any agriculture activities.

Other metals like copper, nickel and lead were detected in traces or within permissible limits. The overall surrounding soils were found to be less in essential nutrients, hence less suitable for plant growth.

Table 14. Tuna port Soil Analysis Result

Sr.No	Month		March.21	April.21	May.21	June.21	July.21	Aug.21	Sept.21	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
	Parameter	Unit	Result											
1	Texture		Sandy Loam											
2	pH	-	8.71	9.02	8.38	7.3	8.56	8.6	8.58	8.62	8.42	8.2	8.2	8.59
3	Electrical conductivity	µs/cm	10600	8650	29500	33400	26800	23400	18400	16200	14070	10805	10805	2839
4	Moisture	%	21.72	22.9	14	21.45	23.66	20.42	21	17	18.17	6.06	6.06	22
5	Total Organic Carbon	%	1.62	2.25	0.94	0.31	0.16	0.18	0.48	0.52	0.2	0.49	0.49	0.96
6	Alkalinity	mg/kg	40.04	80.08	80.08	100.1	140.14	60.06	72.07	60.06	80.08	70.07	70.07	40.04
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	1244	2605.8	7896.2	6228.7	3908.6	4010	1506.6	1620	1956.8	709	709	3545
9	Sulphate	mg/kg	102	107.82	2502.08	2056.4	203	188	202	230	212	778.5	778.5	3891.18
10	Phosphorus	mg/kg	31.44	39.86	0.76	0.97	0.97	0.9	0.89	0.9	2.2	9.21	9.21	50.87
11	Potassium	mg/kg	1178	1028	1128	1161	779.4	786	386	396	539	143	143	192.3
12	Calcium	mg/kg	4843	228.4	320.64	641.3	2241	2341	1585	1620	5752	1315.7	1315.7	2466.12
13	Sodium	mg/kg	501	12092.4	11092.4	10821.6	144.29	160	228.46	230.32	200.4	152.3	152.3	284.57
14	Copper as Cu	mg/kg	52.2	62.2	10.2	11.21	42.6	32.2	52.2	17.4	14.9	35.9	35.9	26.2
15	Lead as Pb	mg/kg	5	4.8	5.4	3.1	4.2	3.8	4.9	6.4	5.8	13.4	13.4	7.5
16	Nickel as Ni	mg/kg	33.3	32.86	16.7	20.71	36.2	37.2	46.2	33.5	35.3	54.5	54.5	39.1
17	Zinc as Zn	mg/kg	56.2	58.26	22.6	32.26	58.6	59.36	66.2	55.9	40.6	89.7	89.7	58.2
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

Table15. IFFCO Plant Soil Analysis Result

Sr.No	Month		March.21	April.21	May.21	June.21	July.21	Aug.21	Sept.21	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
	Parameter	Unit	Result											
1	Texture		Sandy Loam											
2	pH	-	7.98	8.78	8.25	8.16	8.11	8.1	8.16	8.1	7.92	7.77	7.77	8.6
3	Electrical conductivity	µs/cm	28900	36200	44400	48500	23800	20420	25620	26820	16210	22960	22960	1442
4	Moisture	%	23.97	22.1	20.91	13.94	22.09	21.16	22.2	18.2	9.01	6.4	6.4	28.37
5	Total Organic Carbon	%	6.29	1.4	1.52	0.19	0.24	0.18	1.24	1.02	0.49	0.69	0.69	0.71
6	Alkalinity	mg/kg	40.04	60.06	60.06	140.14	140.14	140.04	36.04	80.44	120.12	26.03	26.03	40.04
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	2487	4510	6866.3	6032.5	4309.5	4324	6381	5380	4112.2	4325.9	4325.9	2481.5
9	Sulphate	mg/kg	204	311.7	804.5	75.86	177.9	179.2	196	198	279	3359.5	3359.5	1650.89
10	Phosphorus	mg/kg	21.25	52.7	2.45	1.41	0.8	0.86	0.92	0.82	1.89	10.56	10.56	5.33
11	Potassium	mg/kg	1715	747	762	592.2	644.4	656	820	810	327.4	199.8	199.8	155.01
12	Calcium	mg/kg	4710	468.9	661.32	561.12	3556.8	3618	3386	3400	4061.6	1116.4	1116.4	1500.32
13	Sodium	mg/kg	601	4840.2	5832.2	2992.8	128.22	130	741.5	722.2	488.98	360.72	360.72	432.86
14	Copper as Cu	mg/kg	60.8	52.5	26.2	27.22	61.2	58.2	78.2	38.8	29.5	29.9	29.9	35.6
15	Lead as Pb	mg/kg	1	1.52	8.5	6.2	3.2	3.8	5.6	7.9	6.4	9.3	9.3	10.8
16	Nickel as Ni	mg/kg	27.52	22.62	2020	1823	31.6	32.4	28	13.9	16.6	30.8	30.8	42.9
17	Zinc as Zn	mg/kg	43.2	59.2	89.1	72.62	39.25	38.32	41.6	91.9	104.8	153.2	153.2	102.7
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

Table 16. Khori Creek Soil Analysis Result

Sr.No	Month		March.21	April.21	May.21	June.21	July.21	Aug.21	Sept.21	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
	Parameter	Unit	Result											
1	Texture		Sandy Loam											
2	pH	-	8.75	8.82	8.13	8.36	8.38	8.42	8.46	8.75	8.44	8.53	8.53	8.68
3	Electrical conductivity	µs/cm	8500	16380	39900	21800	23700	23700	17880	16252	13680	22260	22260	1950
4	Moisture	%	19.04	21.2	28.1	18.82	24.41	23.22	24.1	19.1	21.39	9.02	9.02	21
5	Total Organic Carbon	%	1.46	2.2	1.7	0.26	0.32	0.25	0.48	0.62	0.2	0.61	0.61	0.98
6	Alkalinity	mg/kg	60.06	60.06	70.05	80.08	100.1	140.04	190.19	140.2	60.06	52.05	52.05	40.04
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	1144	3658.1	7160.6	2550.3	6114	5982	1701	1820	1800.9	3970.4	3970.4	2836
9	Sulphate	mg/kg	120	129.05	356.6	292	113.8	110	112	120	93.3	315.3	315.3	1292.27
10	Phosphorus	mg/kg	17.74	34.55	7.79	0.79	1.24	1.04	1.05	0.96	1.41	6.92	6.92	8.87
11	Potassium	mg/kg	903	698.4	578.4	700.2	1135.8	1162	345	366	409.2	139	139	160.36
12	Calcium	mg/kg	4235	284.6	460.92	701.4	3981.6	4220	2303	2122	3954	1234.8	1234.8	1839.79
13	Sodium	mg/kg	200	7437.6	6336.6	3164.4	168.3	170	248.5	252	252	144.29	144.29	232.46
14	Copper as Cu	mg/kg	40.6	38.6	29.4	28.2	38.2	42.2	46.2	21.2	9.8	30.8	30.8	31.8
15	Lead as Pb	mg/kg	4.2	3.62	31	23	3.6	3.6	3.2	29.1	3.5	11.1	11.1	5.4
16	Nickel as Ni	mg/kg	31.62	29.62	9	7.8	39.4	41.2	33.2	34.5	23.5	44.1	44.1	42
17	Zinc as Zn	mg/kg	46	42.62	95.8	65.9	52.4	53.4	68	77.9	25.4	76.8	76.8	76.7
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

Table 17. Nakti Creek Soil Analysis Result

Sr.No	Month		March.21	April.21	May.21	June.21	July.21	Aug.21	Sept.21	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
	Parameter	Unit	Result											
1	Texture		Sandy Loam											
2	pH	-	8.39	8.68	7.91	8.26	8.33	8.3	8.26	8.33	8.23	8.02	8.02	8.47
3	Electrical conductivity	µs/cm	13340	4790	38200	37200	16260	17200	16520	17520	9240	14090	14090	2848
4	Moisture	%	22.65	4.13	26.2	14.26	23.65	20.12	18.8	20.22	21.08	23.84	23.84	24.88
5	Total Organic Carbon	%	1.61	0.7	1.58	0.24	0.1	0.11	3.93	3.1	0.72	0.87	0.87	0.84
6	Alkalinity	mg/kg	40.04	80.08	70.05	140.14	80.08	60.06	90.09	80.44	100.1	44.04	44.04	40.04
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	1386	4359.7	9416.7	7160.6	3959	4001	1878.9	2078	514.7	3048.7	3048.7	3190.5
9	Sulphate	mg/kg	214	299.4	3966.5	87.84	93.8	100	112	118	165.1	574.7	574.7	4950.89
10	Phosphorus	mg/kg	35.87	50.04	1.66	1.59	1.77	1.62	1.1	1.02	2.15	4.76	4.76	8.5
11	Potassium	mg/kg	743	865.8	755.8	765	766.8	780	422	460	667.6	121.9	121.9	178.48
12	Calcium	mg/kg	3453	493	821.64	661.32	3038.4	3122	1990	2012	1477	1426.3	1426.3	2450.29
13	Sodium	mg/kg	501	7165.8	6355.8	3736.8	224.4	220	468.94	470.42	470.42	192.38	192.38	492.9
14	Copper as Cu	mg/kg	21.2	19.2	33.7	31.78	22.6	23.4	33.8	35.1	27.6	25.8	25.8	25
15	Lead as Pb	mg/kg	6.8	2.8	15.3	11.4	3.8	4.1	4.8	7.6	8.2	10.5	10.5	7.6
16	Nickel as Ni	mg/kg	22.02	19.22	25.4	15.1	22.6	24.5	26.1	13.2	37.7	39.6	39.6	31.9
17	Zinc as Zn	mg/kg	62	59.8	87.3	77.21	46.6	48.5	49.55	81.9	55.2	59.1	59.1	48.1
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

Table 18. Vadinar DPA Admin Site Soil Analysis Result

Sr.No	Month		March.21	April.21	May.21	June.21	July.21	Aug.21	Sept.21	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
	Parameter	Unit	Result											
1	Texture		Sandy Loam											
2	pH	-	8.46	8.86	8.76	7.27	8.12	8.09	8.02	8.1	7.79	8.07	8.07	7.64
3	Electrical conductivity	µs/cm	585	439	260	511	509	510	523	560	387	1994	1994	1417
4	Moisture	%	7.16	4.62	7.26	6.28	9.44	9.04	8.66	7.26	3.46	4.22	4.22	8.49
5	Total Organic Carbon	%	2.53	0.87	1.16	0.15	0.2	0.21	0.18	0.12	0.85	1.16	1.16	0.32
6	Alkalinity	mg/kg	60.06	40.04	60.06	60.06	100.1	100.1	60.06	60.06	60.06	42.04	42.04	60.06
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	280	90.2	29.43	68.66	39.3	42.2	52	62	21.7	567.2	567.2	141.8
9	Sulphate	mg/kg	330	268	23.2	14.37	13.4	14	12	16	44.7	52.7	52.7	250.38
10	Phosphorus	mg/kg	2.83	5.85	8.5	0.97	0.8	0.78	0.78	0.8	BQL	15.06	15.06	1..88
11	Potassium	mg/kg	131	212.8	302.8	626.4	129.6	130	110	120	70.4	73	73	30.01
12	Calcium	mg/kg	56	244.5	1703.4	124.2	1220	1224	990	910	72.8	65.1	65.1	153.5
13	Sodium	mg/kg	1303	236	246	2116.8	104.2	110	118	110	436.87	460.92	460.92	837.67
14	Copper as Cu	mg/kg	16.6	14.5	80.5	82.66	16.2	17.4	18.6	16.6	88.4	54	54	18.3
15	Lead as Pb	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	3.2	4.8	BQL	BQL	BQL	BQL
16	Nickel as Ni	mg/kg	26.42	18.26	35.3	25.46	18.3	19.3	18.2	13.2	33.8	42.1	42.1	60.2
17	Zinc as Zn	mg/kg	40	38.3	33.2	23.46	46.8	49.2	24	28	66	51	51	84.6
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

Table 19. Vadinar DPA Colony Soil Analysis Result

Sr.No	Month		March.21	April.21	May.21	June.21	July.21	Aug.21	Sept.21	Oct.21	Nov.21	Dec.21	Jan.22	Feb.22
	Parameter	Unit	Result											
1	Texture		Sandy Loam											
2	pH	-	8.82	8.49	8.85	7.82	8.42	8.32	8.56	8.22	8.43	7.84	7.84	7.11
3	Electrical conductivity	µs/cm	875	634	513	464	419	400	420	480	314	490	490	299.6
4	Moisture	%	9.67	6.51	6.35	4.56	7.59	8.22	9.02	8.22	3.95	2.86	2.86	3.96
5	Total Organic Carbon	%	2.42	1.04	1.71	0.11	0.12	0.16	0.21	0.2	0.43	1.24	1.24	0.67
6	Alkalinity	mg/kg	60.06	60.06	70.05	100.1	60.06	80.04	100.1	80.44	80.08	40.04	40.04	40.04
7	Total Nitrogen	%	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	BQL	BQL	BQL	BQL
8	Chloride	mg/kg	290	120.3	40.09	78.47	68.7	67.8	67.8	77	113.4	283.6	283.6	70.9
9	Sulphate	mg/kg	210	424	4.02	13.58	15.5	16.2	18	20	27.7	14.7	14.7	BQL
10	Phosphorus	mg/kg	3.36	7.79	7.35	0.97	0.97	0.88	0.86	0.72	1.74	7.06	7.06	BQL
11	Potassium	mg/kg	103	140	152	876.4	180	182	172	160	62	17	17	28.87
12	Calcium	mg/kg	94	196.4	1463	172.3	1445.4	1400	810	888	65.9	15.9	15.9	20.32
13	Sodium	mg/kg	501	126	166	2565	56.11	68	72	82	256.51	328.66	328.66	472.94
14	Copper as Cu	mg/kg	17.4	18.2	71.6	72.42	23	23	28	17	48.4	77	77	62.3
15	Lead as Pb	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	1.1	2	4.2	6.7	6.7	BQL
16	Nickel as Ni	mg/kg	22.1	21.22	31.8	27.73	21.2	20.4	16.2	12.2	27.3	36.7	36.7	33.3
17	Zinc as Zn	mg/kg	36	35.36	33.5	43.2	38.2	40.4	38.5	36.22	30.5	98.9	98.9	44
18	Cadmium as Cd	mg/kg	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL	BQL

pH

The pH was found at tuna port from 7.3 to 9.02, at IFFCO plant from 7.77 to 8.78, at Khori creek from 8.13 to 8.82, at Nakti creek from 7.91 to 6.68, at Vadinar DPA admin site from 7.7 to 8.86 and 7.11 to 8.85 at Vadinar DPA colony.

Moisture

The moisture was found at tuna port 6.06 to 23.66%, at IFFCO plant 6.4 to 28.37%, at Khori creek 9.02 to 28.1%, at Nakti creek 4.13 to 26.2%, at Vadinar DPA admin site 3.46 to 9.44%, and 2.86 to 9.67% at Vadinar DPA colony.

Electrical conductivity

The Electrical Conductivity was found at tuna port 2839 to 33400 µs/cm, at IFFCO plant 1442 to 48500 µs/cm, at Khori creek 1950 to 39900 µs/cm, at Nakti creek 2848 to 38200 µs/cm, at Vadinar DPA admin site260 to 1994 µs/cm, and 299.6 to 875 µs/cm at Vadinar DPA colony.

Total Organic Carbon

The total organic Carbon was found at tuna port 0.16 to 2.25%, at IFFCO plant 0.18 to 6.29%, at Khori creek 0.2 to 2.2%, at Nakti creek 0.1 to 3.93%, at Vadinar DPA admin site 0.12 to 2.53%, and 0.11 to 2.42% at Vadinar DPA colony.

Texture

The texture was found sandy loam for all location.

Cadmium as Cd

The Cadmium was found below quantification limit for all location.

Zinc as Zn

The zink as Zn was found at tuna port 22.6 to 89.7 mg/kg , at IFFCO plant 38.32 to 153.2 mg/kg , at Khori creek25.4 to 95.8 mg/kg, at Nakti creek 46.6 to 87.3 mg/kg ,at Vadinar DPA admin site 23.46 to 84.6 mg/kg, and 30.5 to 98.9 mg/kg at Vadinar DPA colony.

5.8 Sewage Treatment Monitoring

This involve safe collection of waste water (spent/used water) from wash areas, bathroom, cargo operational units, etc., waste from toilets of various buildings and its conveyance to the treatment plant and final disposal inconformity with the requirement and guide lines of State Pollution Control Board and other statutory bodies.

The waste water is let into sewer network (network of pipes and manholes) and let by gravity and intermittent pumping stations to the main Sewage Treatment Plant (STP).

The Sewage Treatment Monitoring is carried out at Deendayal Port Colony (Gopalpuri), Vadinar Port and Deendayal Port.

STP at Gopalpuri Port Colony

Gopalpuri STP is working properly and overall performance of the existing STP was found satisfactory. The removal efficiency of BOD, TSS was in order. The individual units were also performing well and their removal efficiency is satisfactory. Thus with the sample tested in laboratory the plant is working satisfactory and the individual units are also working well.

STP at Kandla Port

STP with improved capacity of 1.5 MLD at Deendayal Port is operational. The newly installed sewage treatment plant has 1500 cum/day fluidized media reactor based STP to treat domestic waste water generated from the campus and treated water will be utilized for gardening and plantation purpose.

Table 20. Gopalpuri STP Outlet Annual Results

Sr. No.	Parameter	Unit	1st Quarter Mean	2nd Quarter Mean	3rd Quarter Mean	Value (Annual Avg.)	GPCB Prescribed Limit
1	pH	-	7.21	7.36	7.32	7.30	6.5 - 8.5
2	Total Suspended Solids	mg/l	42.94	83.3	105.41	77.22	100
3	Residual Chlorine	mg/l	<0.5	<0.5	<0.5	<0.5	No Limit
4	Chemical Oxygen Demand	mg/l	85.19	96.43	111.01	97.54	100
5	Biochemical Oxygen Demand	mg/l	19.69	25.56	32.87	26.04	30

Table 21. KPT STP Outlet Annual Results

Sr. No.	Parameter	Unit	1st Quarter Mean	2nd Quarter Mean	3rd Quarter Mean	Value (Annual Avg.)	GPCB Prescribed Limit
1	pH	-	7.15	7.37	7.40	7.31	6.5 - 8.5
2	Total Suspended Solids	mg/l	50.21	81.04	100.72	77.32	100
3	Residual Chlorine	mg/l	<0.5	<0.5	<0.5	<0.5	No Limit
4	Chemical Oxygen Demand	mg/l	62.58	90.53	110.26	87.79	100
5	Biochemical Oxygen Demand	mg/l	15.87	24.68	27.25	22.60	30

Table 22. Vadinar STP Outlet Annual Results

Sr. No.	Parameter	Unit	1st Quarter Mean	2nd Quarter Mean	3rd Quarter Mean	Value (Annual Avg.)	GPCB Prescribed Limit
1	pH	-	STP not Working	7.25	7.34	7.30	6.5 - 8.5
2	Total Suspended Solids	mg/l		46.68	55.44	51.06	100
3	Residual Chlorine	mg/l		<0.5	<0.5	<0.5	No Limit
4	Chemical Oxygen Demand	mg/l		62.56	81.72	72.14	100
5	Biochemical Oxygen Demand	mg/l		16.62	22.37	19.5	30

The GPCB specification for pH, TSS, Residual Chlorine , COD and BOD for STP outlet are 6.5 to 8.5 , 100 mg/l, 0.5 mg/l, 100 mg/l and 30 mg/l respectively. The average values for pH at all locations from 7.30 to 7.31, The average values for Total Suspended Solids at all locations from 51.06 to 77.32 mg/l , The average values for COD at all locations from 72.14 to 97.54 mg/l, The average values for BOD at all locations from 19.5 to 26.04 mg/l, Residual Chlorine were found below detectable limit. All parameters for STP outlet are within limit.

5.9 Weather

The data collected from Automatic weather station have been installed and other secondary sources to represent the metrological conditions of the project area has been reviewed and presented below for various attributes such as Temperature, Wind velocity, Relative Humidity, solar radiation, wind direction, Air pressure and Heat index.

Table 23. Weather Results

MONTH		Temperature (°C)	Solar Radiation (w/m2)	Relative Humidity (%)	Wind Velocity (m/s)	Wind Direction	Air pressure (hpa)	Heat index (°C)
March.21	MIN	28.4	166.7	24.7	1.9	North West	1013.2	29.0
	MAX	36.2	292.3	93.0	10.6		1017.3	43.0
April.21	MIN	31.5	134.4	57.0	1.9	South East	1009.0	24.2
	MAX	42.4	576.6	94.0	9.9		1014.1	48.0
May.21	MIN	32.7	157.7	60.2	2.0	South East	1005.3	38.1
	MAX	37.3	383.3	89.0	8.1		1010.6	47.0
June.21	MIN	29.8	208.3	66.0	2.7	South West	1004.9	35.2
	MAX	34.1	654.8	84.0	13.0		1008.9	44.0
July.21	MIN	28.5	158.4	71.2	2.7	South West	1002.4	36.1
	MAX	32.1	751.7	89.0	13.0		1004.1	43.0
Aug.21	MIN	34.1	232.4	73.0	3.0	South West	1001.2	34.7
	MAX	26.1	682.8	90.0	9.7		1008.3	42.0
Sept.21	MIN	26.7	136.0	83.5	1.9	South West	1002.3	33.5
	MAX	36.2	808.9	98.0	12.0		1010.1	49.0
Oct.21	MIN	26.5	252.2	60.0	1.3	South North	1009.3	33.8
	MAX	38.6	746.6	94.0	8.1		1016.5	55.0
Nov.21	MIN	26.5	252.2	60.0	1.3	South North	1009.3	33.8
	MAX	38.6	746.6	94.0	8.1		1016.5	55.0
Dec.21	MIN	10.5	109.9	39.0	1.7	North West	1018.0	27.0
	MAX	31.8	534.3	93.0	4.4		1021.2	30.0
Jan.22	MIN	12.6	115.3	47.2	1.2	North West	1015.9	27.2
	MAX	30.8	530.7	96.0	5.8		1021.9	32.0
Feb.22	MIN	12.6	119.2	45.6	1.3	North West	1006.3	27.8
	MAX	29.2	530.7	98.0	9.6		1022.0	33.0

Temperature

The min temperature for Deendayal Port was 10.5 °C on December. The maximum temperature was recorded 42.4°C on April.

Solar Radiation

The min Solar Radiation was recorded 109.9 w/m2 on December . The maximum solar radiation recorded in the September was 808.9 w/m2.

Relative Humidity

The min Relative humidity was recorded 24.7 % on March and maximum Relative humidity recorded was 98.0 % on February.

Wind Velocity and Wind Direction

The min wind velocity was recorded 1.2 m/s on January. Maximum wind velocity recorded was

13 m/s on June. The wind direction was mostly North West and south west throughout the year.

Air pressure

The min Air pressure was recorded 1001.2 hpa in August. Maximum Air pressure recorded was 1022 hpa on February.

Heat index

The min heat index was recorded 24.22 °C in April. Maximum heat index recorded was 55 °C on November.

6.0 Conclusion

A. Ambient Air

Ambient Air Quality monitoring results for the Second year shows TSPM, PM_{10} and $PM_{2.5}$ concentrations of the ambient air were above the permissible limits as per the National Ambient Air Quality Standards (NAAQS2019). The concentration of $PM_{10}$and $PM_{2.5}$was above the permissible limit at Coal Storage Area, Marine Bhavan and occasionally at Oil Jetty Area and ,Kandla Estate Office, Gopalpuri Hospital Tuna Port area at some occasions.

The concentration of PM_{10} was within the permissible limit at Vadinar locations except Signal Building in November and Vadinar Colony in October & November above the permissible limit.

Deendayal Port has handled 117.5 MMT to 127 MMT of dry cargo in 2021-22. This huge volume of dry cargo handled at DPA along with high winds in coastal areas causes slight rise in the Ambient Air Quality near coal berth.

Very high volume of dry cargo is being handled (especially coal) at berth no. 7, 8 and 9. Besides handling of coal, thousands of vehicles laded with coal and other dry cargo criss-cross the port/harbor roads causing the rise in suspended particles in the air.

B. Drinking Water Quality

The results of the current year monitoring suggest that, the drinking water parameters of all the locations (18 at Kandla and 2 at Vadinar Port) were found within the permissible limits as per the BIS 10500 (2012) drinking water specification.

C. Noise Quality

The day and night time noise quality was found within the permissible limits of the Noise Pollution (regulation and control) rules, 2000. The Day Time and Night Time Average Noise Level (SPL) in all ten locations at Deendayal

Port were within the permissible limits of 75 dB A (for day time) and 70 dB A (for the night time)for an industrial area.

D. Marine Water Quality

The marine water samples were collected from the harbour area and the creek area and were monitored for 28 different parameters. The mean DO levels of DPA waters ranged from 4.9 mg/L to 6.0 mg/L (mean = 5.6 mg/L), which is normal for marine waters of ports and harbors.

Evaluation of the Phytoplankton and Zooplankton population in DPA harbour area and within the immediate surroundings of the port suggests that the Kandla waters harbours low to moderate diversity and abundance of phytoplankton and zooplanktons.

E. Soil

The soil samples were collected from six locations. The 4 locations of Kandla (Tuna port, Khori Creek, Nakti creek, IFFCO plant) and 2 locations of Vadinar (Vadinar DPA Admin site and Vadinar DPA

colony). Soil samples were collected for monitored 18 different parameter.

The pH was found at tuna port from 7.11 to 9.02 Vadinar DPT colony and Tuna Port. Cadmium was found at all soil sample is BQL. (Below quantification limit).

F. Sewage Treatment Plant

Gopalpuri STP is working properly and overall performance of the existing STP was found satisfactory.

A new STP with improved capacity of 1.5 MLD at Deendayal Port is operational which is working as per the standards of CPCB/GPCB.

At Vadinar Port, a new STP was operational which is working as per the standards of CPCB/GPCB.

6.1. Steps taken by Deendayal Port to improve Environment

- "Safety Week" is being celebrated in Kandla Port by demonstrating mock drill, fire fighting, emergency preparedness, health checkup program etc.
- Regular Safety training and mock drill are being carried out and awareness is being created by lectures among the workers of the Port.
- Personal Protective Equipments (PPE like ear plugs, helmets, safety suits, etc are being used during Port Operational work.
- Sewage generated at Port Area as well as in Port colonies is being properly treated through Sewage Treatment Plants at outside Port area at Kandla and Port colony at Gopalpuri. However, DPA is planning to construct a new STP with the latest technology as the existing one is very old.
- Deendayal Port Authority have planted about one lakhs trees in road side dividers, colony areas at Kandla and Gopalpuri, in green belt area of Gandhidham & Adipur Township, Sewage Treatment Plants at Gopalpuri & Kandla and some green belt development plans initiated at different locations in Town ship areas.
- Deendayal Port Authority also carries out Environmental Audit through recognized till 2016 from environmental auditor (Schedule) of Gujarat Pollution Control Board from the year 2010 .Three Audit Reports for the year 2010, 2011 and 2012 were already submitted to GPCB as per the norms.
- DPA planted Mangroves in an area of 1500 hectares from 2005 to 2021: Mangrove Plantation Plan carried out in following phases;

1)	Year2005-06–20 hectares
2)	Year2008-09-50 hectares
3)	Year2010-11–100 hectares
4)	Year2011-12–200 hectares
5)	Year2012-13–300 hectares
6)	Year2013-14-330 hectares
7)	Year2015-17-300 hectares
8)	Year 2018- 20 - 100 hectares
9)	Year2020- 21-100 hectares
Total	**1500hectares**

- Water sprinkling on coal is regularly done to prevent coal dust pollution in the port area.

- To control the dust from bulk cargo like fertilizer, coal, sulphur, etc, the Port-users are encouraged to use hopper during discharge from vessels.
- Annual maintenance contracts have been awarded for garbage collection, cleaning of buildings and roads.
- Deendayal Port Authority is maintaining the records for collection and disposal of Solid Wastes generated from Port area, Residential area and Office Buildings.
- Deendayal Port Authority is regularly submitting the Hazardous Waste Statement in From – IV and Form V in environment sheet every financial year to the Gujarat Pollution Control Board, Gandhinagar.
- Are port on collection and disposal of the wastes from ships is submitted it to GPCB recognized body on regular basis.
- All trucks before leaving the storage yards are covered with tarpaulin and not over loaded as well as there is no spillage during transportation.
- Sewage generated at Port area and Port colonies is being properly treated through Sewage Treatment Plants outside Port area at Kandla and Port Colony at Gopalpuri.
- Deendayal Port has engaged CPCB/GPCB authorized agencies for the disposal of Hazardous waste (spent / used oil from ships) as per the Hazardous Wastes (Management and Handling) Rules.
- Pollution under Control (PUC) Certificate is mandatory for vehicles and equipments operating in the Port.
- Deendayal Port has awarded several projects to M/s Gujarat Institute of Desert Ecology(GUIDE) ,Bhuj relating to monitoring of Marine environment viz;

  - Regular Monitoring of Marine Ecology of Kandla Port Area since 2017-18
  - Creek Bathymetry
  - Analysis of dredging contaminants
  - Strategic Regional Impact Assessment Studies
  - Assessment and Monitoring of Mangrove Plantation in 1500 Ha area.
  - Biodiversity Action Plan for DPA and its surrounding areas

6.1.1 ISO 14001:2015 - Environmental Management System of Deendayal Port Authority

Deendayal port has appointed QMS India Ltd. As for Continual Improvement of ISO 14001:2015 - Environmental Management System with following scope;

- Review of environmental aspect-impacts,
- Review and monitoring of legal requirement
- Review and monitoring of emergency preparedness
- Management review by every six months
- Training of internal auditors and EMC members
- Active participation during external audit.

6.1.2 Green Ports Initiative

Deendayal Port is committed to sustainable development and adequate measures are being taken to maintain the Environmental well-being of the Port and its surrounding environs. Weighing in the environmental perspective for sustained growth, the Ministry of Shipping had started "Project Green Ports" which will help in making the Major Ports across India cleaner and greener. 'Project Green Ports" will have two verticals-one is "Green Ports Initiatives" related to environmental issues and second is **"Swachh Bharat Abhiyaan."**

The Green Port Initiatives include twelve initiatives such as preparation and monitoring plan, acquiring equipments required for monitoring environmental pollution, acquiring dust suppression system, setting up of sewage/waste water treatment plants/ garbage disposal plant, setting up Green Cover area, projects for energy generation from renewable energy sources, completion of shortfalls of Oil Spill Response (OSR) facilities (Tier-I), prohibition of disposal of almost all kind of garbage at sea, improving the quality of harbor wastes etc.

Deendayal port has also appointed GEMI as an Advisor for "Making Deendayal Port a Green Port- Intended Sustainable Development under the Green Port Initiatives.

- Deendayal Port has also signed MoU with Gujarat Forest Department in August 2019 for Green Belt Development in an area of 31.942 Ha of land owned by Deendayal Port Authority. The plantation is being carried out by the Social Forestry division of Kachchh.

7. Suggestions

7.1 Ambient Air Quality

PM_{10} values at Coal storage area, Marine Bhavan, Oil Jetty and Tuna Port were occasionally found above the permissible standards and $PM_{2.5}$ was occasionally found above permissible limits at Coal storage area. (100µg/m^3 for PM_{10}& 60 µg/m^3 for $PM_{2.5}$). The principle reason for higher PM_{10}values at Coal Storage and Marine Bhavan are bulk handling of coal, other dry cargo and heavy traffic of transport vehicles.

7.1.1 Sprinkling

- Heavy duty Water sprinklers should be used inside port where large scale dry cargo is handled.
- Mobile air Sprinklers should also be procured, which suppresses the fine dust from blowing during handling of dry cargo.

7.1.2 Enclosed conveyors

- Port users should be motivated to use enclosed conveyors which prevents secondary dust emissions due to wind in the port area.

7.1.3 Mechanized handling systems

- This involves using screw type un loaders which results in much less spillage and loss of material as compared to bucket un loaders. Mechanized systems can also use pre-packed containers for ease and pollution free loading unloading. Diligent use of various systems can keep the pollution due to ports at minimum level.

- Besides these prevention measures, Gujarat Pollution Control Board (GPCB) has also issued guidelines for handling of Coal. Guidelines for Coal Transport, Storage and Handling given below should be strictly followed; (*https://gpcb.gujarat.gov.in/uploads/coal-handling-guidelines1.pdf)*

7.2 GPCB Guidelines for Coal handling units:

(A) Location criteria

- In case of coal handling activities at the ports and jetties or extension thereof, the distance and land use criteria may be relaxed and compensated by advanced/sophisticated pollution control measures and mechanization & thick plantation, however all such ports and jetties, where coal handling is

carried out, shall provide closed conveyor belt and mechanization for handling of coal.

(B) Storage and handling criteria

- Coal handling unit/Agency shall store coal in such a way that coal heap should not be higher than 5 meter and clear distance between two adjoining heaps at G.L. should be 5 meters, so that in case of fire, approach is available.
- There should be mechanized loading/unloading system from the loading /unloading area to the stacking yards and in to the vehicles.
- Coal handling unit/Agency shall take all corrective steps to resolve the issue of air pollution at permitted coal storage/handling area where coal is being stored.

(C) Transport criteria

- Coal handling unit/Agency shall ensure that all trucks before leaving the storage yard shall be showered with water with adequate system, Shall be covered with tarpaulin or any other effective measure/device completely and also that trucks are not overloaded as well as there is no spillage during transportation.
- The vehicle carrying the coal should not be overloaded by raising the height of carriage. Weigh scale shall be provided within the loading area only and port/coal park authority shall ensure that no over loading is done.
- The top of the vehicle should be covered with fixed cover to avoid spillage or dusting of coal.

(D) Pollution prevention criteria

- Coal handling unit/Agency shall provide paved approach with adequate traffic carrying capacity
- Coal handling unit/Agency shall construct compound wall all along periphery of the premises with minimum 9 meters height
- Continuous water sprinkling shall be carried out on the top of the heap at regular intervals to prevent dusting, fire & smoke. To prevent fugitive emission during loading/unloading, fixed pipe network with sufficient water storage and pump shall be installed. Water sprinkling shall be carried out at each and every stage of handling to avoid generation of coal dust or other dust within premises
- Coal handling unit/Agency shall ensure regular sweeping of coal dust from internal and main road and also ensure that there is adequate space for free movement of vehicles.
- The following adequate Air Pollution Control Measures shall be installed and to be operated efficiently.
- Construction of effective wind breaking wall suitable to local condition to prevent the suspension of particles from the heaps.
- Construction of metal road & RCC Pucca flooring in the plot area/godown etc.
- System for regular cleaning and wetting of the floor area within the premises.
- Entire coal storage area/godown should be covered with permanent weather shed roofing and side walls i.e., in closed shed, in case of crushing/sieving/grading activity is carried out (i.e. G. I. Sheet)along with adequate additional APCM should be installed. Coal handling unit/Agency shall carryout three rows plantation with tall growing tress all along the periphery of the coal handling premises, inside & outside of the premises along with road.

- Proper drainage system shall be provided in all coal storage area so that water drained from sprinkling & runoff is collected at a common tank and can be reused after screening through the coal slit or any other effective treatment system.
- All the engineering control measures and state of art technology including covered conveyer belts, mechanized loading and unloading, provision of silo etc. shall be provided in addition to the measurers commended in the environmental guidelines for curbing the pollution.

(E) Safety requirement

- Coal handling unit/Agency shall provide adequate fire-fighting measure to avoid any fire or related hazards including adequate water storage facility, and the premises shall be exclusively used for storage of the coal.

- An onsite emergency plan shall be prepared and implemented by coal handling unit.

(F) Legal criteria

- Necessary permission from all the applicable regulatory authorities and adequate steps under the provisions of applicable environmental acts/rules shall be taken.

- Coal handling unit/Agency shall prepare EMP (Environment Management Plan) and implement the same in true spirit and thus maintain overall environment of that area.

- Coal handling unit/Agency shall not carry out the operation of loading/unloading of coal/coal dust at any place, till adequate air pollution control equipment for dust control/suppression are installed and efficiently operated and the consent under the provisions of Air (Prevention & Control of Pollution) Act, 1981 is obtained by the coal yard owners/Coal handling unit/Agency/coal importers.

- Coal handling unit/Agency shall operate continuous Ambient Air Quality Monitoring Stations as per CPCB guideline.

- In case of port which provides the facility to individual developers an agreement/MoU shall be made between port authority and developer for curtailment of pollution. Port authority shall be responsible for supervising and controlling the pollution control related activities and implementation of the environmental guidelines.

7.3 Sewage Treatment Plant at Vadinar

- At Vadinar, the sewage waste water from the colony is connected in to new STP. Is commissioned and fully operational to handle the Sewage Waste Water.

8.0 ANNEXURE I-A
Ambient Air Quality Standards (NAAQS)

Pollutants	Time weighted average	Concentration in Ambient air µg/m³		
		Industrial Areas	Residential /Rural & Other areas	Sensitive Areas
Sulphur Dioxide (SO_2	Annual	50	50	20
	24hours**	80	80	80
Respirable Particulate Matter(size>10um) (RPM) PM_{10}	Annual	60	60	60
	24hours**	100	100	100
Particulate Matter(size>2.5um) $PM_{2.5}$	Annual	40	40	40
	24hours**	60	60	60
Nitrogen Dioxide (NO_2)	Annual	40	40	30
	24hours**	80	80	80

- Annual arithmetic mean of minimum of 104 measurements in a year taken twice a week. 24 hourly at uniform interval
- 24 hourly / 8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days

Note:

- National Ambient Air Quality Standard: The levels of air quality with an adequate margin of safety, to protect the public health, vegetation and property.
- Wherever and whenever two consecutive values exceeds the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.
- The State Government/State Board shall notify the sensitive and other areas in the respective states within a period of six months from the date of Notification of National Ambient Air Quality Standards.

[{S.O.384 (E), Air (Prevention & Cont. of Pollution) Act,1981 dated April 11,1994]

ANNEXURE I-B

Drinking Water Standards (BIS)

Sr. No.	Parameter	Unit	Acceptable Limits	Permissible Limits
1	pH	-	6.5 to 8.5	6.5 to 8.5
2	Total Dissolved Solids	mg/L	500	2000
3	Turbidity	NTU	1	5
4	Odor	-	Agreeable	Agreeable
5	Color	Hazen Units	5	15
6	Conductivity	µs/cm	NS*	NS*
7	Bio.Oxygen Demand	mg/L	NS*	NS*
8	Chloride as Cl	mg/L	250	1000
9	Ca as Ca	mg/L	75	200
10	Mg as Mg	mg/L	30	100
11	Total Hardness	mg/L	200	600
12	Iron as Fe	mg/L	0.3	NS*
13	Fluorides as F	mg/L	1	1.5
14	Sulphate as SO_4	mg/L	200	400
15	Nitrite as NO2	mg/L	NS*	NS*
16	Nitrate as NO3	mg/L	45	NS*
17	Salinity	%	NS*	NS*
18	Sodium as Na	mg/L	NS*	NS*
19	Potassium as K	mg/L	NS*	NS*
20	Manganese	mg/L	0.1	0.3
21	Hexavalent Chromium	mg/L	NS*	NS*
22	Copper	mg/L	0.05	1.5
23	Cadmium	mg/L	0.003	NS*
24	Arsenic	mg/L	0.01	0.05
25	Mercury	mg/L	0.001	NS*
26	Lead	mg/L	0.01	NS*
27	Zinc	mg/L	5	15
28	Bacterial Count	CFU/100ml	Absent	Absent

*Not specified in IS10500:2012

Bacteriological Standards (for Drinking water)

	Organisms	Requirements
All water intended for drinking		
	(a)E.coliorthermo-tolerant Coli form bacteria	Shall not be detectable in any 100 ml sample
Treated water entering the distribution system		
	a)E.coliorthermo-tolerant Coliformbacteria	Shall not be detectable in any 100 ml sample
	b)Total Coli form bacteria	Shall not be detectable in any 100 ml sample
Treated water in the distribution system		
	a)E.coliorthermo-tolerant Coli form bacteria	Shall not be detectable in any 100 ml sample
	b)TotalColiformbacteria	Shall not be detectable in any 100 ml sample

(BIS specifications (IS10500-2012)

ANNEXURE -I-C

Noise Quality Standards

Area Code	Category of Area	Limits in dB(A) Leq	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

- Day Time is recorded in between 6.00 A.M. and 10.00 P.M.
- Night time is recorded in between 10.00 P.M. to 6.00 A.M.
- Silence zone is defined as areas up to 100 meters around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by the Competent Authority.
- Use of vehicular horns, loud speakers and bursting of crackers shall be banned in these zones.
- Mixed categories of areas should be declared as one of the four above mentioned categories by the Competent Authority and the corresponding standards shall apply.

[Source: EPA Notification [G.S.R.1063 (E) dt.26.12.1989 published in the Gazette No.643 dt.26.12.1989.]