DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

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DEENDAYAL PORT AUTHORITY

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EG/WK/5202 (D)/ Part (CRZ 2)/ 119 Dated: 12/12/2025

To,
The Director (Env.) & Member Secretary,
Forest & Environment Department,
Govt. of Gujarat,
Gujarat Coastal Zone Management Authority,
Block No.14, 8th floor, New Sachivalaya,
Gandhinagar - 382 010

Sub: Single Point Mooring (SPM) and allied facilities off Veera in Gulf of Kutch for handling crude oil on BOT basis in the state of Gujarat by M/s. Kandla Port Trust (Now Deendayal Port Authority)– **Six monthly compliance report of conditions stipulated in CRZ Recommendations reg.**

Ref.:
1. Letter No. ENV-10-2011-1883-E dated 24/05/2012
2. DPT letter No. EG/WK/4712/Part I/1164 dated 06/06/2013
3. DPT letter No. EG/WK/4712/Part I/1164 dated 04/01/2014
4. DPT letter No. EG/WK/4712/Part I/128 dated 15/05/2014
5. DPT letter No. EG/WK/4712/Part I/226 dated 15/10/2014
6. DPT letter No. EG/WK/4712/Part I/227 dated 06/05/2015
7. DPT letter No. EG/WK/4712/Part I/165 dated 15/10/2015
8. DPT letter No. EG/WK/4712/Part I/130 dated 09/05/2016
9. DPT letter No. EG/WK/4712(EC)/Part I/128 dated 08/12/2016
10. DPT letter No. EG/WK/4712(EC)/Part I/233 dated 28/06/2017
11. DPT letter No. EG/WK/4712(EC)/Part II/601 dated 12/12/2017
12. DPT letter No. EG/WK/4712(EC)/Part II/286 dated 08/06/2018
13. DPT letter No. EG/WK/4712(EC)/Part II/10 dated 15/02/2020
14. DPT letter No. EG/WK/4712/EC/Part II/40 dated 12/11/2020
15. DPT letter No. EG/WK/4712/EC/Part II/152 dated 12/07/2021
16. DPA letter No. EG/WK/(D) Part (CRZ 2) /134-1 dated 01/02/2022
17. DPA letter No. EG/WK/(D) Part (CRZ 2)/126 dated 30/06/2022
18. DPA letter No. EG/WK/5202 (D)/Part (CRZ 2)/228 dated 01/02/2023
19. DPA letter No. EG/WK/5202 (D)/Part (CRZ 2)/345 dated 04/08/2023
20. DPA letter No. EG/WK/5202 (D)/Part (CRZ 2)/12 dated 10/01/2024
21. DPA letter No. EG/WK/5202 (D)/Part (CRZ 2)/124 dated 30/08/2024
22. DPA letter No. EG/WK/5202 (D)/Part (CRZ 2)/28 dated 12/02/2025
23. DPA letter No. EG/WK/5202 (D)/Part (CRZ 2)/28 dated 14/07/2025

Sir,

Kindly refer above-cited references for the said subject.

In this connection, it is to state that the Gujarat Coastal Zone Management Authority, vide the above-referred letter dated 24/05/2012, had recommended Deendayal Port Authority the subject project.

Subsequently, the MoEF&CC, GoI, had accorded the Environmental & CRZ Clearance vide letter dated 11/12/2013 for the subject project. Subsequently, MoEF&CC extended the validity of the Environmental Clearance till 10/12/2023.

Now, as directed under Specific Condition No. 26 mentioned in the CRZ Clearance letter dated 25/05/2012, i.e. ***A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the DPT on a regular basis to this Department and MoEF&CC, GoI'***, please find enclosed herewith point-wise compliances of the conditions stipulated in CRZ recommendations issued by GCZMA vide letter dated 24/05/2012 along with necessary annexures (**Annexure 1**) for the period April, 2025 to September, 2025 for kind information & record please.

Further, as per the MoEF&CC, Notification S.O.5845 (E) dated 26.11.2018, in which it is mentioned that, "***In the said notification, in paragraph 10, in sub-paragraph (ii), for the words "hard and soft copies" the words "soft copy" shall be substituted".*** Accordingly, we are submitting herewith a 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,

XEN (EMC)
Deendayal Port Authority

Encl.: as above

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 1

Compliance Report for the period April 2025 to September 2025

Subject: Point-wise Compliance of the conditions stipulated in CRZ recommendation granted by Forest & Environment Department, GoG for the project "Single Point Mooring (SPM) and allied facilities off Veera in Gulf of Kutch for handling crude oil on BOT basis in the state of Gujarat by M/s. Kandla Port trust".

Ref No: CRZ recommendations issued vide letter No. ENV-10-2011-1883-E dated 24/05/2012 for the subject project.

S. No.	CRZ Conditions	Compliance Status
	SPECIFIC CONDITIONS	
I	The DPT 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 adhered to by DPA.
II	The COT shall be outside the CRZ areas as submitted by the KPT.	No activity has started yet.
III	The KPT shall obtain all necessary permissions from different Government Departments/Agencies before commissioning their activities.	No activity has started yet. However, it is relevant to mention that, DPA had already obtained CTE/NOC from GPCB vide letter No. PC/ CCA – KUTCH – 971/ GPCB ID: 36299/ 106252 dated 06/03/2012 and GPCB further extended the CTE validity vide Order dated 02/03/2017.
IV	No dredging, reclamation and construction activities shall be carried out in the CRZ area categorised as CRZ I (A), and it shall have to be ensured that the mangrove habitats and other ecologically important and significant areas, if any, in the region are not affected due to any of the project activities	No activity has started yet.
V	The KPT shall be held responsible for any accidental oil spill, if takes place due to rupture/damage of pipelines and the KPT shall bear the total cost for remedial measures and restoring the original environment in the area.	No activity has started yet.
VI	No effluent or sewage shall be discharged into the sea/creek or in the CRZ area and shall be treated to confirm to the norms prescribed by the	No activity has started yet.

S. No.	CRZ Conditions	Compliance Status
	Gujarat Pollution Control Board and would be reused/recycled within the plant premises to extract possible.	
VII	The KPT 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 and shall submit the same to this department after having it vetted through the Indian coast guard.	No activity has started yet. It is relevant to mention that, DPA already has Oil Spill Contingency and Disaster Management Plan.
VIII	No ground water shall be tapped to meet with the water requirements during the construction and/or operation phases.	No activity has started yet.
IX	The KPT shall contribute towards the cost of any common study that may be carried out for the KPT region for environmental protection and management issues.	Point noted
X	The KPT shall implement all the suggestions/recommendations given by the NIO in the marine rapid EIA report.	No activity has started yet.
XI	The KPT shall strictly comply with all the conditions stipulated by the Gujarat Pollution Control Board in its consent to establish (NOC) and the CCA	No activity has started yet.
XII	The KPT 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.	DPA/successful bidders will bear the cost of external agencies that may appoint by the Department for supervision/monitoring of proposed activities and the environmental impact of proposed activities.

S. No.	CRZ Conditions	Compliance Status
XIII	The KPT shall take up mangrove plantation in an area of 50 Ha. as well as greenbelt development with the Gujarat ecology commission/forest department.	As per the directions of the GCZMA and MoEFCC, GoI, to date, DPA has undertaken a Mangrove Plantation in an area of 1650 Hectares since the year 2005. The details have already been communicated with the earlier compliance reports submitted. It is also relevant to mention here that, as per the direction of the Gujarat Coastal Zone Management Authority, DPA has already prepared and submitted a report on the mangrove conservation and management plan formulated by the Gujarat Institute of Desert Ecology during the study period of Jan-April, 2015 (Report already submitted along with earlier compliance reports submitted). For regular monitoring, DPA vide work order dated 3/5/2021 has assigned work to M/s GUIDE, Bhuj for Monitoring of mangrove plantation carried out by DPA (Period from 24/5/2021 to 23/5/2022). The final report submitted by M/s GUIDE has already been communicated with the earlier compliance report submitted**.** Further DPA has assigned work to M/s GUIDE, Bhuj vide work order dated 10/06/2024 for "Monitoring of Mangrove Plantation 1600 Ha carried out by DPA" for the Period of 10/06/2024 to 09/06/2025. The final report submitted by GUIDE, Bhuj is attached here as **Annexure- A.** DPA had entrusted the work to Forest Department, Gujarat for developing a greenbelt in and around the Port area at a cost of Rs. 352 lakhs in an area of about 32 hectares and the work is already completed. Further, DPA has appointed the Gujarat Institute of Desert Ecology (GUIDE) for "Green belt development in Deendayal Port Authority and its Surrounding Areas, Charcoal site' (Phase-l)" vide Work Order

S. No.	CRZ Conditions	Compliance Status
		No.EG/WK/4757/Part [Greenbelt GUIDE], dated 31st May 2022. The final report has already been communicated with the earlier compliance report. DPA has assigned the Greenbelt development in Deendayal Port Authority and its surrounding areas, Phase II, to M/s GUIDE vide Work order EG/WK/4751/Part (Greenbelt)/327 dated 23.06.2023. A copy of the final report submitted by GUIDE has already been communicated along with last compliance report. Additionally, DPA has given the work of "maintenance of Greenbelt Development in Deednayal Port Authority at Kandla (phase-II) for two years" to M/s. GUIDE vide work order Civil/engineering/EMC/820/greenbeltdeve-lopementphaseII/2023/45 dated 17/07/2025. Work order is attached herewith as **Annexure- B.** Further, DPA has assigned the "Greenbelt Development in Deednayal Port Authority (DPA) and its Surrounding Areas (Phase III)along with two years maintenance period" vide work order Civil/Engineering/pipeline/3564/GBDinDP-A&ItssurroundingIII/2024/14 dated 27/01/2025. Inception report submitted by GUIDE, is attached herewith as **Annexure- C.**
XIV	The construction camps shall be located outside the CRZ area and the construction 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 construction labours.	No activity has started yet.
XV	The KPT shall have to contribute finically for taking up the socio-	CSR activities are being attended by DPA.

S. No.	CRZ Conditions	Compliance Status
	economic up-lifting activities in this region in consultation with the forest and environment department and the district collector/district development officer.	Copy of the activities undertaken by DPA as a part of CSR is enclosed as **Annexure D.**
XVI	A separate budget shall be earmarked for environmental management and socio-economic activities and details there of shall be furnished to this department as well as to the MoEF, GOI. The details with respect to the expenditure from this budget head shall also be furnished.	The allocation made under the scheme of "Environmental Services & Clearance thereof other related Expenditure" during RBE 2025-26 is Rs. 585 Lakhs.
XVII	A separate environmental management cell with qualified personnel shall be created for environmental monitoring and management during construction and operational phases of the project.	DPA already has an Environment Management Cell. Further, DPA has also appointed an expert agency to provide Environmental Experts from time to time. Recently, DPA appointed M/s Precitech Laboratories, Vapi vide work order dated 04/10/2024. (A copy of Work Order is attached as **Annexure E)** In addition, it is relevant to submit here that DPA has appointed a Chief Manager (Environment & Safety) and two manager (Environment & Safety) on a contractual basis for a period of 3 years, further extendable to 2 years (A copy of the Duty report is attached here as **Annexure – F)**
XVIII	An environmental report indicating the changes, if any, with respect to the baseline environmental quality in the coastal and marine environment shall be submitted every year by the KPT to this department as well as to MoEF, GOI	No activity has started yet.
XIX	A six-monthly report on compliance of the conditions mentioned in this letter shall have to be furnished by the KPT on a regular basis to this department/MoEF, GOI	DPA has been submitting six monthly compliance reports vide referred letters dated 06/06/2013, 04/01/2014, 15/10/2014, 06/05/2015, 15/10/2015, 09/05/2016, 28/06/2017 04/12/2017, 12/11/2020, 12/07/2021 01/02/2022, 30/06/2022, 01/02/2023, 04/08/2023, 10/01/2024, 30/08/2024, 12/02/2025 and 14/07/2025 to MoEF&CC, GoI
XX	Any other conditions that may be stipulated by this department from time	DPA/Successful bidder will comply with any other condition that may be stipulated

S. No.	CRZ Conditions	Compliance Status
	to time for environmental protection/management purpose shall also have to be complied with the KPT.	by Forest and Environment Department, GoG from time to time for environmental protection/ management purposes.

Annexure - A

FINAL REPORT

For the Project entitled

Monitoring of Mangrove Plantation (1600 Ha) carried out by Deendayal Port Authority, Kandla

DPA Work order No. EG/WK/ 4751/Part (Marine Ecology Monitoring)/70. Dt. 10.06.2024

Submitted to

Deendayal Port Authority

Gandhidham- 370201

Dist: Kachchh, Gujarat-, India

Submitted by

Gujarat Institute of Desert Ecology

Mundra Road, Bhuj-370 001

Dist: Kachchh, Gujarat, India

JUNE 2025

FINAL REPORT

for the Project entitled

Monitoring of Mangrove Plantation (1600 ha) carried out by Deendayal Port Authority, Kandla

DPA Work order No. EG/WK/4751/Part (Marine Ecology Monitoring)/70. Dt.10.06.2024.

Submitted by

Gujarat Institute of Desert Ecology

Mundra Road, Bhuj-370 001

Dist: Kachchh, Gujarat

Submitted to

DEENDAYAL PORT AUTHORITY
KANDLA

Deendayal Port Authority

Gandhidham, Dist: Kachchh, Gujarat-370201

JUNE -2025

Gujarat Institute
of Desert Ecology

Certificate

This is state that the Final Report for project entitled "**Monitoring of Mangrove Plantation (1600 ha) carried out by Deendayal Port Authority, Kandla**" has been prepared in line with the Work order issued by the Deendayal Port Authority Vide. Ref. No. EG/WK/4751/Part (Marine Ecology Monitoring)/70. Dt.10.06.2024.

The work order is for a period of one year (10.06.2024 - 09.06.2025) for the above-mentioned study.

Authorized Signatory **Institute Seal**

PO. Box No. 83, Opp. Changleshwar Temple, Mundra Road, Bhuj (Kachchh) - 370 001, Gujarat (India)
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Project Team

Project Coordinator: Dr. V. Vijay Kumar, Director

Project Personnel

Principal Investigator

Dr. B. Balaji Prasath, Senior Scientist

Co-Investigator

Dr. Kapilkumar Ingle, Project Scientist-II

Team Members

Dr. L. Prabhadevi, Advisor

Dr. Dhara Dixit, Project Scientist-I

Mr. Dayesh Parmar, Senior Scientific Officer

Mr. Ketan Kumar Yogi, Junior Research Fellow

Snapshot of the Project, "Regular Monitoring of Mangrove Plantation (1600 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)/70 dated 10/06/2024
2	Duration of the project	One year from 10.06.2024 to 09.06.2025
3	Period of the survey carried out for various components	September, 2024 – April, 2025
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	06 blocks in Sat Saida Bet 02 blocks in Nakti creek 05 block at Kantiyajal Site
6	Components of the report	
6a	Mangrove density	Sat Saida Bet: Density of mangrove varied from 100 to 4000 and individuals/ha and tree height ranging from 70 - 240cm Nakti creek: Density of mangrove varied from 400 – 1600 individuals/ha and tree height ranges from 100 - 170 cm. Kantiyajal: Density of mangrove varied from 500 - 1600 individuals/ha tree height ranges from 70-140 cm.
6b	Avg. Carbon stock 0-30 cm depth (%)	The Avg. Carbon stock of mangrove plantation varied from 39.87 to 62.81%. The highest Carbon stock potential was at Nakti creek.

6c	Assessment of Carbon values (Mg C ha^{-1})	The Carbon values of mangrove plantation varied from 1,920.93 to 4043.5. The highest carbon values potential was at Sat Saida Bet.
6c	Assessment of CO_2 equivalent	The CO_2 equivalent was maximum 31.65 at Sat Saida Bet while at Nakti creek it was 27.66 and at Kantiyajal it was 24.97.
7	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.

Contents

1. Introduction

Mangrove forests are important ecosystems that exhibit high productivity and biodiversity. These forests flourish in varying depths of saline waters and with specialized root structures called pneumatophores that provide vital habitat for diverse macro- and micro fauna (Mullarney et al. 2017). Additionally, mangroves can sequester carbon dioxide at rates up to four times that of terrestrial forests per unit area, further proving their importance for reducing global warming (Alongi 2022). Aquatic tourism and fisheries also rely heavily on mangroves making it economically important alongside its carbon sequestration potential. The international scientific community has gradually adopted the importance of economic ecological functions and services provided by mangroves. However, these ecosystems face unsustainable use and destruction which leads to poorly restored coverage of mangroves (Sidik et al. 2023). To address these issues, researchers have concentrated on developing restoration methods through plantation and conservation programs aimed at sustaining mangroves ecological and economic aspects.

India accounts for roughly 3.3 % of the world's total mangrove cover, equating to 0.15% of the total land area, which signifies a meagre fraction. Mangrove forests are located on the coasts of 9 Indian states and four Union Territories. The country's total area is estimated to be around 4992 Km^2, with nearly 57 % of this figure sitting on the east coast, 31 % on the west, and 12 % in the Andaman and Nicobar Islands (FSI, 2021). The three types of mangrove ecosystems in India include: insular located on the Andaman and Nicobar Islands and continental, which consist of two further classified as estuarine deltaic found on the country's east coast and backwater on the western side (Shah and Ramesh 2022). India possesses the most significant number of true mangrove species accounting for 46, which includes 42 species and 4 natural hybrids belonging to 14 groups and 22 genera. The east coast is home to 40 mangrove species which belong to 14 families and 22 genera. The west coast is populated by 27 species from 16 genera and 11 families, while the Andaman and Nicobar Islands host the richest diversity of mangroves in India – 38 species from 13 families and 19 taxa (Ragavan et al. 2016). Mangrove forests can be defined by their unparalleled primary productivity which is the rate of organic carbon conversion from carbon dioxide respiration outpacing all other forms of biomass in nearly all terrestrial habitats (Harishma et al. 2020). The living biomass and sediments are rich in nutrients sequester what's known as "blue carbon", which can be stored for

centuries. The phrase “blue carbon” was coined in 2009 to highlight the importance of conserving and restoring marine and coastal ecosystems for climate change mitigation and other ecosystem services. However, “blue carbon” encompasses various definitions, and its original definition included all organic material accumulated by marine organisms, as well as the potential for managing marine ecosystems to reduce greenhouse gasses and assist mitigation and conservation efforts of climate change (Lovelock and Duarte 2019).

Although accounting for a small portion of tropical forests, it notes that the position of mangroves at the land-sea interface gives them the ability to impact the carbon cycle of the coast significantly. The contribution of coastal and marine ecosystems, including mangroves, is more effective than terrestrial systems in mitigating climate change through carbon sequestration and storage (Choudhary et al. 2024). The management of blue carbon ecosystems is disregarded concerning climate change policies and is usually missing from national carbon accounts and international carbon payment systems. There are two main accepted methods for estimating the biomass of mangroves: field measurements and remote sensing with a GIS-based approach. Petrokofsky et al. (2012) consider field measurements to be accurate and dependable while validation between remote sensing data and field data is necessary. Active protection and restoration initiatives have recently been carried out through field data collection to support the satellite data, enhancing the modelling of the global carbon cycle. Furthermore, these coastal ecosystems provide a wide range of services necessary for climate change adaptation, such as the protection of coastlines and nutrition for people globally (IUCN, 2017). Carbon sequestration by mangroves ecosystems can be included in national accounts in the international scope.

In conclusion, as woody habitats mangroves serve as crucial carbon sinks in coastal regions. In addition, Mangrove forests serve as natural barriers against storms, erosion, and rising sea levels, directly guarding coastal regions and amplifying local economies receive economies' benefits. This function is even more important in climate change due to the increasing frequency and intensity of extreme weather. In addition, healthy mangrove ecosystems aid in mitigating water pollution, which is essential for maintaining clean water, stabilizing sediments, and filtering debris. Thus, conserving and restoring mangroves is not simply an environmental obligation but one of the unique and

effective measures to strategically safeguard coastal populations. Protect ecosystems and conserve them, which now builds the case for more advanced and active integrated coastal policies with greater focus on ecological systems and human welfare. The Deendayal Port Authority (DPA) has actively engaged in mangrove plantation initiatives following the directives of the Ministry of Environment, Forests, and Climate Change (MoEFCC), Government of India. The monitoring of the mangrove plantation carried out by the DPA has been undertaken by the Gujarat Institute of Desert Ecology (hereafter GUIDE) regularly as per the specification in the work order (EG/WK/4751/part Marine Ecology Monitoring)/70 dated 10.04.24. This report describes the monitoring results of the mangrove plantation managed by the DPA at Nakti creek, Kantiyajal and Sat Saida Bet from 2024 to 2025.

2. Rationale of the project

The Deendayal Port Authority (DPA) is one of India's most developed ports as it has one of the largest cargo capacities in India. DPA is located in the strategic region of Gujarat on the upper north-western coast of India and is one of the largest creek-based ports in the country. It is situated at the Gulf of Kachchh at the southern point and is regarded as one of India’s twelve major ports. The most significant of this location is its semi-diurnal tidal range of around 6 to 7 meters. This enables DPA to have a powerful pull in trade since the significant tidal difference helps with navigation in the port-channel docking areas, thereby increasing maritime trade activity. For the past seven years, DPA has continuously been constructed and upgraded further enhancing its prime geographic ports and the natural resources. The Port area is complimented by a unique creek ecosystem containing diverse life forms like veracious mangrove regions of about 193.1 km^2 and extensive mudflats around 312.9 km^2. Kandla region contains a network of intricate creeks and saltwater mudflats which have sparse range of halophytic mangrove vegetation interspersed with brackish landforms.

The area within 10 kilometres of the port is predominantly developed and includes salt works, human settlements, and port infrastructure to the north and west. Eastern and southern peripheries are marked by ecological features like creek systems, mangrove formations, and mudflats, which indicate the region's ecological value. DPA has had considerable movements of materials, machines, and personnel alongside extensive construction activity as part of its infrastructural development expansion. Such activity

has almost certainly changed the ecological composition of the area. To site these issues and reduce environmental degradation, DPA has undertaken considerable projects, from time to time towards the conservation of the mangroves and other plants and the protection of their coastal habitats within the borders of its property. The authority has also focused on expanding conservation efforts to improve mangrove cover because of the important ecosystem services provided by these plants such as protection of coastline, habitat for fauna and flora, and carbon dioxide storage.

From 2005 to 2024, DPA has managed a remarkable mangrove plantation project covering an area of 1,600 hectares carefully through various implementing agencies at Sat Saida Bet and Nakti creek in Kandla and Kantiyajal in Bharuch district (Figure 1). The DPA has entrusted the task of evaluating the status of 1600 ha of mangrove plantation in these locations to the GUIDE, Bhuj. The detailed report on the mangrove plantation evaluation includes periodic monitoring and reporting so that DPA obtains a comprehensive detailed evaluation of the advancement and ecological effect of the mangrove plantations, which allows for adequate management decisions concerning the preservation of these vulnerable coastal ecosystems.

3. Objectives of the Study

The evaluation and health assessment of the mangrove ecosystem are the primary scopes of this research. Focus is also given to addressing and managing ecosystem loopholes. The further findings will support the formulation of precise management propositions. To attain the above purposes the following objectives were formulated:

- To conduct an extensive survey of the 1600ha planted mangrove area in Sat Saida Bet, Nakti creek in Kachchh and in Kantiyajal, Bharuch district.
- To assess the level of the plantation and also the health of the mangroves and growth of the species.
- To estimate the carbon stock that could potentially be stored in the soil under the mangrove plantation and its carbon sink value about climate change impacts.

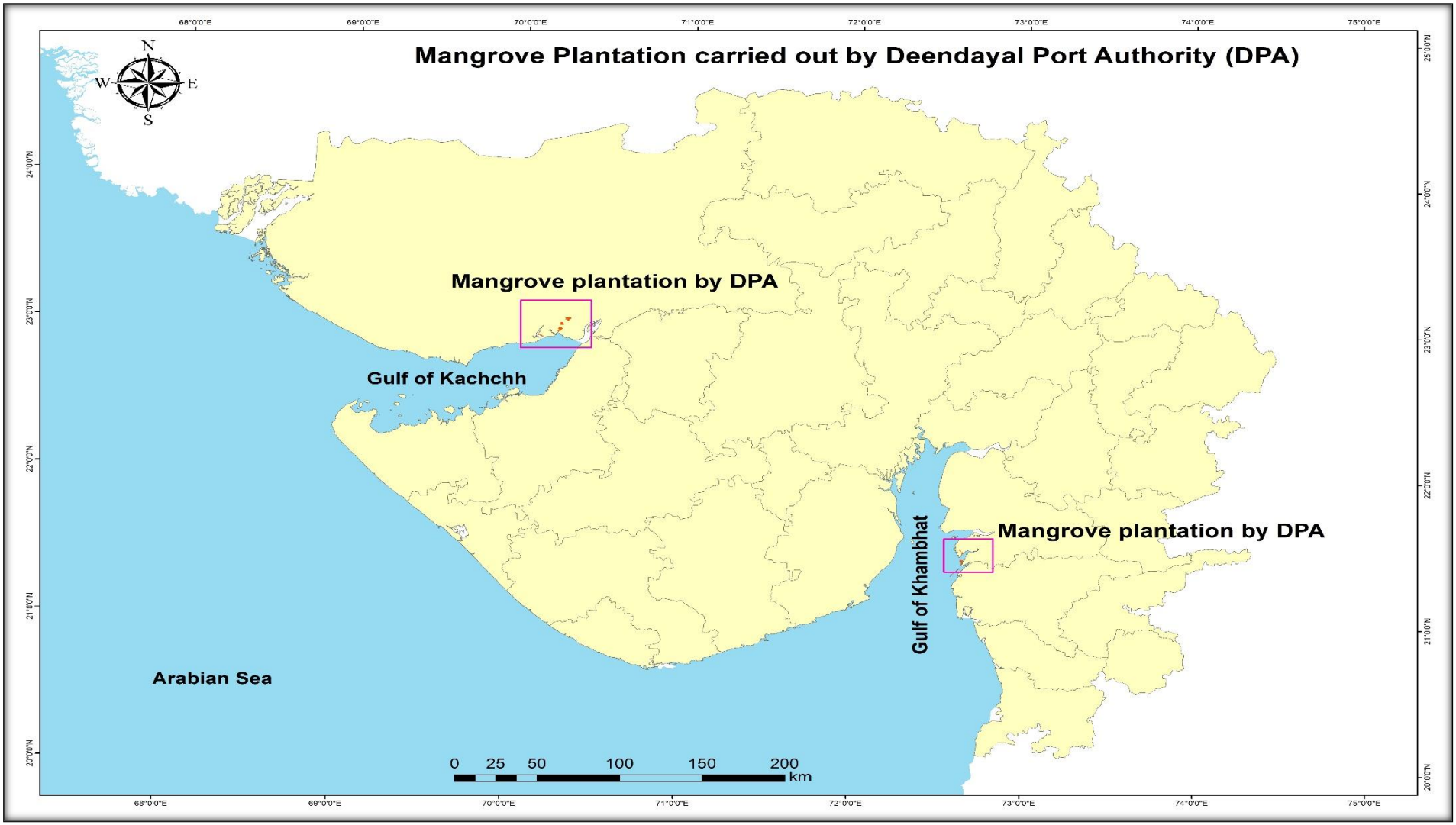

Figure 1: Mangrove plantation carried out by DPA at Sat Saida Bet and Nakti creek in Kachchh district and Kantiyajal in Bharuch district

4. Study Area

The region of Deendayal Port is examined in terms of its ecology, infrastructure, and geography which comprise the environmental setting. Additionally, the port's coordinates are located at 22°59'39.77''N, 70°13'20.14''E and its average altitude lies 20 feet above mean sea level. Moreover, the average rainfall was 466 mm (in 2021) and its climate features an annual maximum temperature of 42.8°C and an average minimum of 21.3°C.The area has high relative humidity – at 60% for the rest of the year, 80% during the southwest monsoon (June to September), and down to 50% in November-December. The average wind speed is reported at 4.65 m/s and is highest in June at 10.61 m/s. Droughts occur frequently every five years, in two out of five-year cycles (Figure 2).

The coastal area is characterized by flat marsh land featuring dense mangrove growth, mudflats, creek systems, salt marshes, halophytes, salt pans, and swamps. The only freshwater infusions accompany coastal flooding during monsoon months due to flash floods. There are no perennial or seasonal rivers and the region lacks any form of: irrigation, Cape Town water, Gandhidham taluka receives rainfall, or 15-20 erratic days a year. Besides the National Highway 8A, Gandhidham Railway Station, Bhuj airport (~60 km northwest), Tuna village (12 km North), and Gandhidham Town (12 km northwest) are the other key infrastructural features of the region. Survey of India's top sheets covering the area are 41J1, 41I4 and the port region falls under seismic zone V which has a high risk of earthquakes. There are no major rivers, streams, reserved forests, significant historical locations, or modern dams in the vicinity. These unique surroundings form the ecological balance and infrastructural development of Deendayal Port. The plantation site coordinates are (N 21°27'01.1'', to 21°26'54.24'' and E 72°40'36.04, to 72°38'58.22'') positioned to take advantage of the exuberantly developing mangrove patch which is in the Kantiyajal region of Bharuch District, Gujarat. Both summer and winter have set tropical temperature ranges of 25 °C to 42 °C and an easterly wind of 8 km/h. The area experiences low humidity of 35% as well. Strong tidal currents can be observed in the adjacent marine area, where high tidal coefficients are measured. These factors combine with the warm temperature of shallow waters to dictate the pace of marine life and fishing activities in the region year-round (Figure 3).

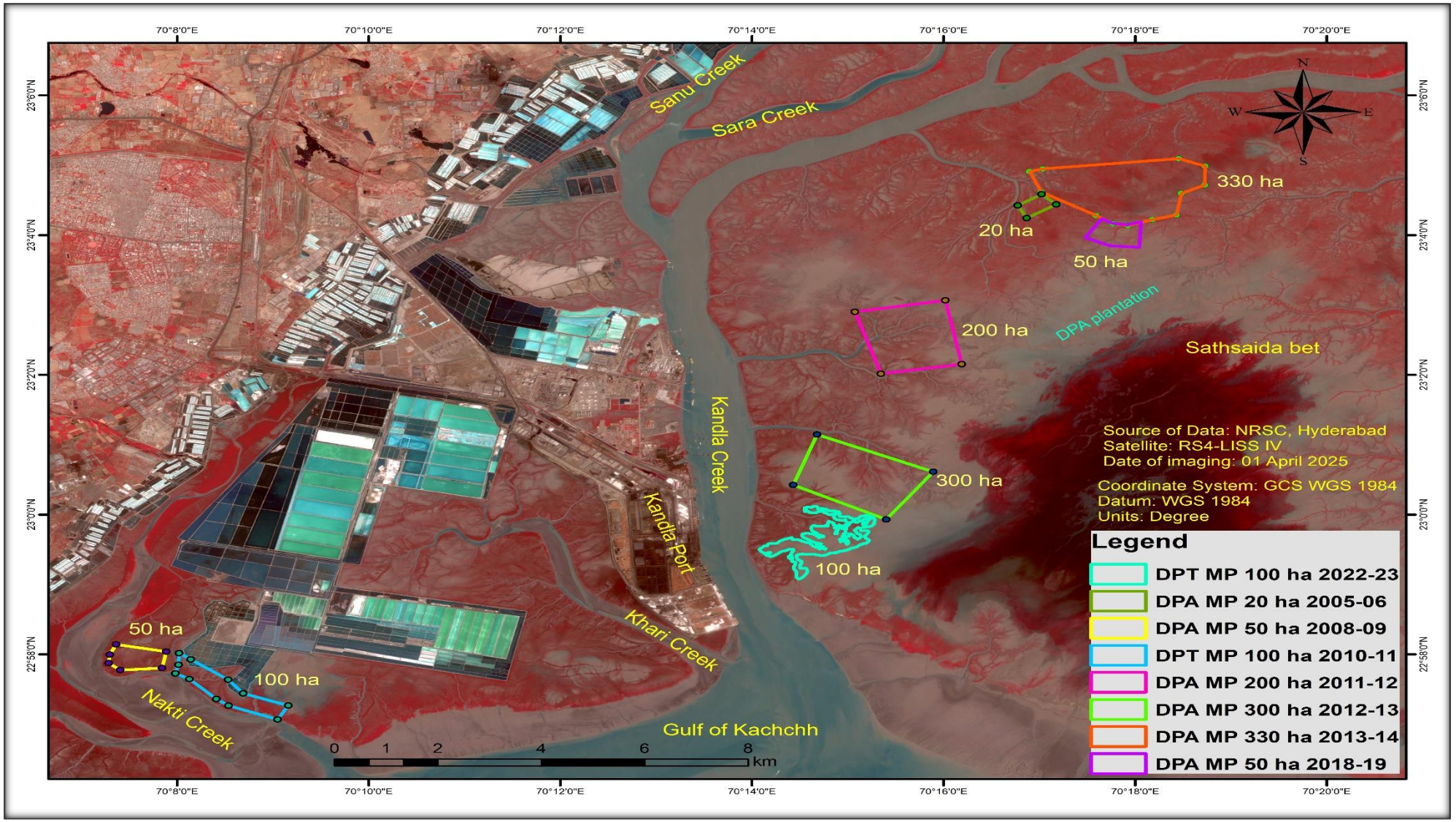

Figure 2: Location of Mangrove Plantation sites at Sat Saida Bet and Natki Creek in Kandla district

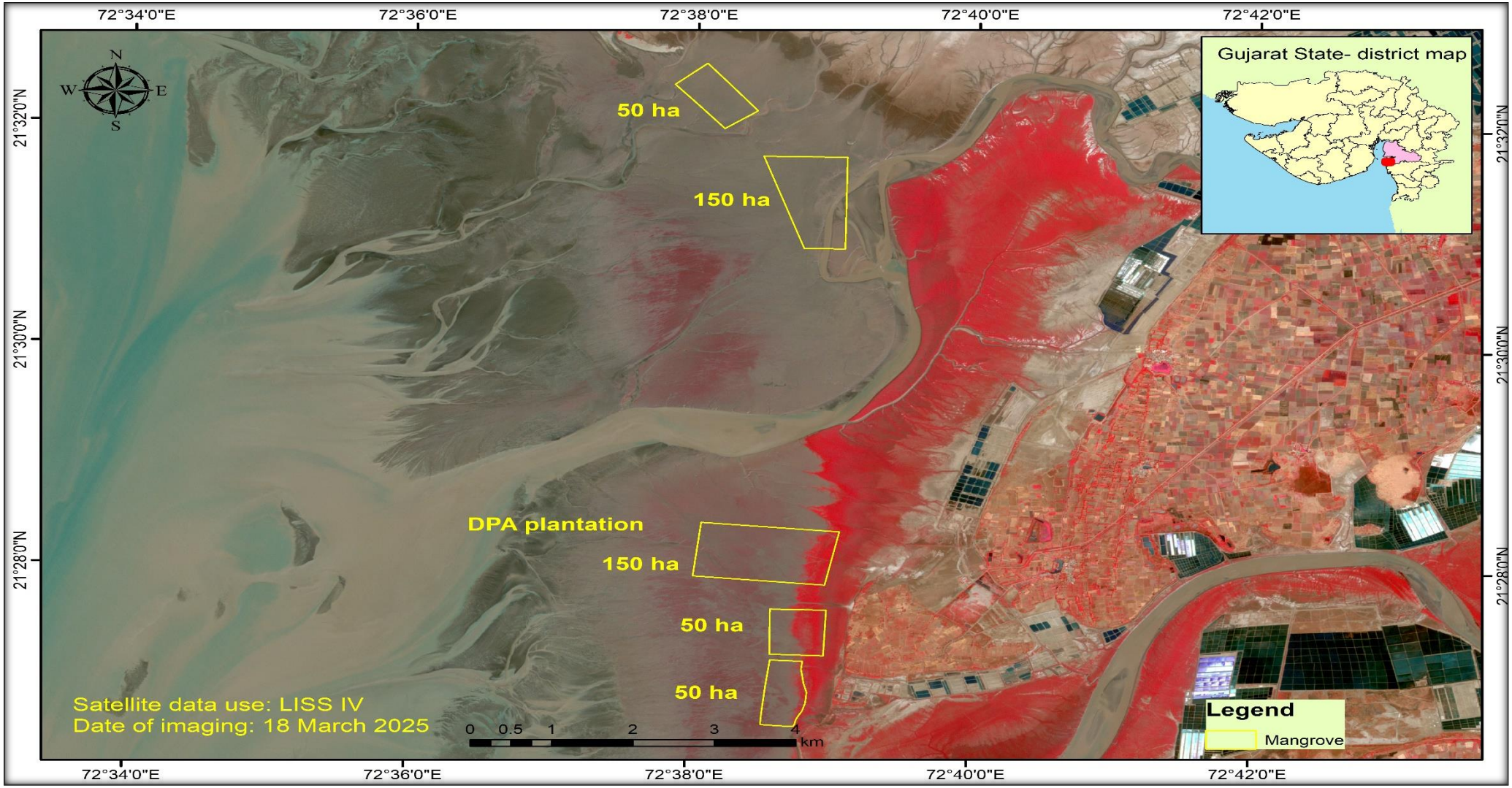

Figure 3: Location of Mangrove Plantation sites at Kantiyajal in Bharuch district

5. Details of the plantation sites

This study examined the status of mangroves at Sat Saida bet and Nakti creek in the Kandla (Kachchh) district and Kantiyajal in the Bharuch district covering more than ten blocks spanning 1400 ha, where plantation activities were conducted from 2005 to 2021. Nevertheless, this analysis (2021-2023) adds another 200 ha of plantations at Sat Saida bet (100 ha) and Kantiyajal (100 ha), which increases the area of the study to 1600ha. The focus of this study for the years 2024-2025 is to assess the actual density of the mangrove plantations developed in these areas. Together with evaluating the carbon sequestration potential of these mangrove ecosystems which are key in reducing climate change impacts through capturing and storing carbon dioxide from the atmosphere. In addition, the study attempts to recommend possible actions for the protection of these ecosystems to safeguard mangrove habitats enabling a healthy and resilient environment. The descriptions of the mangrove plantation work implemented over time by the DPA are found in Fig – 2 & 3 and Table 1. This data will help to illustrate the progress made and the ongoing need for conservation initiatives in these vital ecosystems.

Table 1. 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
	2022-2023	100	*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
	2021-2022	50	*A. marina*	Gujarat Ecology Commission
		50	*A. marina*	Gujarat Ecology Commission
Total Area (ha)		**1600**		

5.1 Plantation at Sat Saida bet (1000 ha)

The mangrove ecosystem of Sat Saida bet with six blocks has been investigated in 1000 hectares (Table 1 and Figure 4 to Figure 9) of mangrove area between 2005 - 2023 which includes studies done by Gujarat Institute of Desert Ecology (2005-2006), Forest Department of Gujarat (2011-2014), and Gujarat Ecology Commission (2018-2023). Sat Saida bet is located on the eastern shore of Kandla creek of Gulf of Kachchh. The unique Island of 253.8 km^2 area is located opposite to Deendayal port. It has sparse and 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. It is familiar that mudflats with favourable tidal amplitude are suitable for mangrove plantation. So, DPA chose Sat Saida Bet area to execute the mangrove plantation activities.

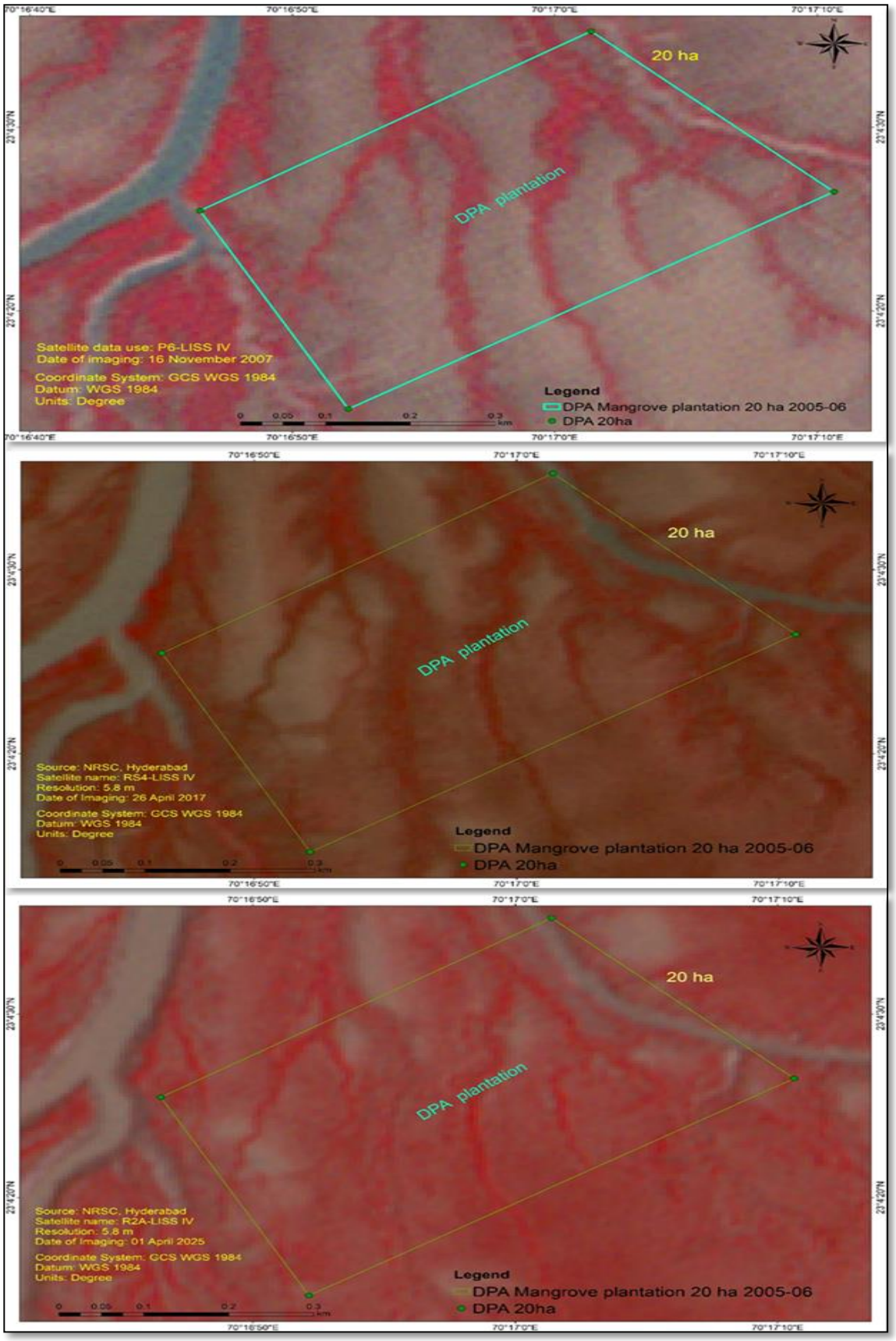

Figure 4: Satellite imageries of the 20 Ha plantation site at Sat Saida Bet (2007, 2017, and 2025)

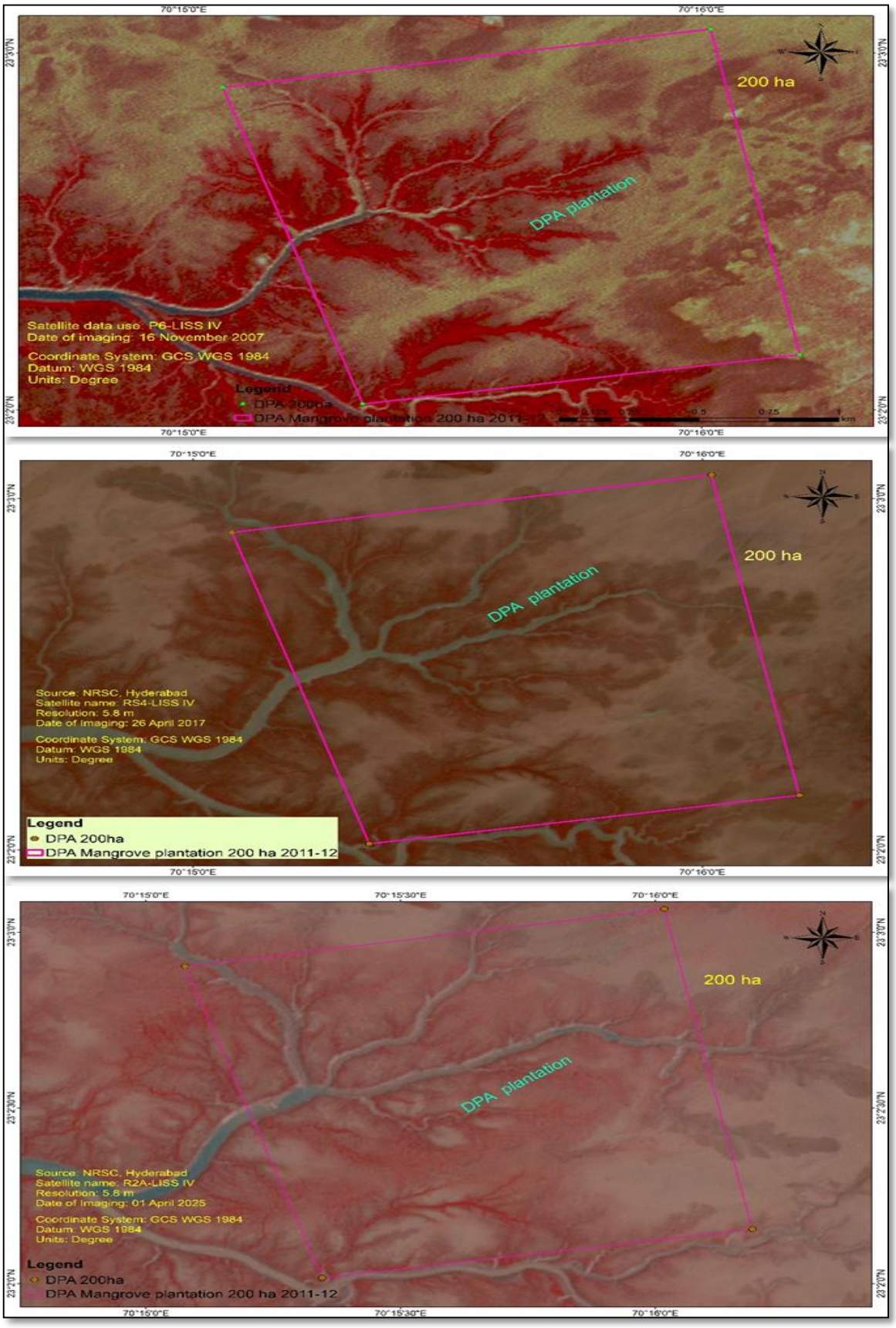

Figure 5: Satellite imageries of the 200 Ha plantation site at Sat Saida Bet (2007, 2017, and 2025)

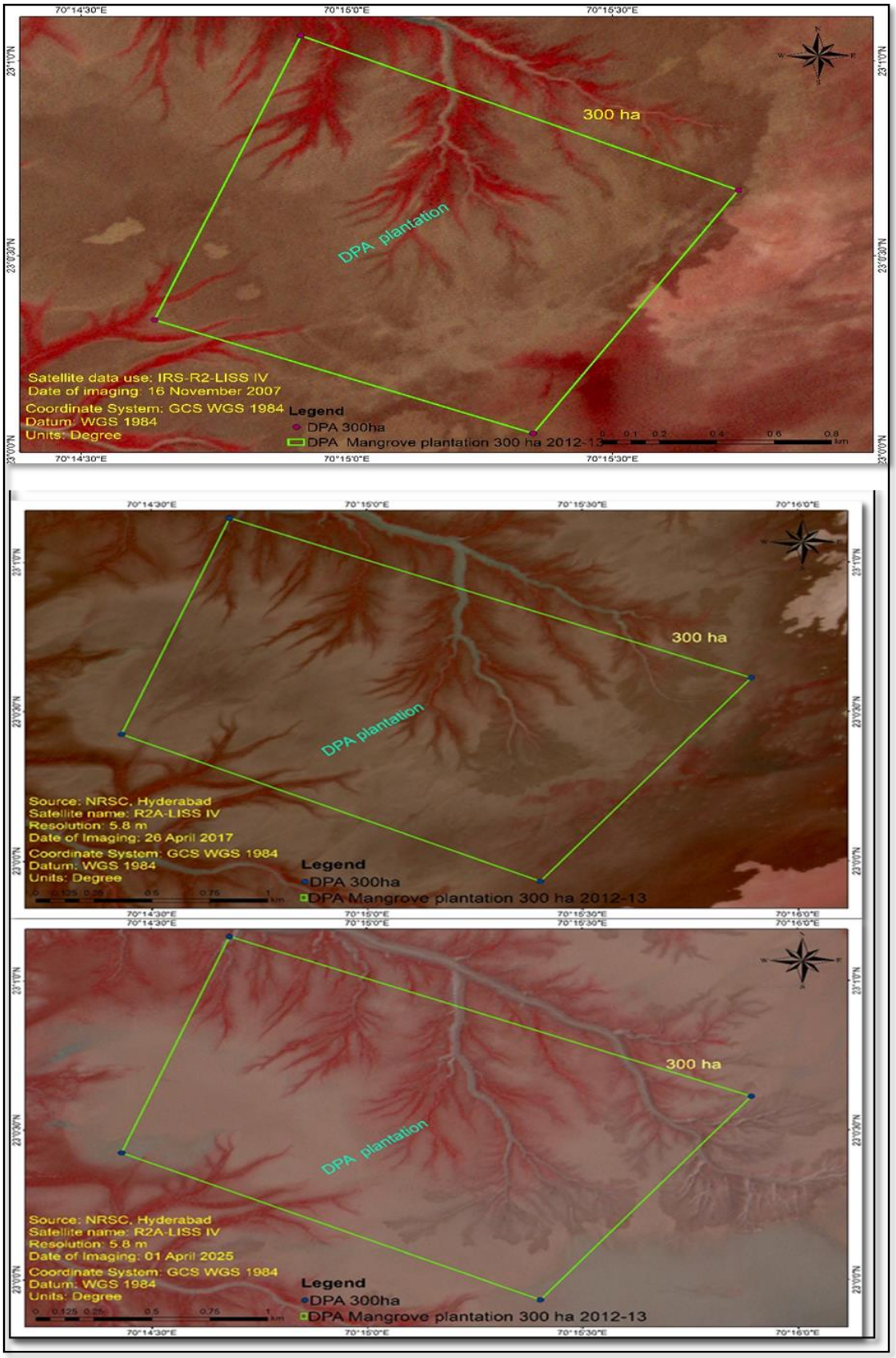

Figure 6: Satellite imageries of the 300 Ha plantation site at Sat Saida Bet (2007, 2017, and 2025)

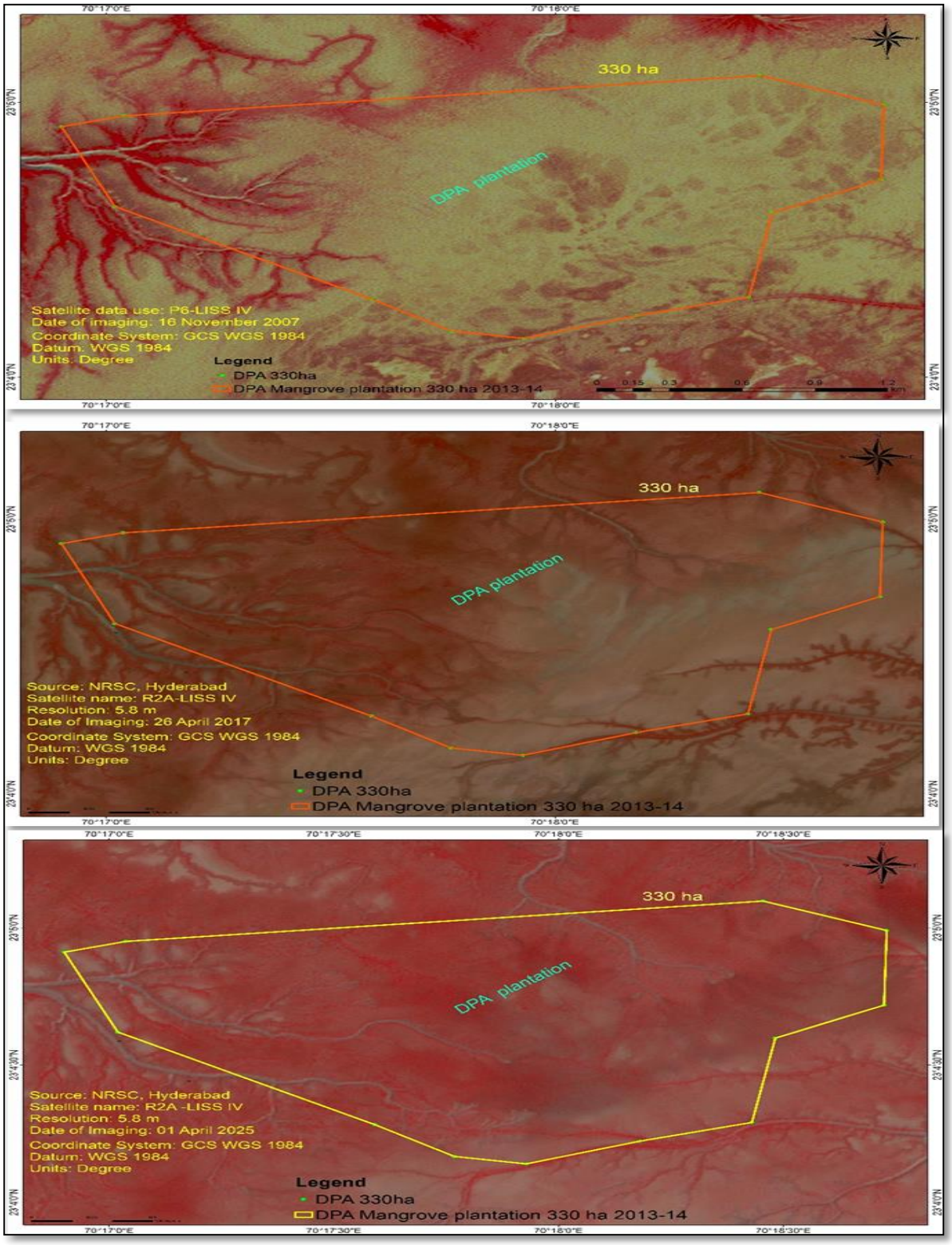

Figure 7: Satellite imageries of the 330 Ha plantation site at Sat Saida Bet (2007, 2017, and 2025)

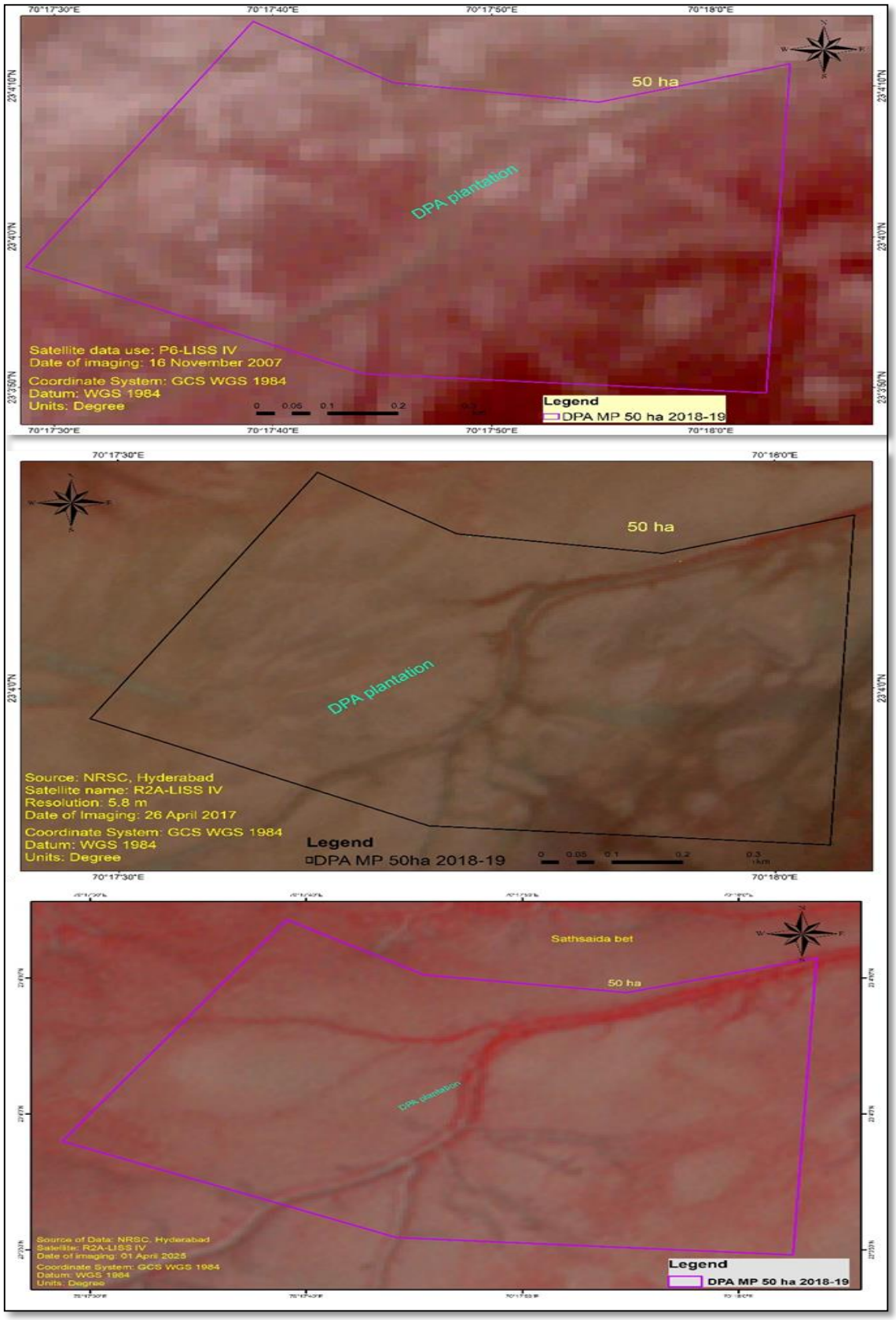

Figure 8: Satellite imageries of the 50 Ha plantation site at Sat Saida Bet (2007, 2017, and 2025)

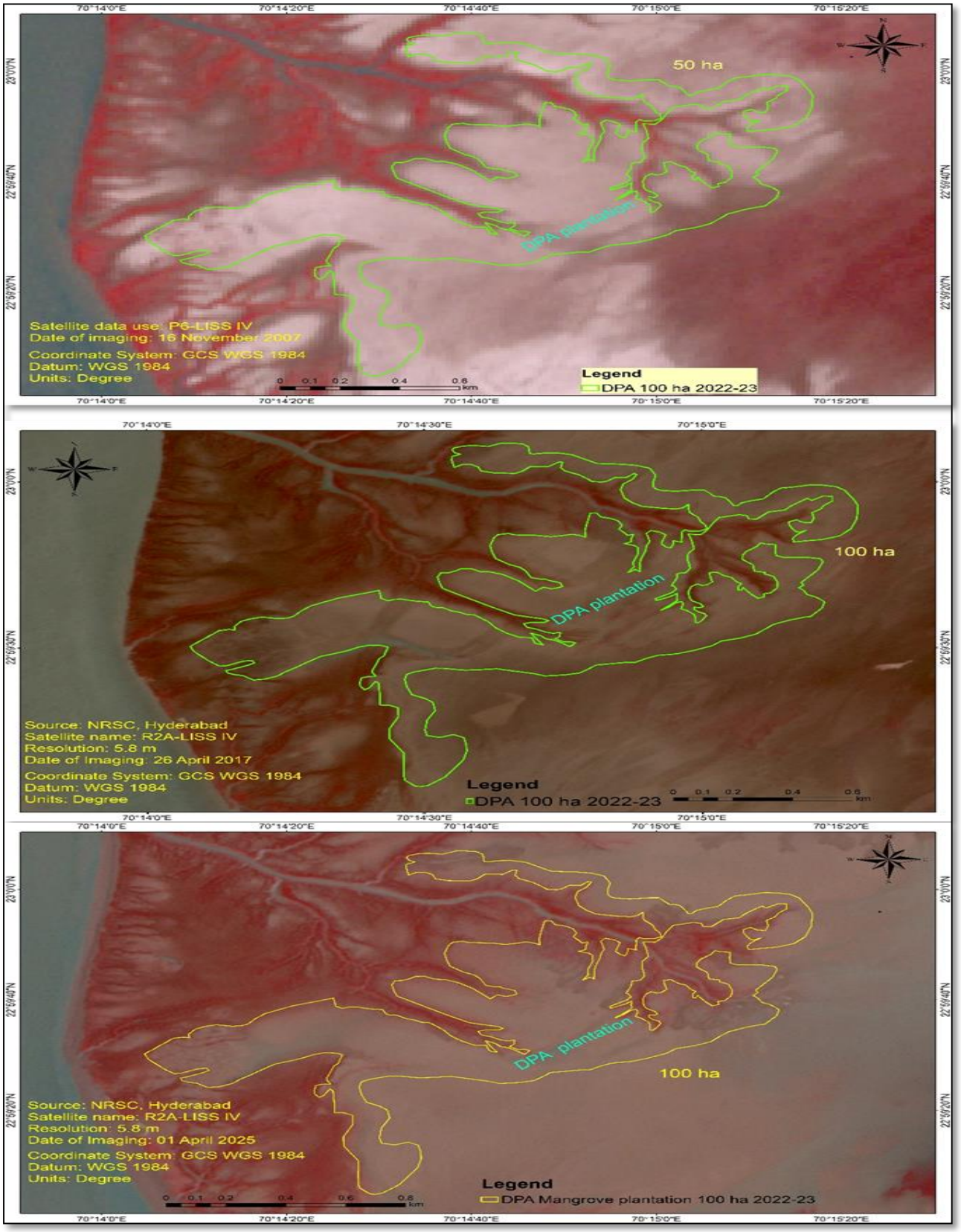

Figure 9: Satellite imageries of the 100 Ha plantation site at Sat Saida Bet (2007, 2017, and 2025)

5.2 Mangrove plantation at Nakti creek (150 ha)

A detailed area of 150 hectares of mangrove plantation, consisting of two distinct parts, was constructed in Nakti Creek; one more significant block of 100 hectares and a smaller block of 50 hectares. Additionally, this project was divided amongst multiple organizations for collaborative efforts towards maintaining the coastal habitat. The outset of the project was started by M/s Patel Construction Co. based out of Gandhidham, which started working on the project around 2008 to 2009. The second phase was executed by the Gujarat Ecology Commission from 2010 to 2011. The description of these attempts is included in Table 1, and Figures 10, 11. Both construction phases required attention to overcoming challenges related to biodiversity, so the project focused on three main techniques: replanting saplings from nurseries, creating otla beds, and using direct seed dibbling. The venture aimed to reclaim biodiversity alongside protecting the success of the mangrove plantation. Therefore, researchers decided to plant *Avicennia marina and Rhizophora mucronata*, a salt tolerant mangrove species that plays a vital role in controlling erosive forces and provides essential habitat for flora and fauna along the coast.

Unlike the former one, the more significant block which is 100 hectares on the other side of the creek had more variety in the species of mangrove to increase ecological complexity and diversity of different ecosystems. Furthermore, this section contained A. *marina, Rhizophora mucronata,* and *Ceriops tagal*. The addition of these species was intentional and improved the overall ecological balance and the overall health of the mangrove ecosystem. The project intends to restore the mangrove habitat using various plant species. However, the goal is also to strengthen, local coastal ecosystems, biodiversity, and the sustainable health of the coastal environment. This type of broad strategy regarding mangrove planting highlights the critical role that various indigenous species have in tackling the problem of coastal erosion while simultaneously sustaining both marine and terrestrial fauna and flora.

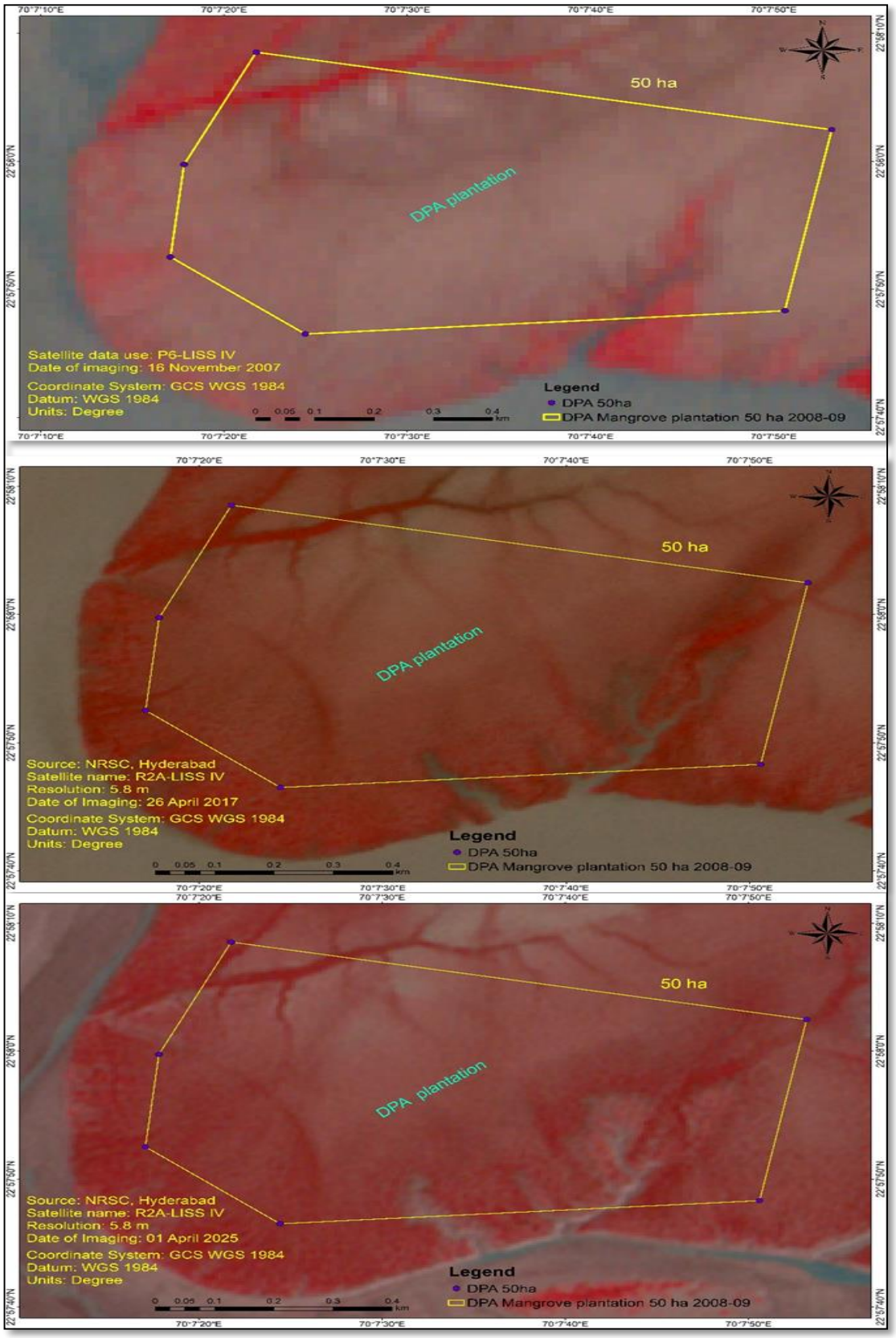

Figure 10: Satellite imageries of the 50 Ha plantation site at Nakti Creek (2007, 2017, and 2025)

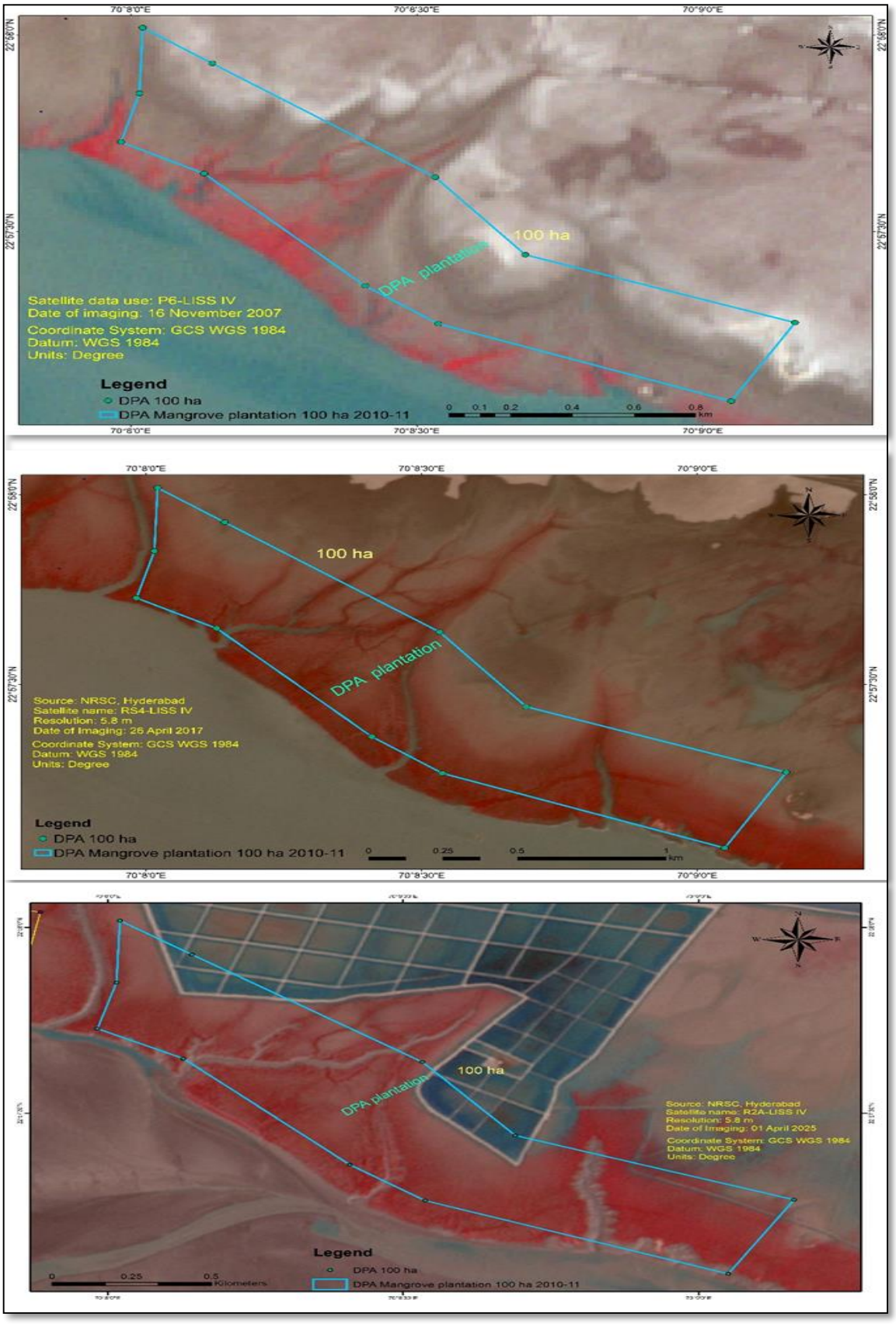

Figure 11: Satellite imageries of the 100 Ha plantation site at Nakti Creek (2007, 2017, and 2025)

5.3 Mangrove plantation at Kantiyajal (450 ha)

The mangrove ecosystem of Kantiyajal with Four blocks has been investigated in 450 hectares (Table 1 and Figure 12 to Figure 16) of mangrove area between 2015 - 2022 including studies done by Gujarat Ecology Commission (GEC). The GEC has been concentrating on the increase of local biodiversity by carrying out mangrove plantation activities in Kantiyajal area of Bharuch District. The commission undertook planting of grey mangroves *Avicennia marina* from 2015 to 2016, planting 150 hectares. A. marina is alongside coastlines and acts as a natural barrier, serving core ecological functions like habitat creation. It was a significant milestone in ecological restoration because of its importance to coastal region. During the subsequent year (2016-2017), they continued with *A. marina* planting but this time they added another key mangrove species *Rhizophora mucronata*. By replanting 150 hectares of land, the region demonstrated a commitment to a highly diverse ecological landscape and a robust environment. In the third block, 2018-2019, only 50 hectares of *A. marina* were planted. However in the fourth block, 2021-2022 mangrove plantation period, *A. marina* planting increased to 100 hectares. That indicates renewed focus towards ecological conditions, and restorations, which allows for more extensive plantation efforts. Dunes, coastal and other erosion are broader spread issues which the plantation programs would help together with losing ecosystem diversity. These steps are critical in retaining local biodiversity which showcases some of the lesser known features to be preserved in the Kantiyajal region of Bharuch District during ongoing efforts to manage balance in its unique ecological network.

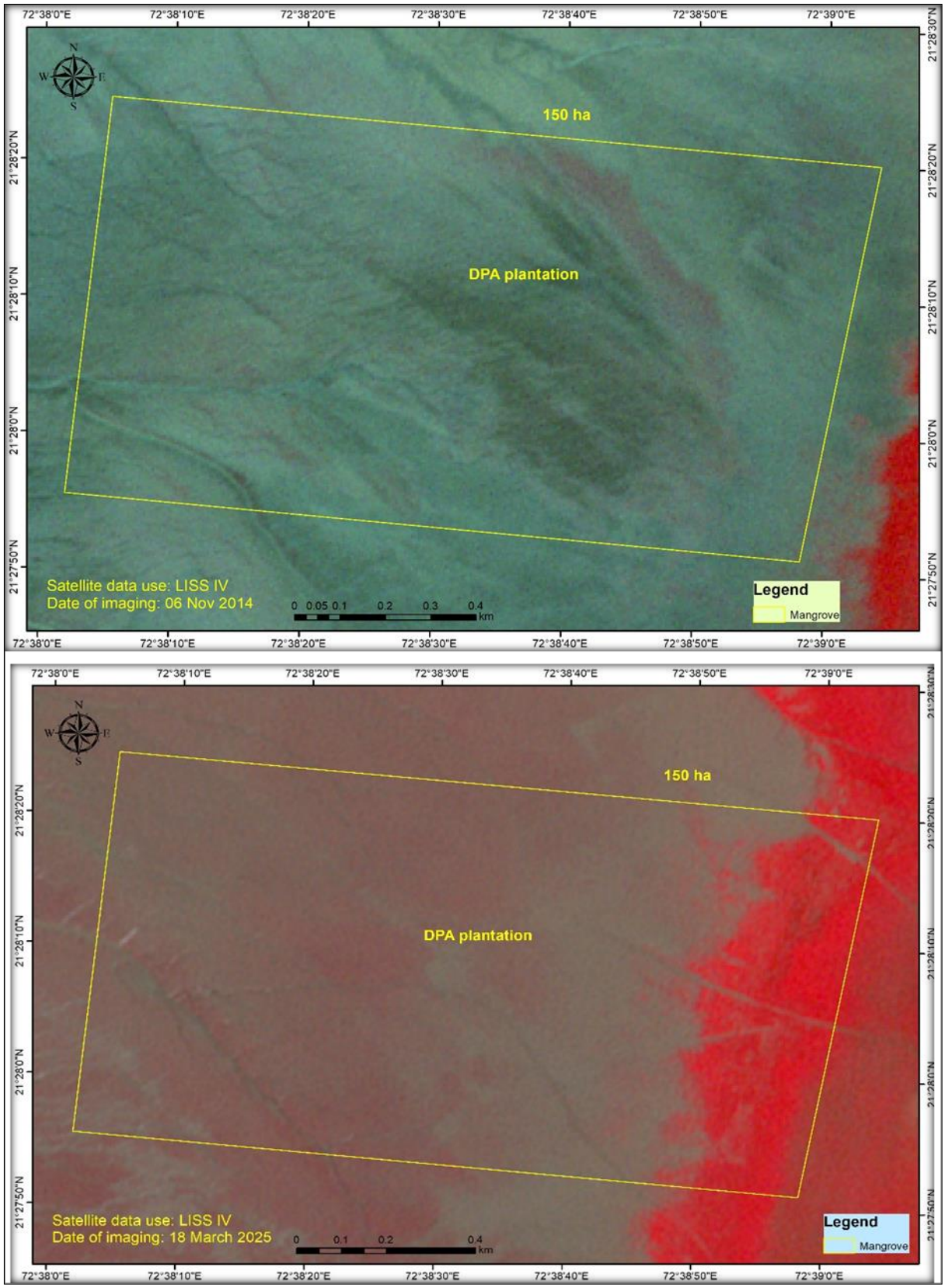

Figure 12: Satellite imageries of the 150 Ha block-1 plantation site at Kantiyajal (2014 and 2025)

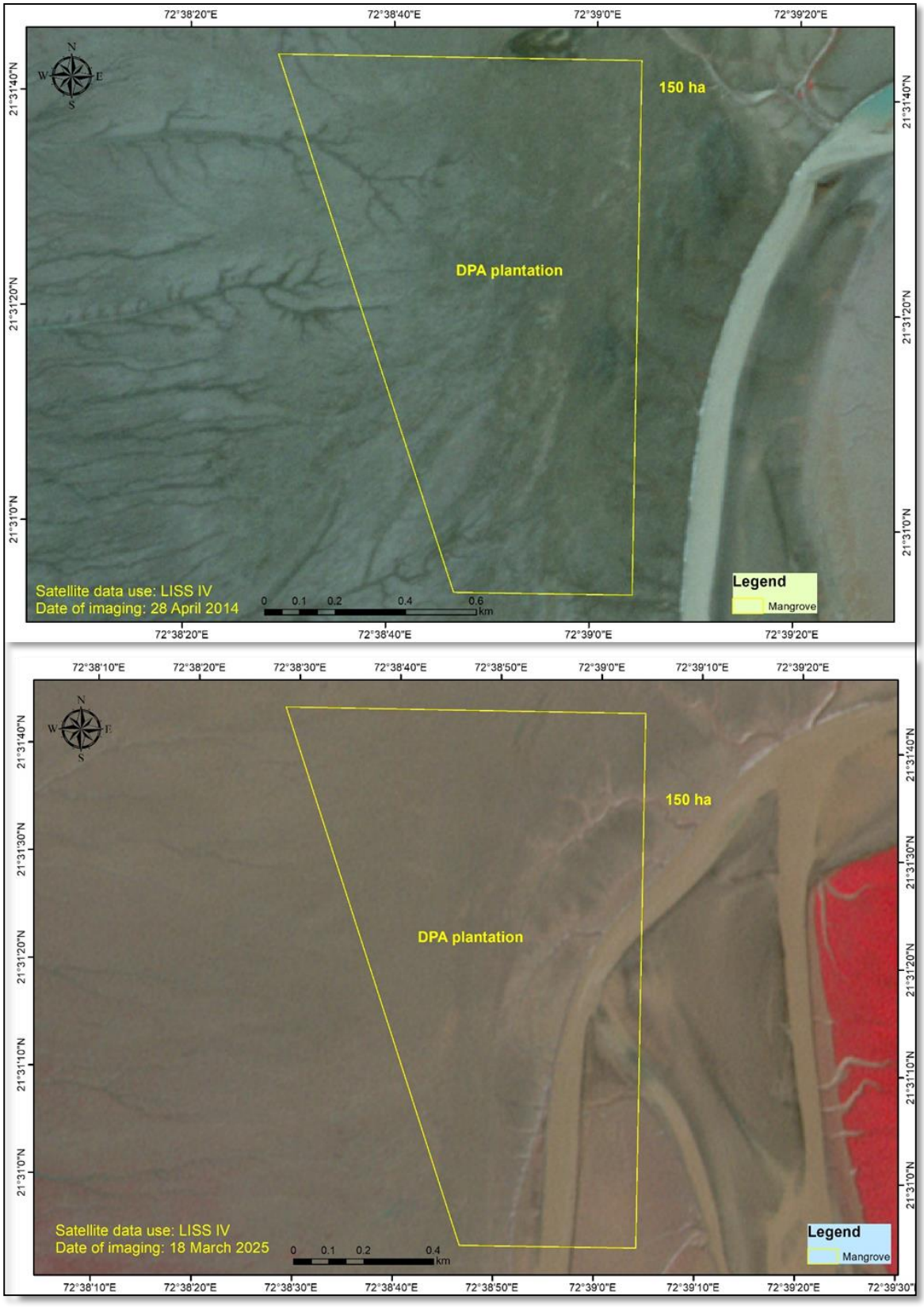

Figure 13: Satellite imageries of the 150 Ha block-2 plantation site at Kantiyajal (2014 and 2025)

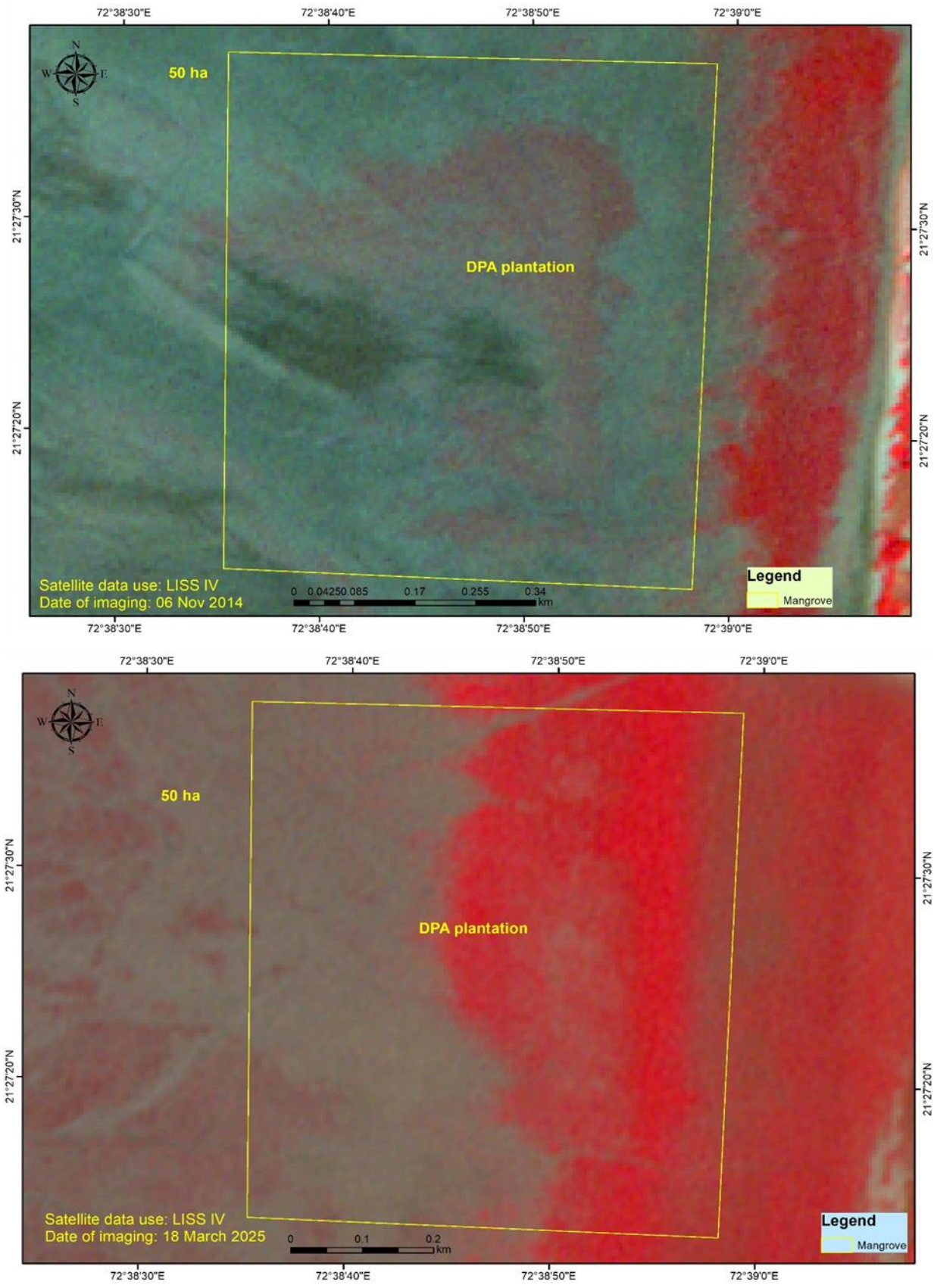

Figure 14: Satellite imageries of the 50 Ha block-3 plantation site at Kantiyajal (2014 and 2025)

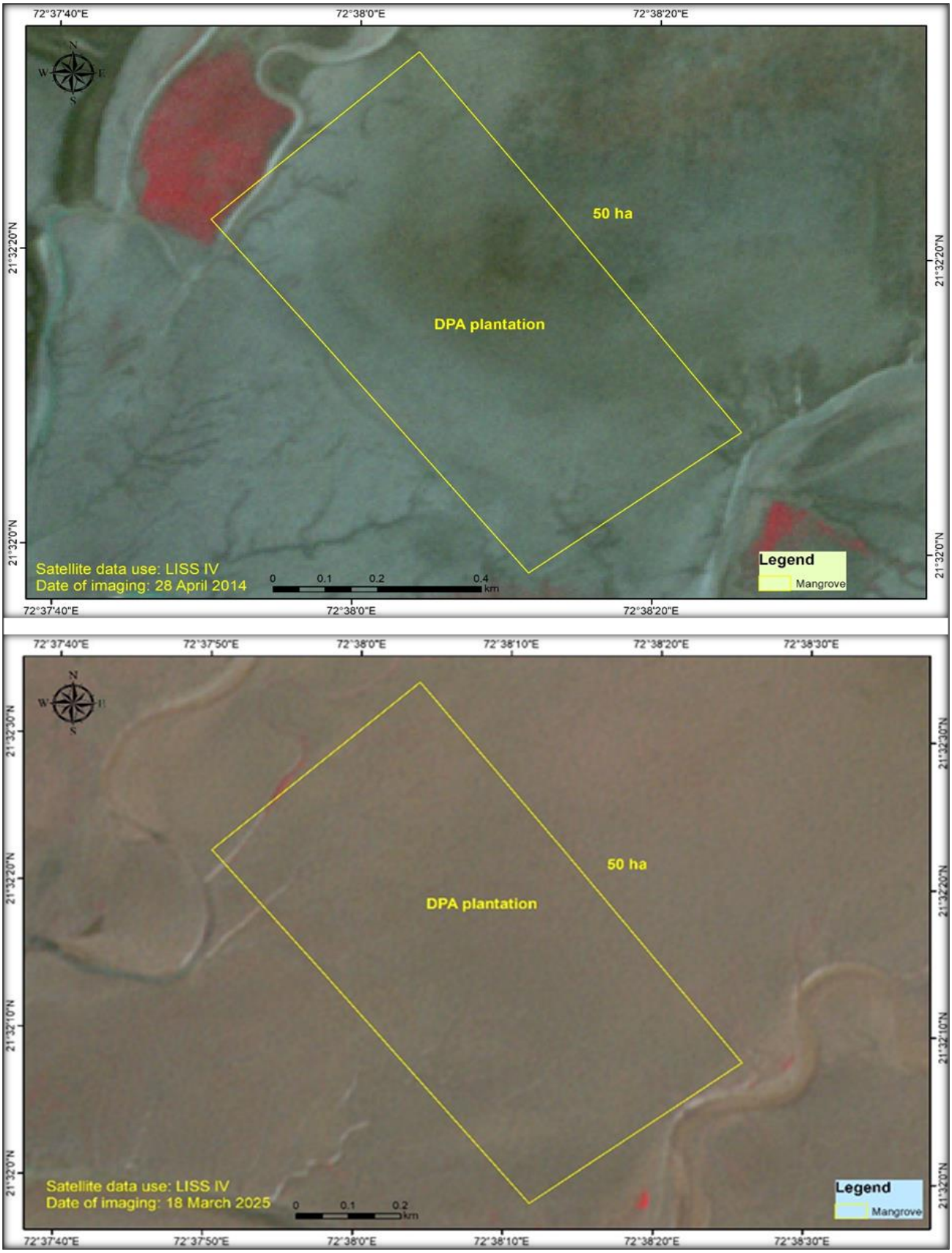

Figure 15: Satellite imageries of the 100 (50-1) Ha block-4 plantation site at Kantiyajal (2014 and 2025)

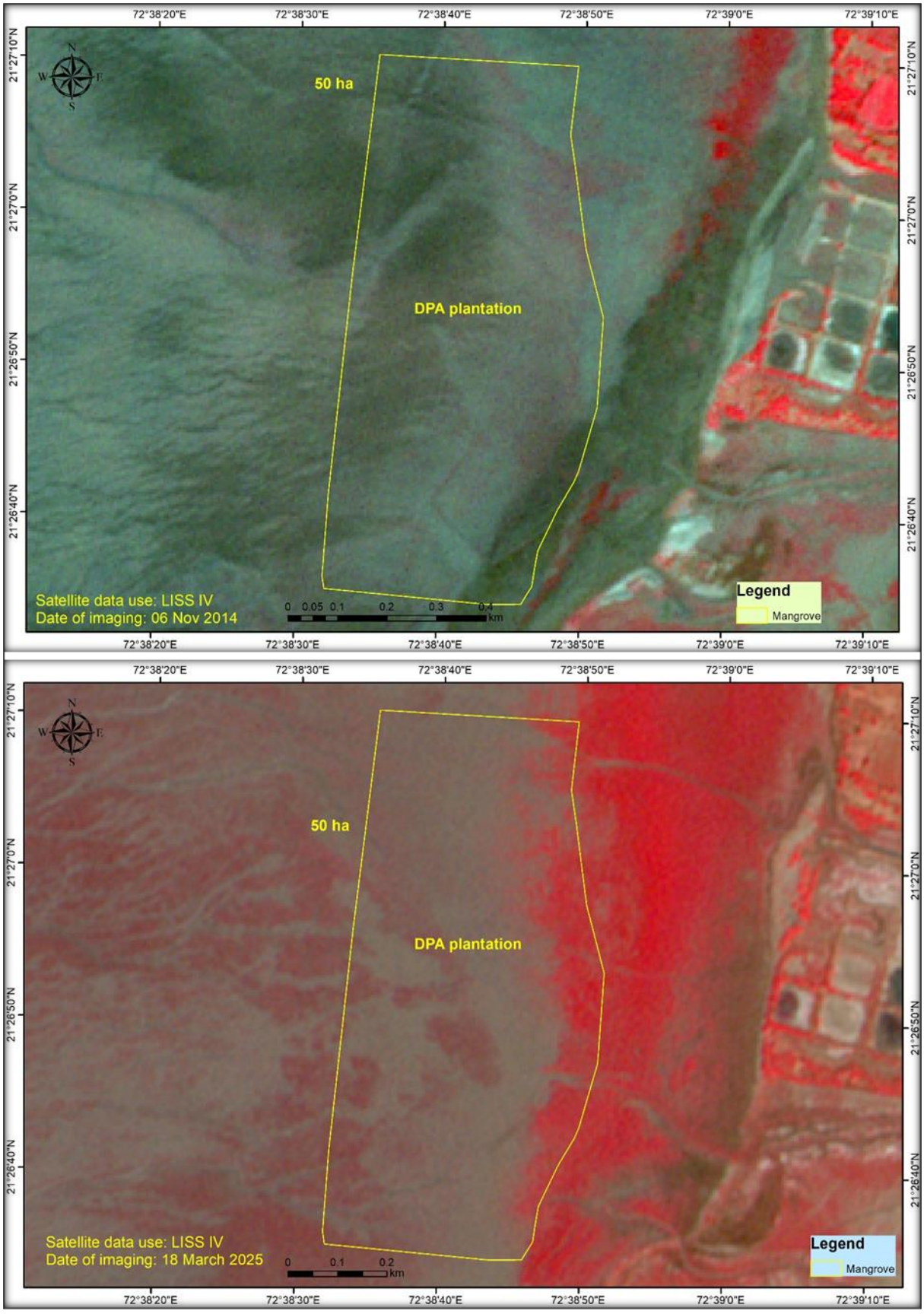

Figure 16: Satellite imageries of the 100 (50-2) Ha block-5 plantation site at Kantiyajal (2014 and 2025)

5.4 Regular mapping through GIS & RS

Mangrove plantations in 1600 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. The table 2 provides a comprehensive overview of sampling sites within a 1,600-hectare mangrove plantation in Gujarat, India, detailing specific blocks and sampling points across three locations: Sat Saida Bet and Nakti Creek in Kachchh district, and Kantiyajal in Bharuch district. Each site is divided into several blocks base on year of plantation in three different areas, with each block containing multiple sampling and GIS points identified by precise geographic coordinates. This structure enables systematic ecological monitoring by allowing researchers to track environmental changes across different spatial scales and habitats within the plantation. The detailed coordinates facilitate accurate mapping and comparison of ecological data, supporting effective management and conservation of these vital mangrove ecosystems.

Table 2. Comprehensive Details of GIS and Sampling Sites within the 1600-Hectare Mangrove Plantation in 2025

Sat Saida Bet, Kachchh district				Nakti Creek, Kachchh district				Kantiyajal, Bharuch District			
HA	Sampling point	Longitude	Latitude	HA	Sampling point	Longitude	Latitude	HA	Sampling point	Longitude	Latitude
	Block -1				Block -1				Block -1		
20	1	70° 17' 3"	23° 4' 25"	50	1	70° 7' 22"	22° 57' 55"	150	1	72° 38′ 52.63″	21° 31′ 38.34″
	2	70° 16' 53"	23° 4' 25"		2	70° 7' 46"	22° 57' 57"		2	72° 38′ 41.87″	21° 31′ 31.73″
					3	70° 7'37.07"	22°57'50.13"		3	72° 38′ 41.31″	21° 31′ 19.26″
									4	72° 38′ 44.87″	21° 31′ 8.35″
									5	72° 38′ 52.66″	21° 31′ 8.14″
									6	72° 38′ 53.9″	21° 30′ 57.95″
									7	72° 38′ 47.47″	21° 30′ 54.83″
	Block -2				Block -2				Block -2		
200	1	70° 15' 13"	23° 2' 37"	100	1	70° 8' 17"	22° 57' 34"	150	1	72° 38′ 55.72″	21° 28′ 15.14″
	2	70° 15' 11"	23° 2' 46"		2	70° 8' 18"	22° 57' 30"		2	72° 38′ 59.27″	21° 28′ 5.57″

	3	70° 15' 22"	23° 2' 44"		3	70° 8' 22"	22° 57' 35"		3	72° 38′ 46.93″	21° 28′ 4.47″
	4	70° 15' 18"	23° 2' 21"		4	70° 8' 31"	22° 57' 28"		4	72° 38′ 34.92″	21° 28′ 8.45″
	5	70° 15' 29"	23° 2' 25"		5	70° 8' 32"	22° 57' 23"		5	72° 38′ 29.21″	21° 28′ 13.88″
	6	70° 15' 40"	23° 2' 34"						6	72° 38′ 26.62″	21° 27′ 58.01″
	7	70° 15' 52"	23° 2' 40"						7	72° 38′ 50.13″	21° 27′ 56.08″
	8	70° 15' 49"	23° 2' 48"								
	9	70° 15' 40"	23° 2' 43"								
	10	70° 15' 27"	23° 2' 36"								
Block -3				Block -3				Block -3			
300	1	70° 15' 41"	23° 0' 40"					50	1	72° 38′ 46.3″	21° 27′ 4.29″
	2	70° 15' 43"	23° 0' 35"						2	72° 38′ 41.64″	21° 26′ 52.77″
	3	70° 15' 38"	23° 0' 29"						3	72° 38′ 44.8″	21° 26′ 41.13″
	4	70° 15' 34"	23° 0' 37"								
	5	70° 15' 31"	23° 0' 44"								
	6	70° 15' 26"	23° 0' 47"								
	7	70° 15' 22"	23° 0' 46"								
	8	70° 15' 5"	23° 0' 47"								
	9	70° 15' 7"	23° 0' 54"								
	10	70° 15' 1"	23° 0' 55"								

	11	70° 14' 55"	23° 0' 55"								
	12	70° 14' 52"	23° 0' 50"								
	13	70° 14' 49"	23° 0' 53"								
	14	70° 14' 47"	23° 0' 57"								
	15	70° 14' 42"	23° 1' 1"								
Block -4				Block -4				Block -4			
330	1	70° 17' 38"	23° 4' 30"					50	1	72° 38′ 51.29″	21° 27′ 32.55″
	2	70° 17' 50"	23° 4' 24"						2	72° 38′ 51.43″	21° 27′ 22.37″
	3	70° 17' 25"	23° 4' 31"						3	72° 38′ 49.22″	21° 27′ 17.0″
	4	70° 17' 10"	23° 4' 37"								
	5	70° 17' 55"	23° 4' 13"								
	6	70° 17' 42"	23° 4' 23"								
	7	70° 17' 15"	23° 4' 45"								
	8	70° 17' 27"	23° 4' 38"								
	9	70° 17' 35"	23° 4' 41"								
	10	70° 17' 42"	23° 4' 41"								
	11	70° 17' 47"	23° 4' 38"								
	12	70° 17' 54"	23° 4' 34"								
	13	70° 17' 16"	23° 4' 53"								
	14	70° 17' 24"	23° 4' 50"								
	15	70° 17' 31"	23° 4' 52"								
Block -5				Block -5						Block -5	

50	1	70°17'12.44"	23° 4'20.00"					50	1	72° 38′ 3.7″	21° 32′ 25.84″
	2	70°17'11.03"	23° 4'13.28"						2	72° 38′ 8.14″	21° 32′ 11.76″
	3	70°17'21.64"	23° 4'12.93"						3	72° 38′ 22.07″	21° 32′ 8.35″
Block -6				Block -6						Block -6	
100	1	70° 14' 18"	22° 59' 34"								
	2	70° 14' 31"	22° 59' 34"								
	3	70° 14' 40"	22° 59' 46"								
	4	70° 14' 56"	22° 59' 46"								

6. Results

The mangrove monitoring study results of the three sites, Nakti creek Kantiyajal and Sat Saida bet during 2025 are presented below.

6.1 Monitoring of mangrove plantation at Sat-Saida Bet

The 20 ha mangrove plantation was carried out at the Sat-Saida Bet near DPA port, Kandala. This plantation was carried out during the year 2005-06 by Gujarat institute of Desert Ecology, executed this plantation with the help of community participation. The results showing a high tree density of 2,200 trees per hectare. The average tree height is reported as 139.09 cm, while the average girth is 10.36 cm indicating relatively young or slender trees. The average canopy width is 2.3 meters, suggesting moderate foliage coverage. Overall, this area appears to be densely populated with slim, possibly young trees, and the height value should be double-checked for accuracy (Plate 1).

Plate 1: Mangrove plantation 20 Ha at Sat Saida Bet site Block- 1 during a visit in 2025

The Plate 2 and figure 17 and 18 shows information from ten quadrants (Q1-Q10) within a 200-hectare area, including tree density, average height, and girth, ocular diameter of the trunk and canopy cover. Densities have quite a range of 1,200 to 3,800 trees per quadrant. Tree heights and girths do not differ tremendously, but the canopy cover is rather balanced with some quadrants such as Q5 having fairly high canopy values compared to all other quadrants density, while other quadrants like Q7 and Q10 with very high density having lower canopy values. This implies that greater tree density does not always result in increased canopy cover due to competition for resources affecting the tree growth and canopy expansion. Collectively, the data reveals the diversity in the structure of forests throughout the area sampled.

Plate 2: Mangrove plantation 200 Ha at Sat Saida Bet site Block- 2 during a visit in 2025

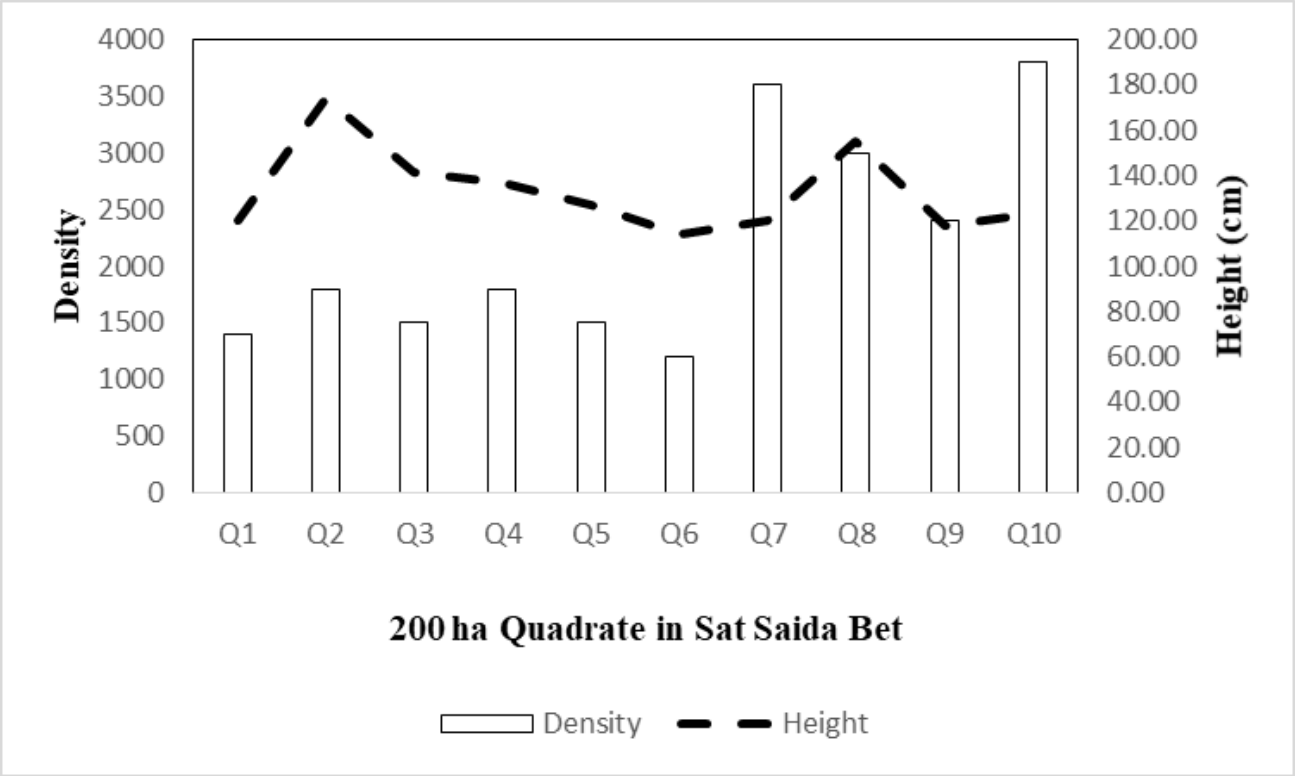

Fig.17 Details of density (No) and height of mangroves in 200 ha plantation area in 2011-2012 at Sat Saida Bet.

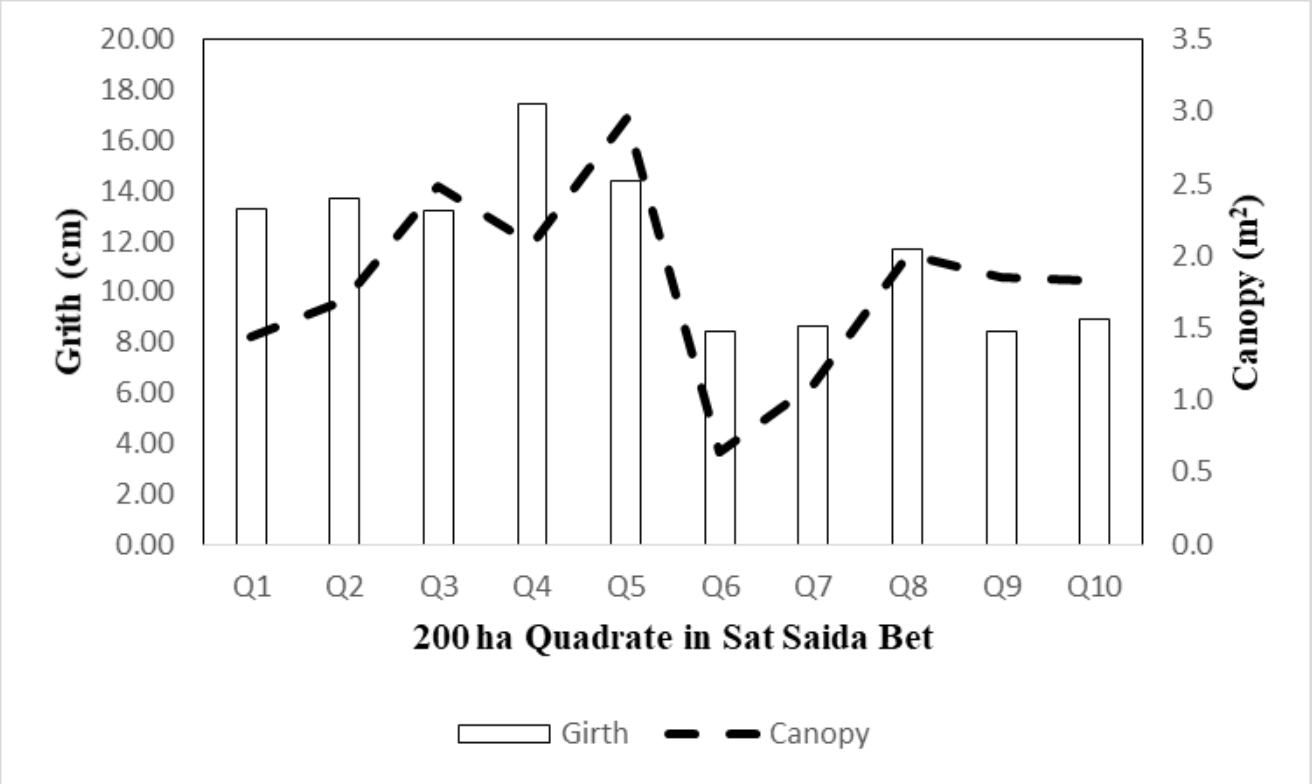

Fig. 18 Details of Canopy and Basal Girth of mangroves in 200 ha plantation area in 2011-2012 at Sat Saida Bet.

The monitoring result information related to a 300-hectare site presented in the figure 19 and 20 and plate 3 demonstrates that density of trees in this area ranges from 1300 to 2600 individuals at its peak in Q5 and lowest in Q8. Average height of the trees is from 128 to142 cm with the highest in Q6 whereas girth ranges from 11.73 to 15 cm, maxima in Q3. Canopy cover usually increases with value of height and is at its max Q6 of 2.01 and min of 1.61 m^2. The data can be interpreted that degree of density does not correlate with amount of height or girth.

Plate 3: Mangrove plantation 300 Ha at Sat Saida Bet site Block- 3 during a visit in 2025

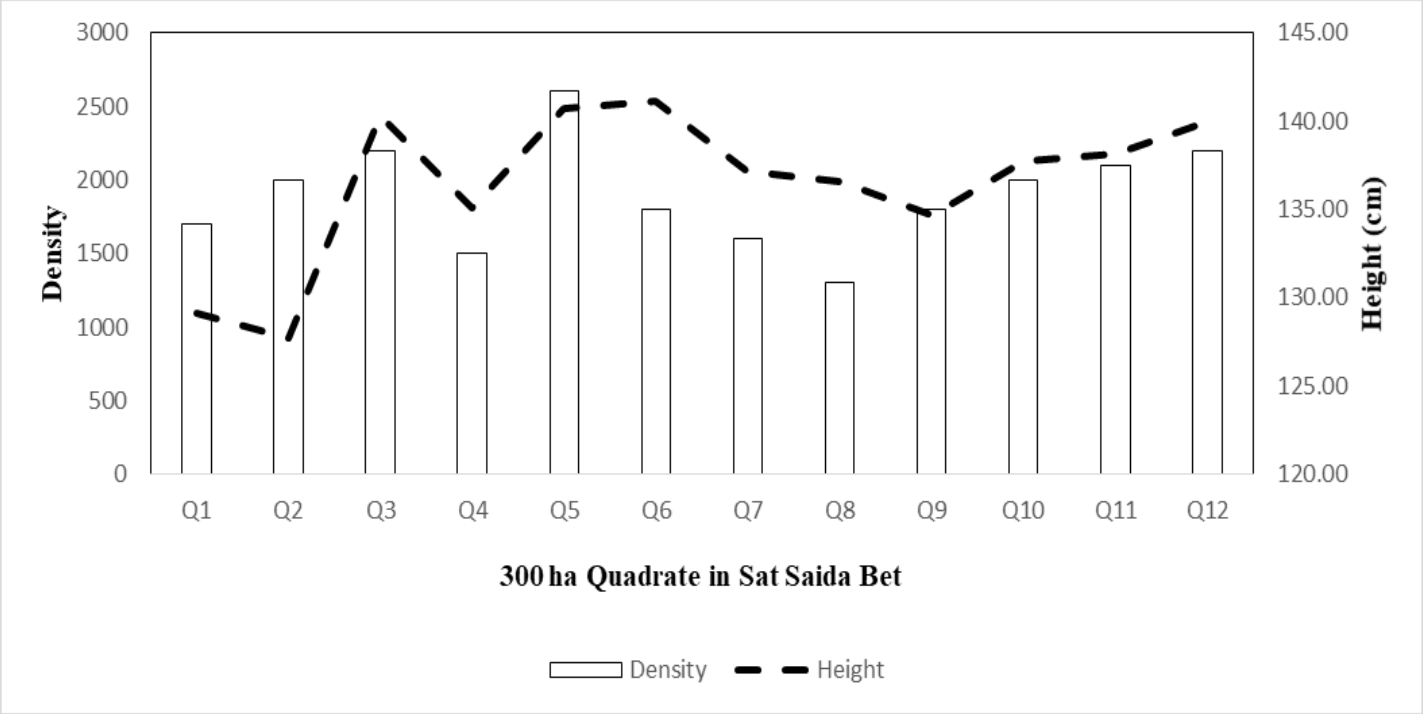

Fig.19 Details of density (No) and height of mangroves in 300 ha plantation area in 2012-2013 at Sat Saida Bet.

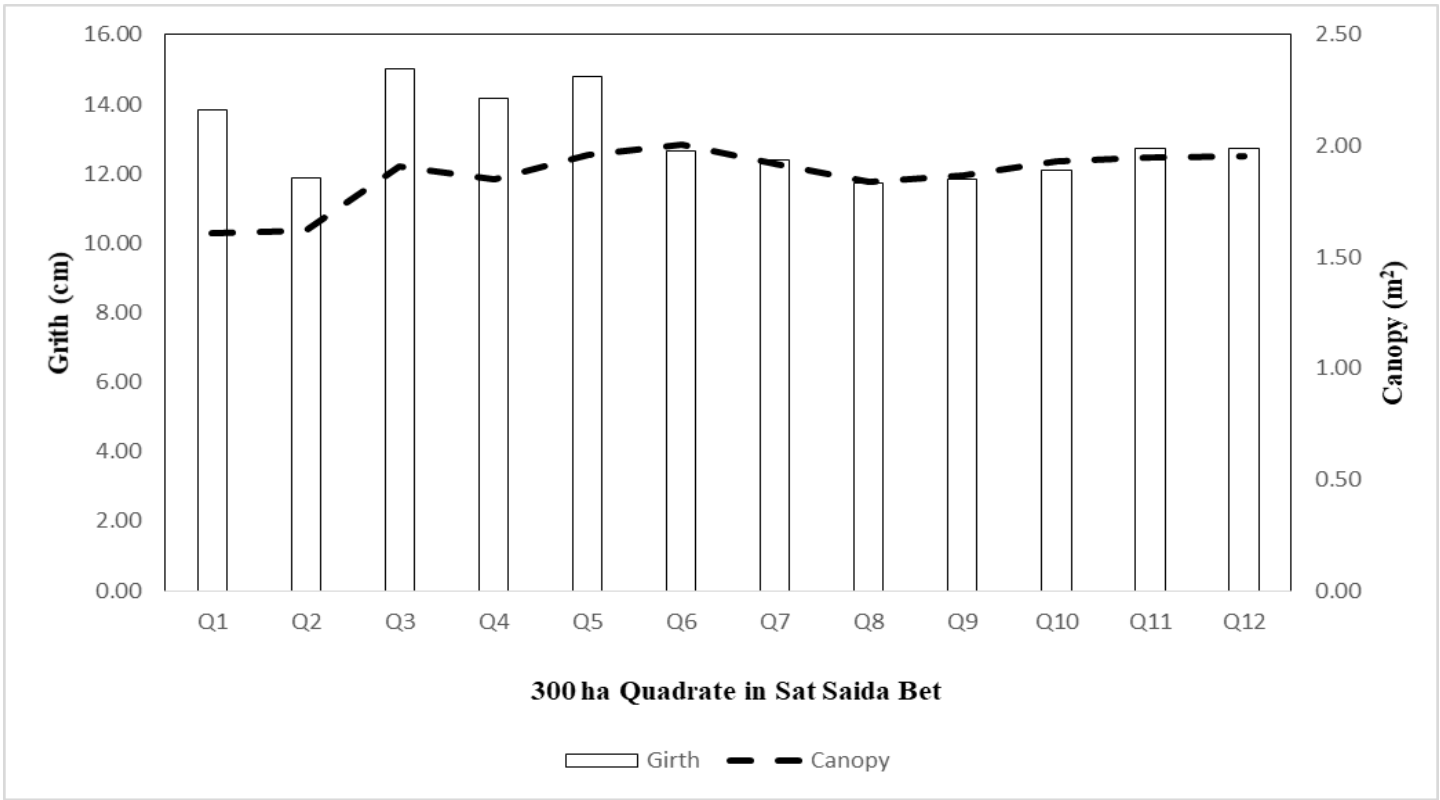

Fig.20 Details of Canopy and Basal Girth of mangroves in 300 ha plantation area in 2012-2013 at Sat Saida Bet.

The plate 4 and figure 21 and 22 shows the data on tree measurements across fourteen (Q1 to Q14) quadrants within an area of 330 ha detailing density, height, girth and canopy spread. The density seems to vary in a very wide range of 1300 to 4000 trees/ha, with a greater density often relating to lesser girth and canopy size which indicates that there is competition for resources. The height of the trees measured ranges from 127cm to 185cm, the girth ranges from 8 to 15 cm and the canopy spread from 1.08 to 3.12 m^2. It is worth mentioning that quadrants which contain lower density like Q5 and Q11 tend to have their girth and canopy size greatly expanded hence suggesting that trees which are in sparser regions are able to grow broader and larger in canopies.

Plate 4: Mangrove plantation 330 Ha at Sat Saida Bet site Block- 4 during a visit in 2025

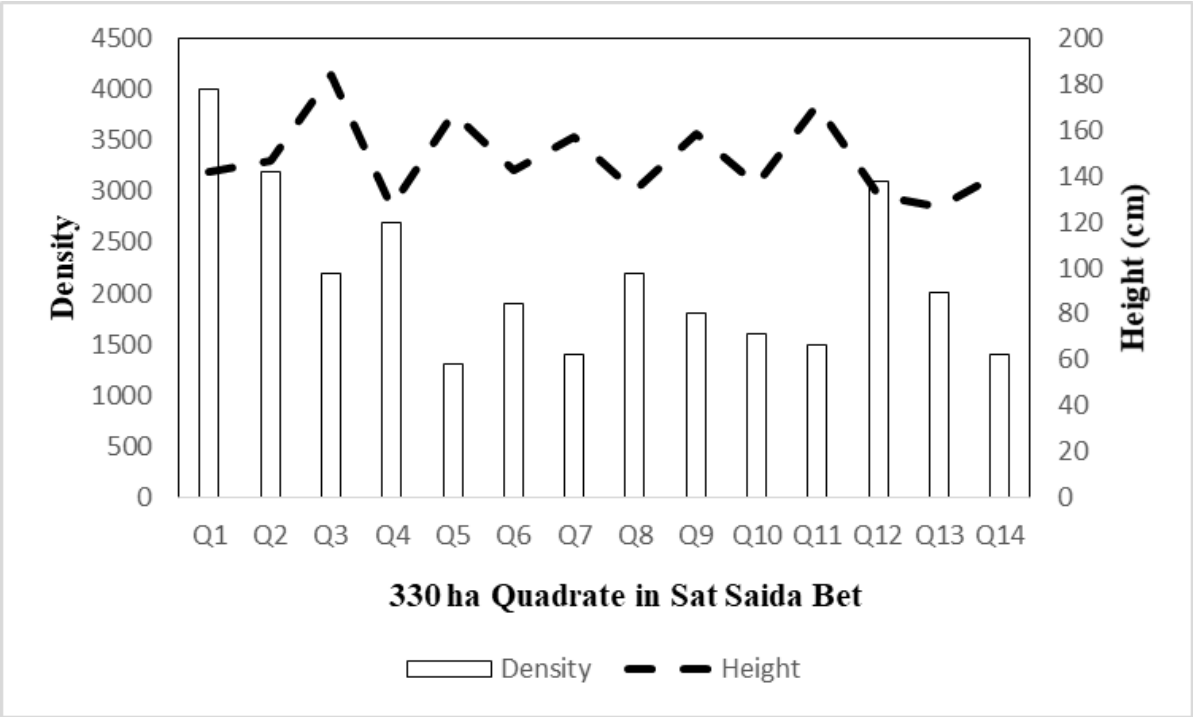

Fig. 21 Details of density (No) and height of mangroves in 330 ha plantation area in 2013-2014 at Sat Saida Bet

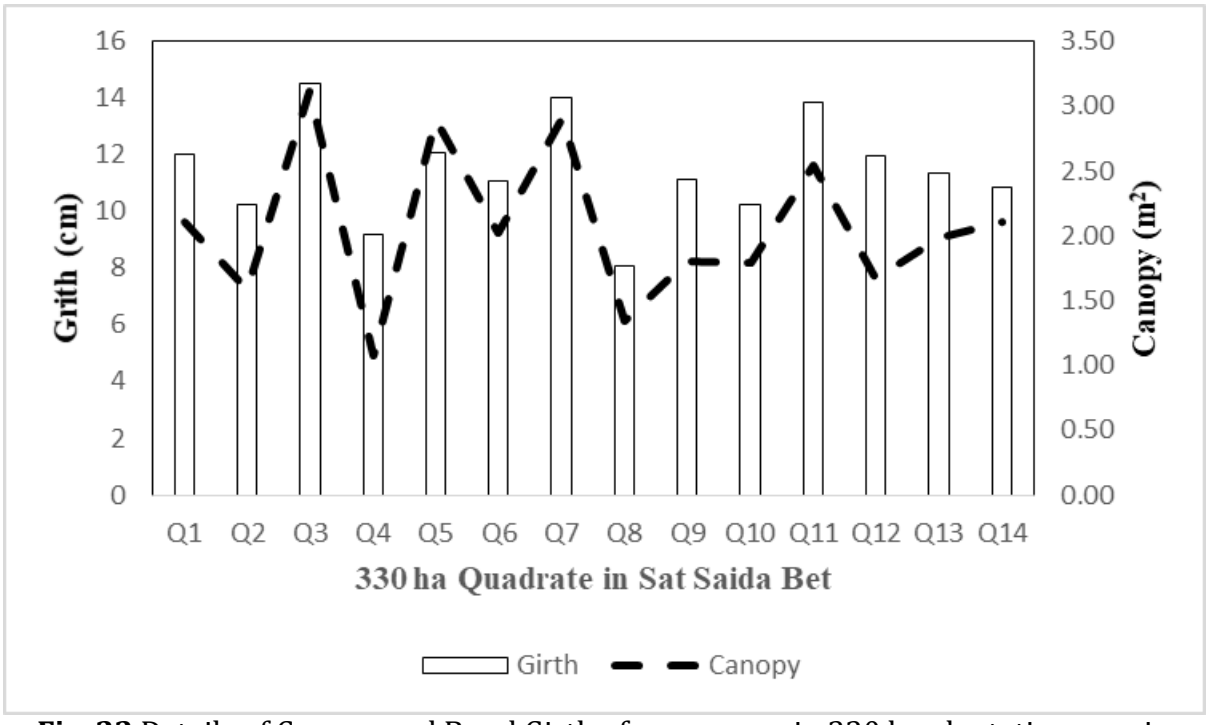

Fig. 22 Details of Canopy and Basal Girth of mangroves in 330 ha plantation area in 2013-2014 at Sat Saida Bet.

The figures 23 and 24; plate 5 illustrate that in a 50 hectare area in Sat Saida Bet, Q1 sustains the highest tree density at 2200 trees as well as the tallest average height of 133.64 and also has the largest average girth of 15.18 and broadest average canopy of 1.8 indicating a more mature. In addition, Q2 and Q3 have even lower densities of 900 and 1200 trees respectively alongside progressively smaller average height, girth, and canopy values suggesting these areas are relatively younger, less established, or more disturbed in comparison to Q1.

Plate 5: Mangrove plantation 50 Ha at Sat Saida Bet site Block- 5 during a visit in 2025

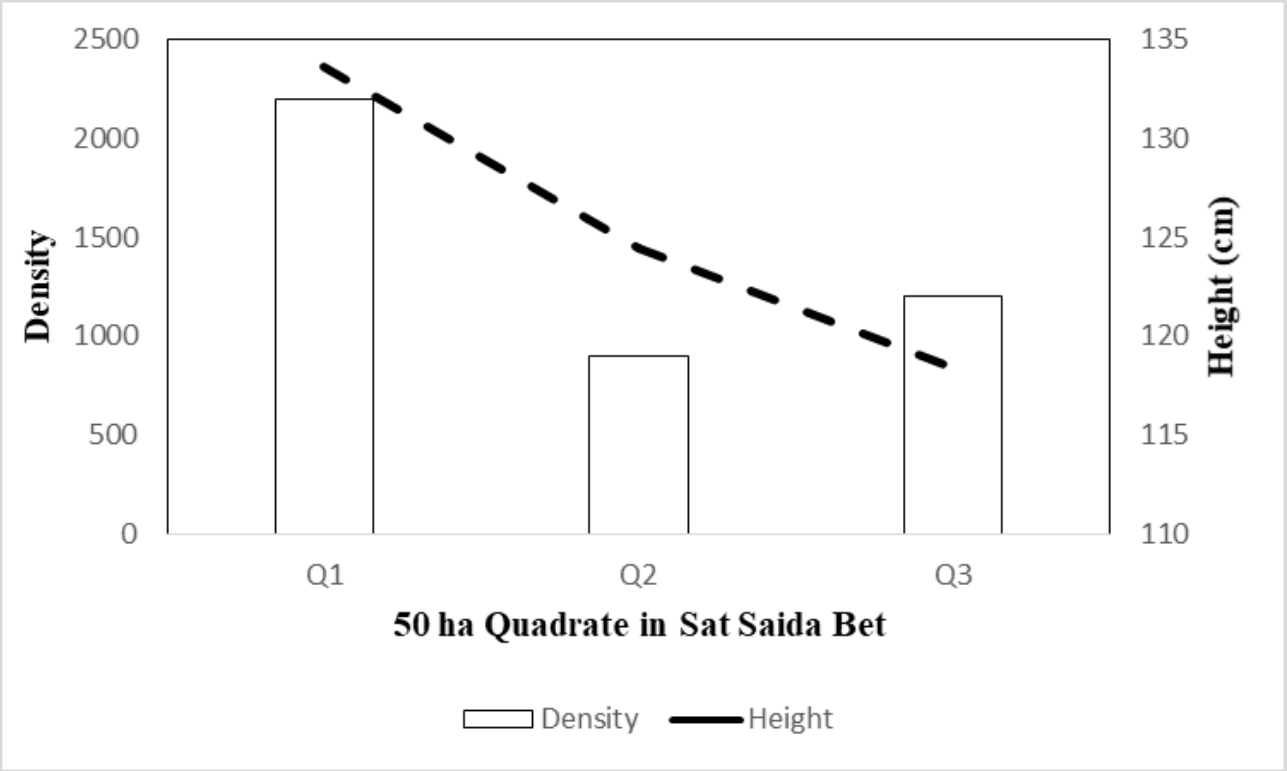

Fig.23 Details of density (No) and height of mangroves in 50 ha plantation area in 2018-2019 at Sat Saida Bet.

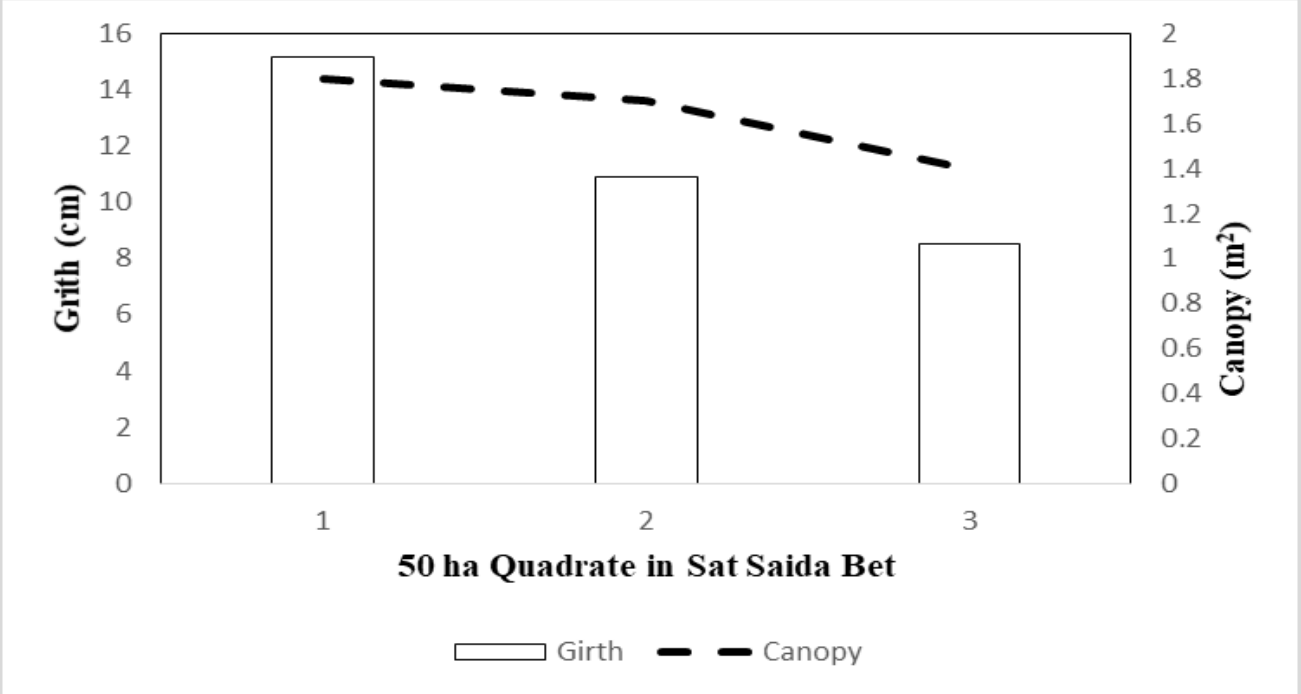

Fig. 24 Details of Canopy and Basal Girth of mangroves in 50 ha plantation area in 2018-2019 at Sat Saida Bet.

The tree population data regarding their density, height, girth, and canopy spread is presented through five quadrants (Q1–Q5) in a 100-hectare range. Q1 has the highest trees that measure 224 cm as well as having the largest girth of 17 cm and the highest canopy cover of 5.60 m^2; though having moderate density of 1000. On the contrary, Q2 displays the lowest density of 100, shortest trees of 100 measuring the smallest girth of 7 cm, and the lowest canopy of 0.72 m^2 which points towards undeveloped sparse vegetation. Q4 has the highest density (1300) average tree height of (115), girth (8), moderate canopy of (1.15) indicating denseness but less mature trees. Q3 and Q5 display median ranges for all parameters. It can also be seen from the data that forest structure is most characteristic in Q1 which shows a stand of fewer taller trees, as opposed to Q4 which has more, but smaller trees. (Plate 6; Figure 25 and 26). There are few natural grow trees are observed.

Plate 6: Mangrove plantation 100 Ha at Sat Saida Bet site Block- 6 during a visit in 2025

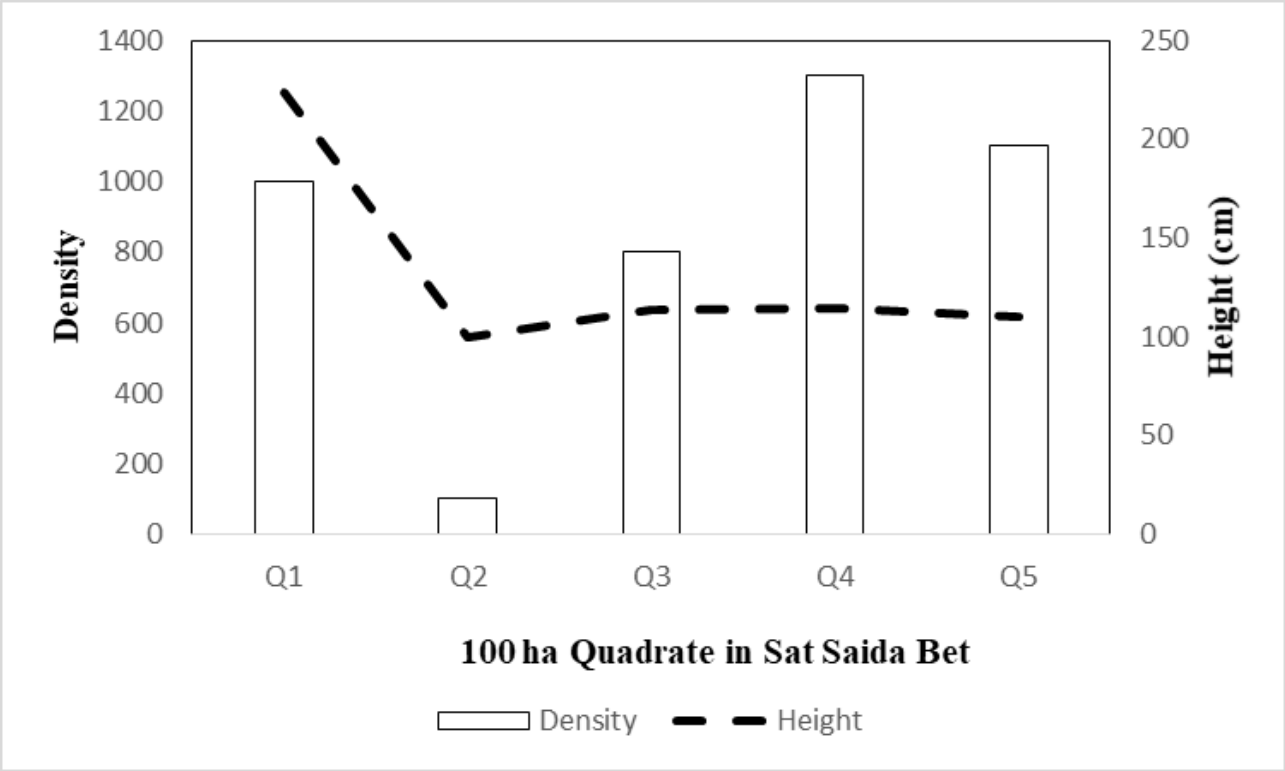

Fig. 25 Details of density (No) and height of mangroves in 100 ha plantation area in 2022-2023 at Sat Saida Bet

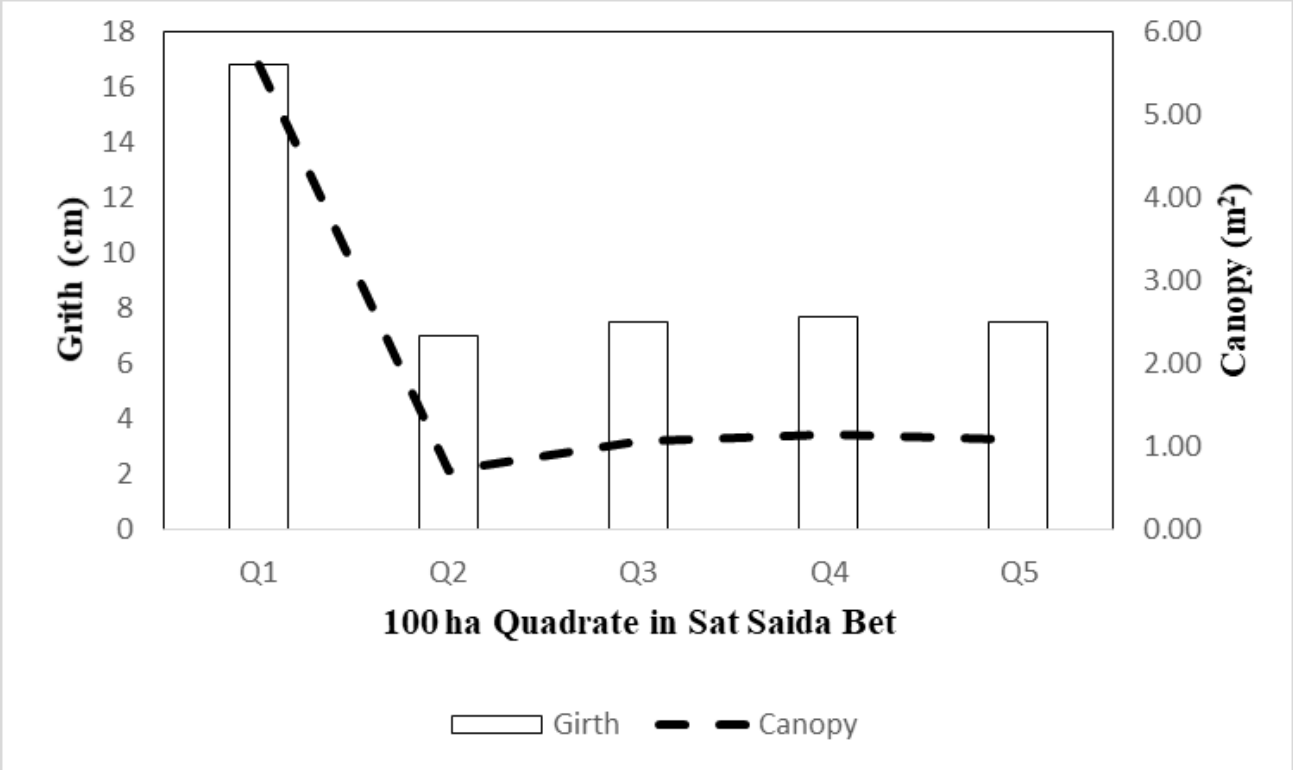

Fig. 26 Details of Canopy and Basal Girth of mangroves in 100 ha plantation area in 2022-2023 at Sat Saida Bet.

6.2 Monitoring of mangrove plantation at Nakti Creek

The figure 27 and 28; Plate 7 summarizes the structural characteristics of mangroves in a 50-hectare plantation at Nakti Creek during 2008-2009, comparing two quadrants (Q1 and Q2). Q1, with a higher density of 1500 trees per hectare, shows smaller average tree height (175 cm), basal girth (9 cm), and canopy spread (2.0 m). In contrast, Q2, with a lower density of 500 trees per hectare, has mangroves that are taller (182 cm), have thicker trunks (11 cm girth), and wider canopies (3.7 m).

Plate 7: Mangrove plantation 50 Ha at Nakti Creek site Block- 1 during a visit in 2025

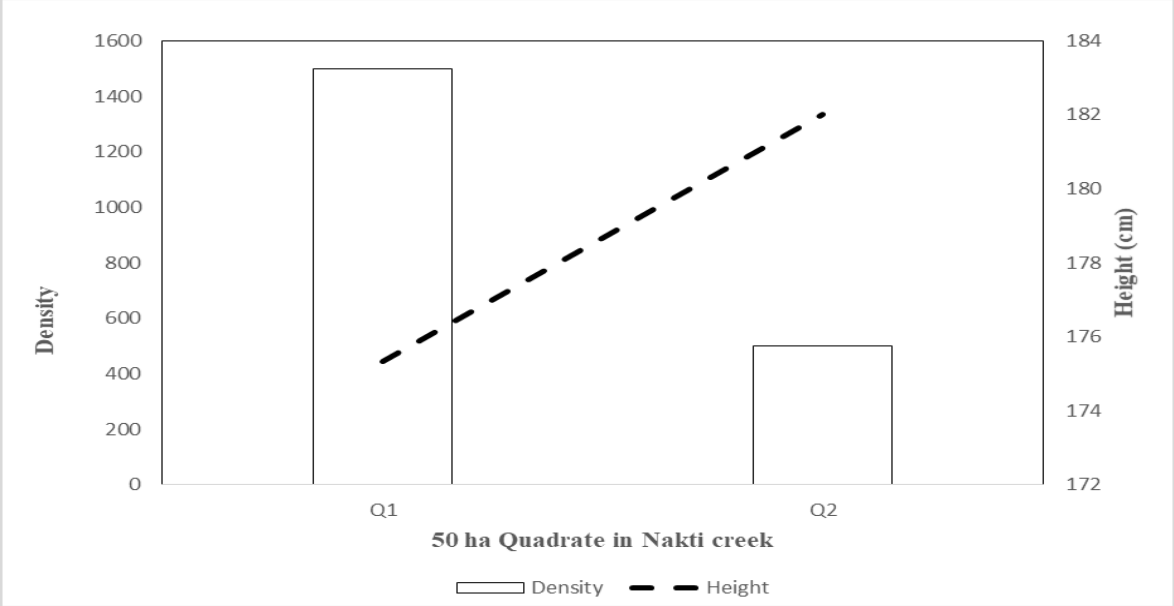

Fig. 27 Details of density (No) and height of mangroves in 50 ha plantation area in 2008-2009 at Nakti Creek.

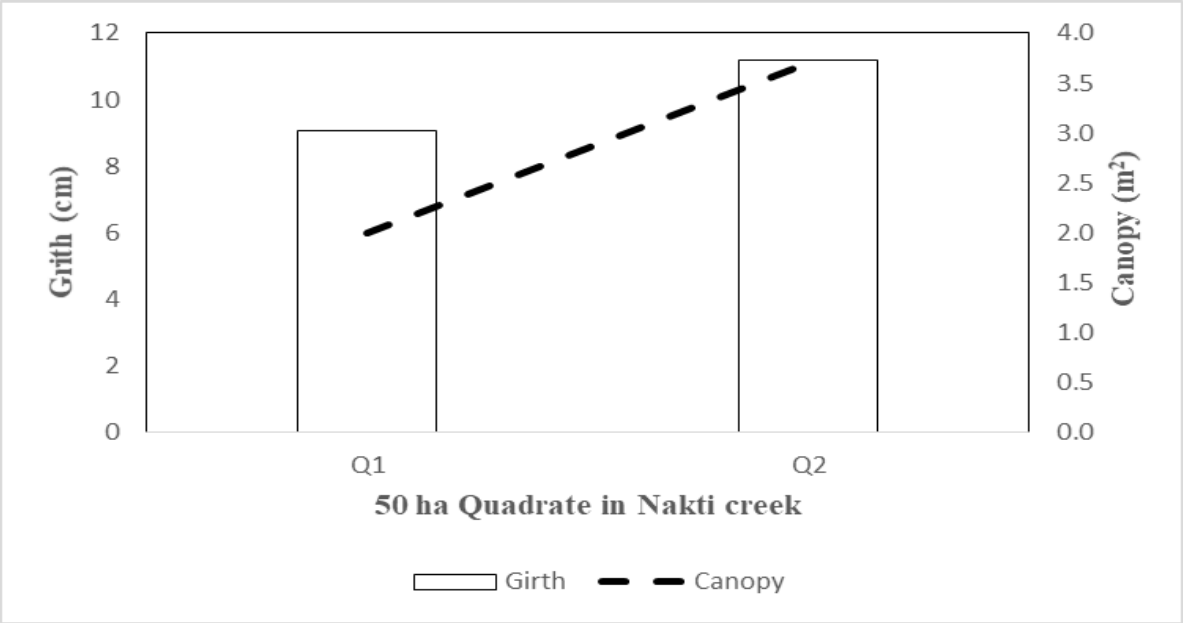

Fig. 28 Details of Canopy and Basal Girth of mangroves in 50 ha plantation area in 2008-2009 at Nakti Creek.

The Figure 29 illustrates the variations in tree density, height, girth and canopy size in five quadrants (Q1-Q5) over a 100 hectare mangrove plantation area in 2010-2011, which shows remarkable differences across that space. Q2 contains the greatest tree density (1600/Ha) along with a height that is above average (156 m) and broad canopy (3.8 m). Q5 contains the lowest density trees (1000/Ha), but reaches remarkable height (171 m) signifying that lesser competition might allow stretched growth. Moderate density in Q3 possessing the thickest trunks (15 cm girth) along with 3.5 m wide canopy could identify older or stouter trees. Q1 without exception has lower values for each of the parameters which suggests younger trees or less competitive stands, whereas Q4 shows intermediate figures 30 and plates 8.

Plate 8: Mangrove plantation 100 Ha at Nakti Creek site Block- 2 during a visit in 2025

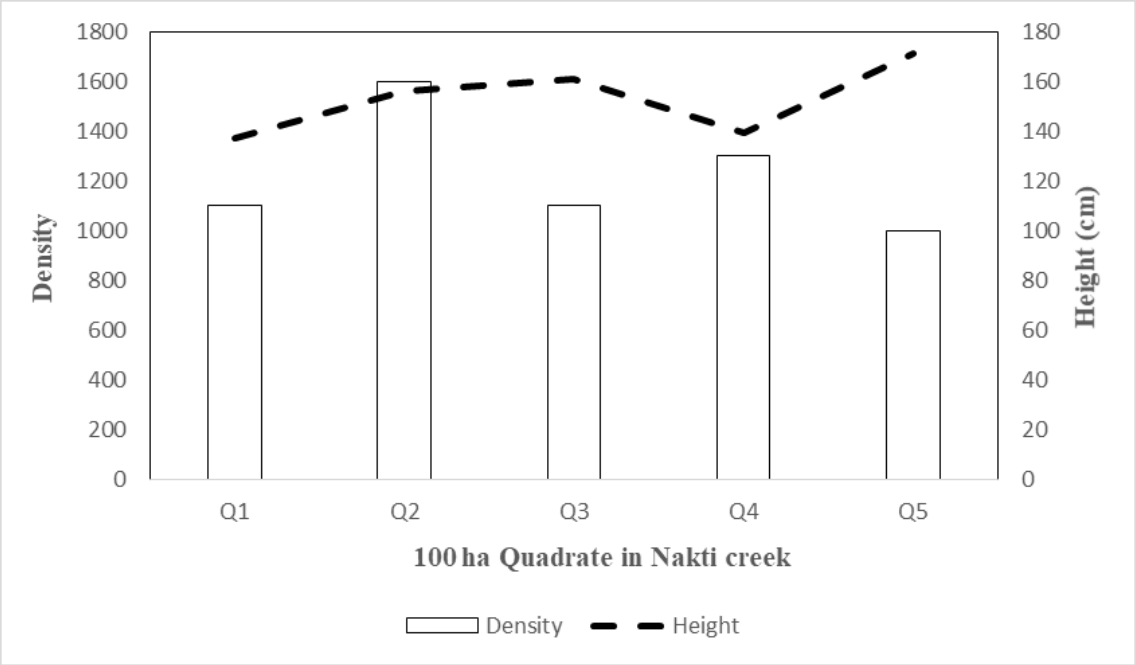

Fig.29 Details of density (No) and height of mangroves in 100 ha plantation area in 2010-2011 at Nakti Creek

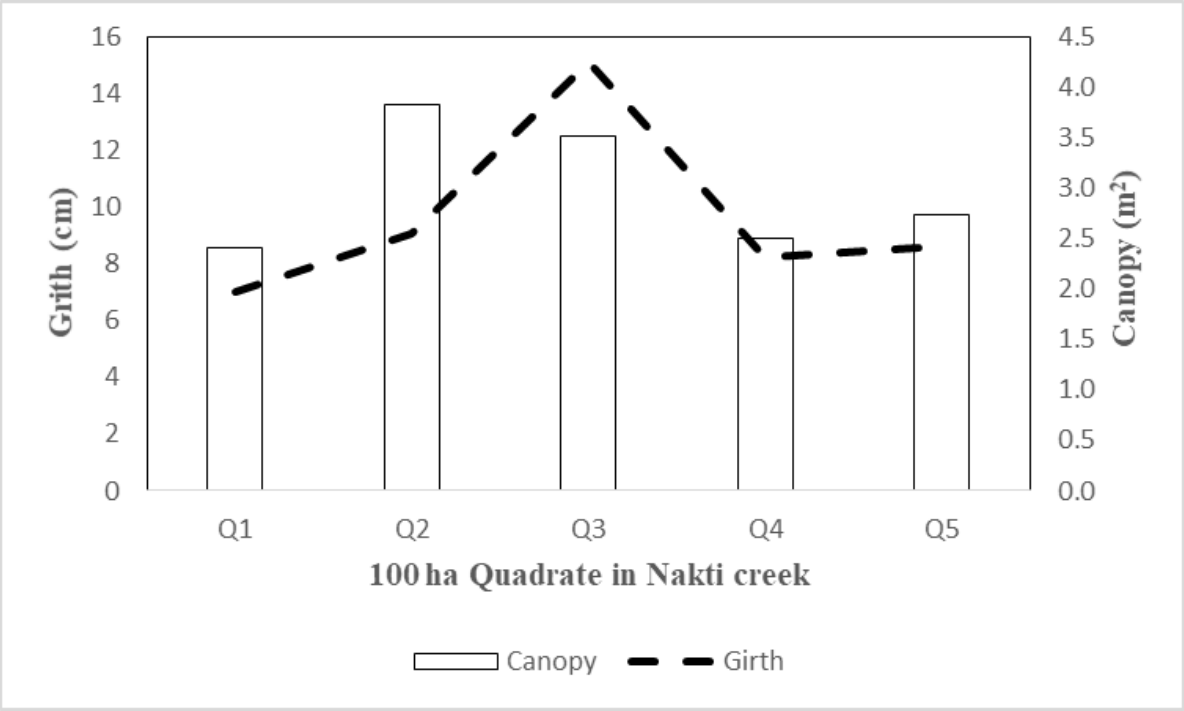

Fig.30 Details of Canopy and Basal Girth of mangroves in 100 ha plantation area in 2010-2011 at Nakti Creek.

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6.3 Monitoring of mangrove plantation at Kantiyajal

The plate 9 and figure 31 and 32 illustrates the data of tree density, mean height, girth and canopy size of individual quadrants from seven quadrants (Q1 – Q7) that lie within a 150-hectare area at kantiyajal mangrove plantation area. The values exhibit considerable: densities were found between 500 and 1200, height ranged from 108 to 152 cm, girth was between 7 and 12 cm, and canopy span varied from 0.51 to 2.29 m^2, Q2 contains the highest trees (152) but Q2 has the moderate canopy (1.24 m^2). Furthermore, Q1 and Q5 have the greater canopies (2.29 and 2.07 m^2) but have average heights. Such data can be used to study forest structure, tree growth, and the habitat diversity in the surveyed region.

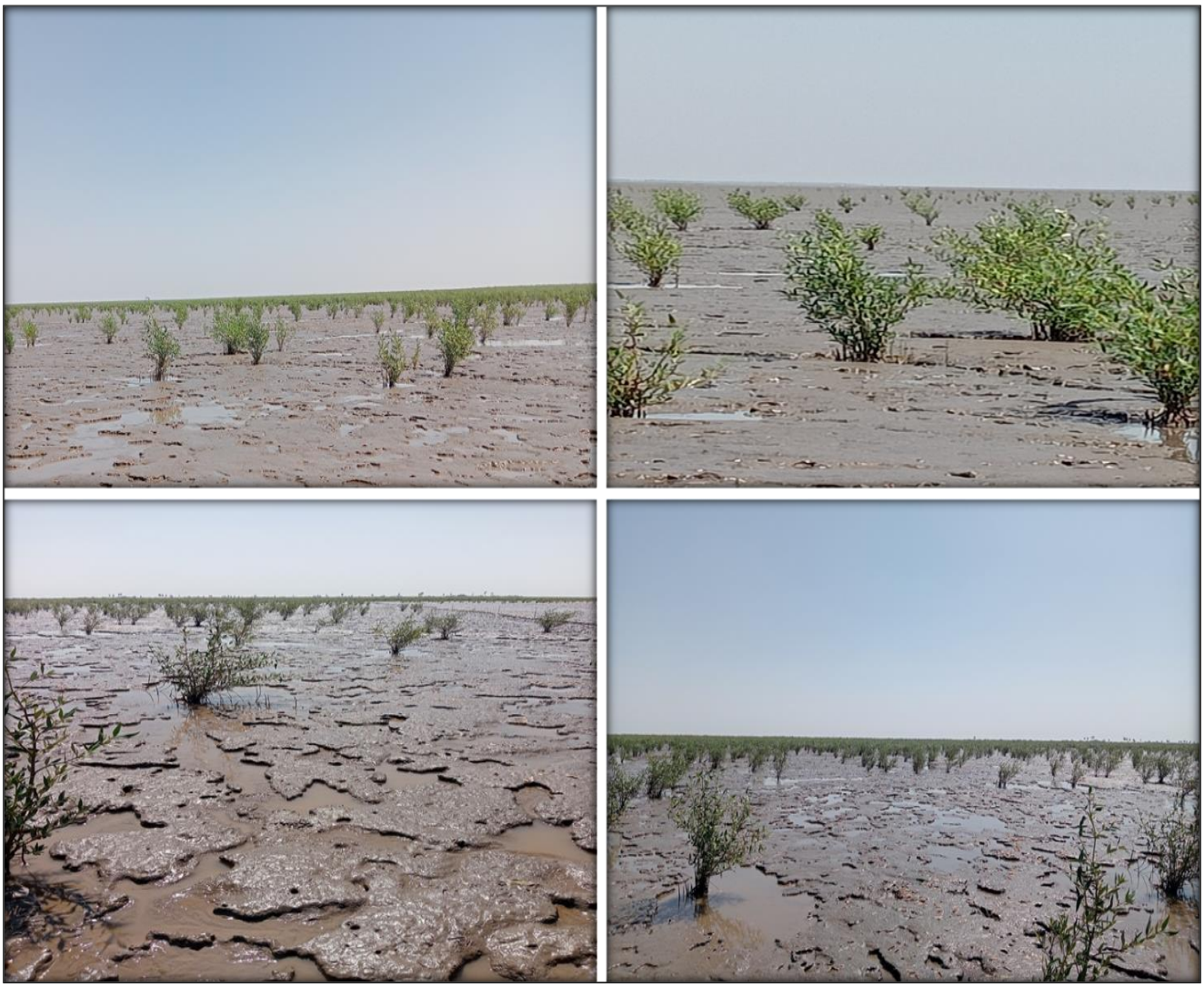

Plate 9: Mangrove plantation 150 Ha at Kantiyajal site Block- 1 during a visit in 2025

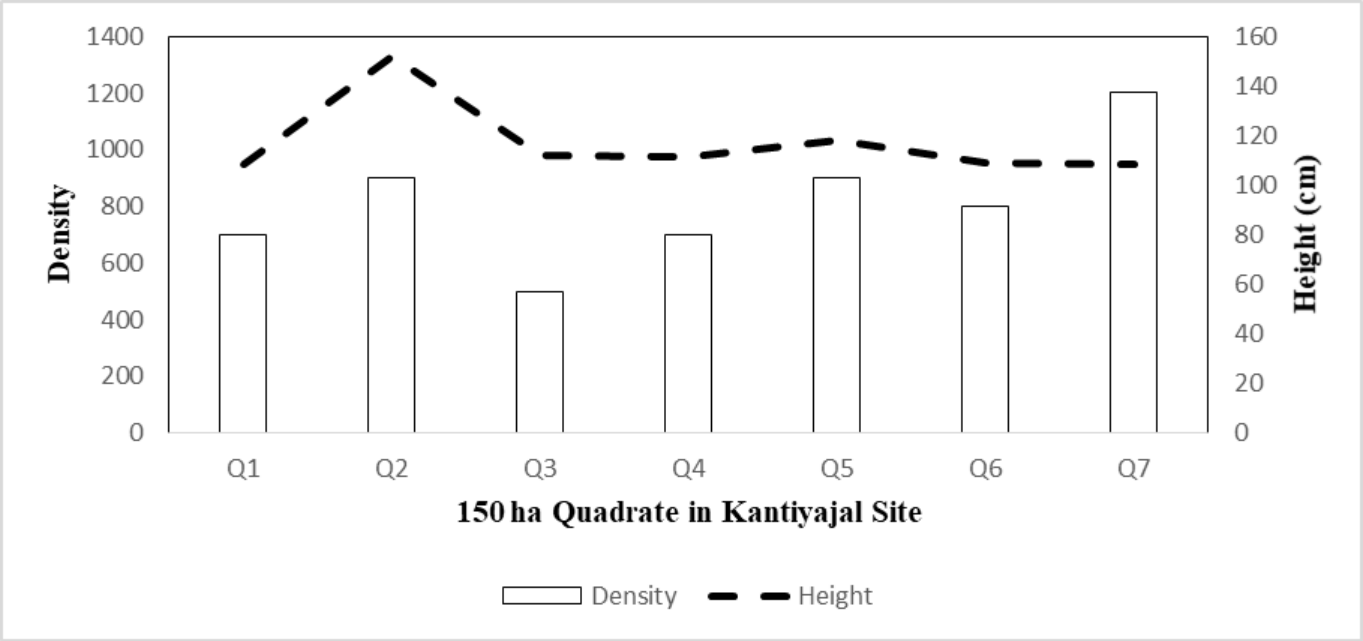

Fig.31 Details of density (No) and height of mangroves in 150 ha plantation area in 2015-2016 at Kantiyajal site

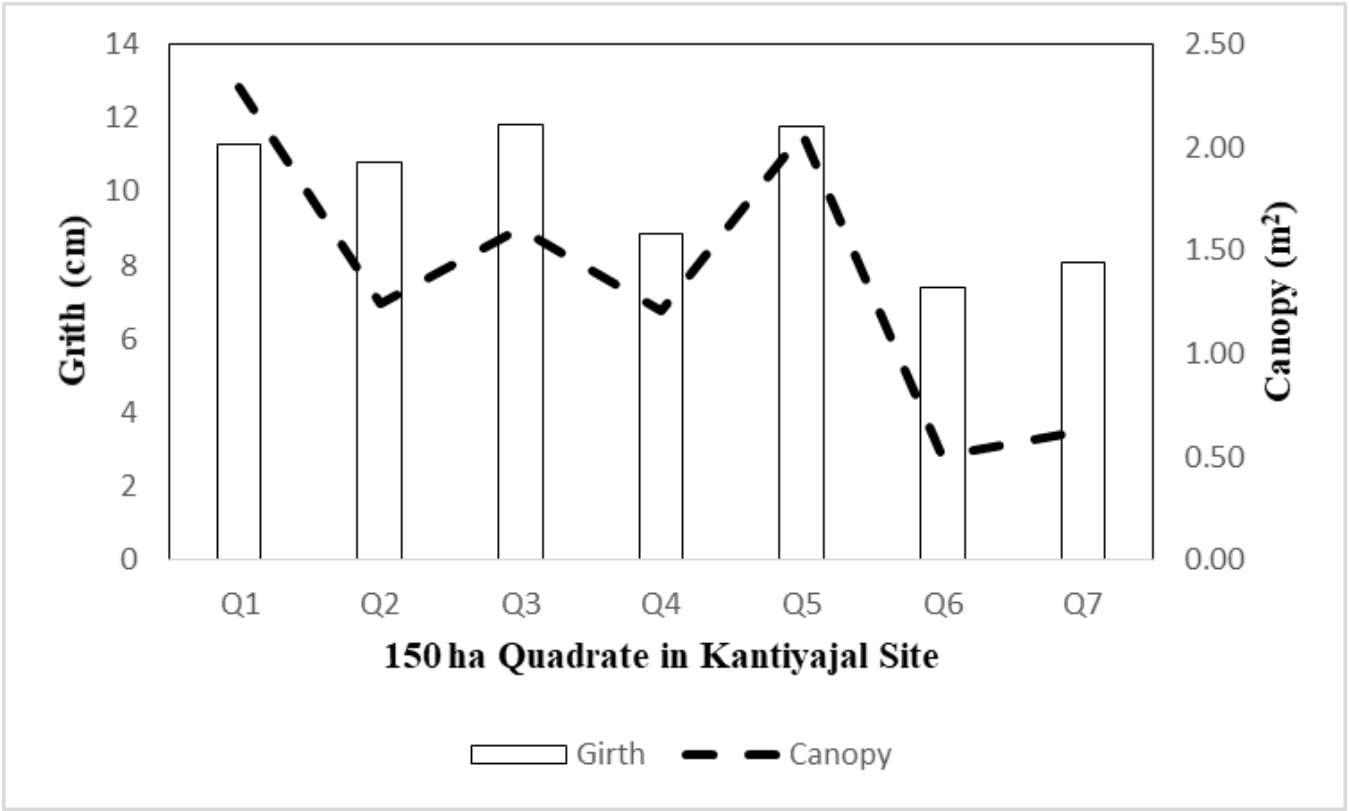

Fig.32 Details of Canopy and Basal Girth of mangroves in 150 ha plantation area in 2015-2016 at Kantiyajal site

The plate 10 shows the area where 150 ha were mangrove planted from 2016 to 2017. Since this area were many sparse mangroves with a height of less than 70 cm and a girth of less than 8 cm. The densities values also very low compare to other site were significant between 500 and 800 plants/ ha.

Plate 10: Mangrove plantation 150 Ha at Kantiyajal site Block- 2 during a visit in 2025

Plate 11: Mangrove plantation 50 Ha at Kantiyajal site Block- 3 during a visit in 2025

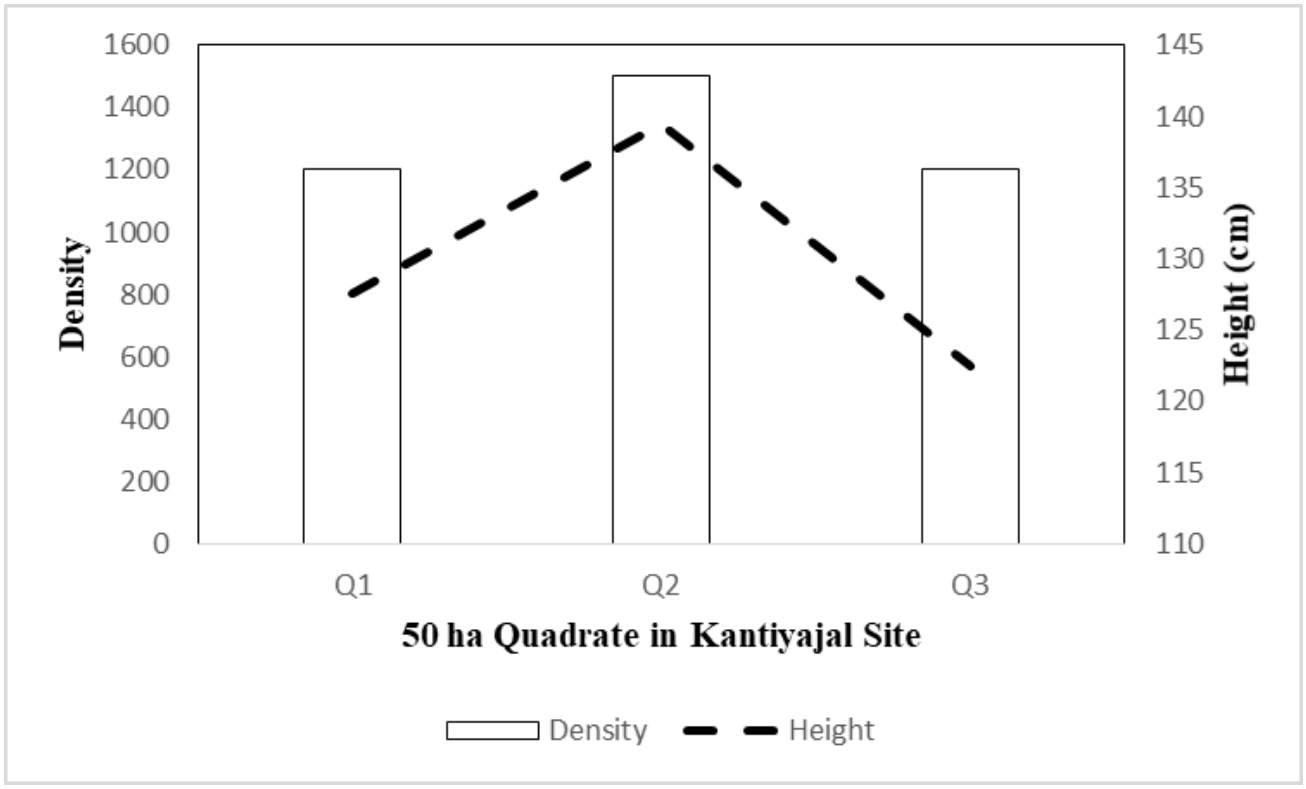

Fig.33 Details of density (No) and height of mangroves in 50 ha plantation area in 2018-2019 at Kantiyajal site

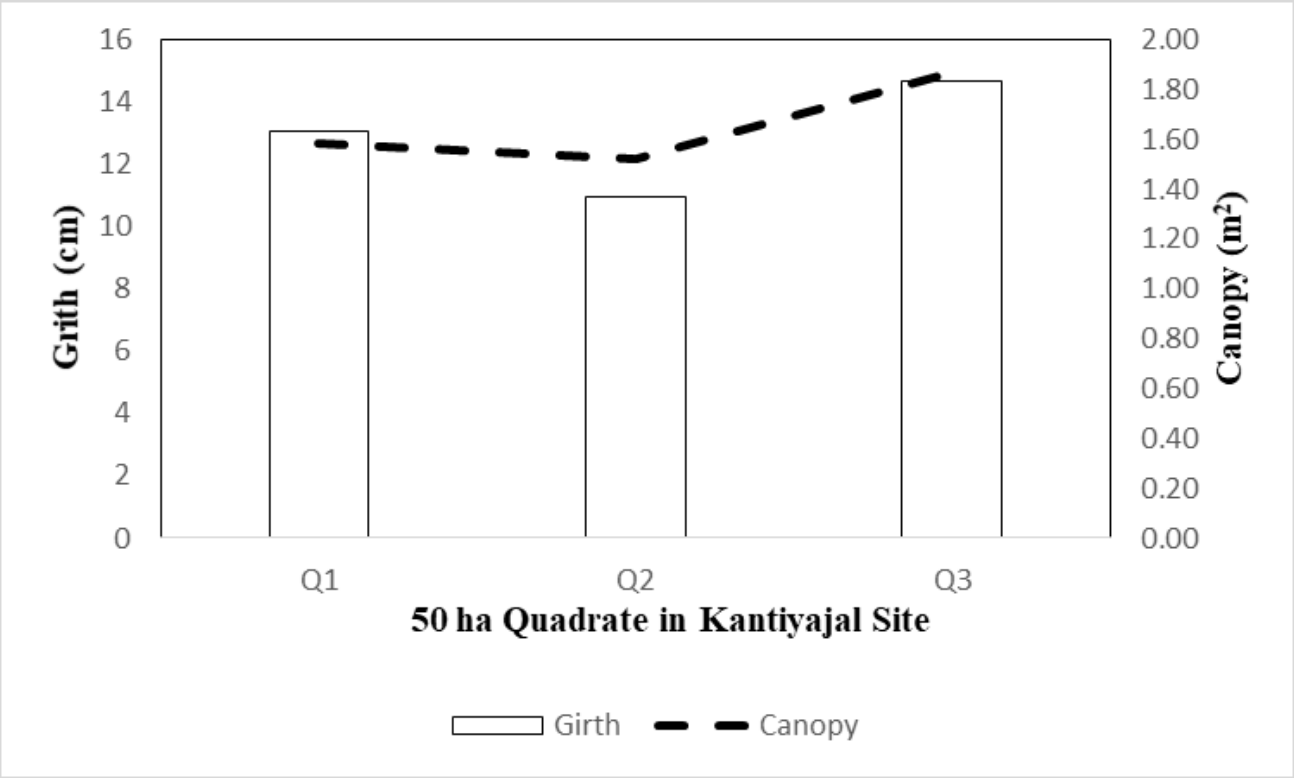

Fig.34 Details of Canopy and Basal Girth of mangroves in 50 ha plantation area in 2018-2019 at Kantiyajal site

The plate 12 shows that 50 mangrove plantation area planted area 2021 to 2022. The area was sparse so many mangrove less than 50 cm height and girth less than 6 cm. The values exhibit considerable, densities were found less than 300.

Plate 12: Mangrove plantation 100 (50-1) Ha at Kantiyajal site Block- 4 during a visit in 2025

The plate 13 and figure 35 and 36 presents data for three quarters (Q1, Q2, Q3) over a 50-hectare area in mangrove plantation 100 (50-2) Ha area in 2021-2022 at Kantiyajal site , showing tree density, average height, girth, and canopy size. In Q1, the density is 600 trees/ha, height is 116 cm, girth is 7 cm, and canopy is 3.4 m^2. In Q2, density increases to 700, height slightly decreases to 113 cm, girth remains 7 cm, but canopy drops sharply to 0.8 m^2. By Q3, density peaks at 1000, height rises to 123 cm, girth increases to 7.40 cm, and canopy recovers to 1.7 m^2. Overall, the data suggests fluctuations in tree characteristics, with density and height generally increasing, but canopy size showing significant variation across quarters.

Plate 13: Mangrove plantation 100 (50-2) Ha at Kantiyajal site Block- 5 during a visit in 2025

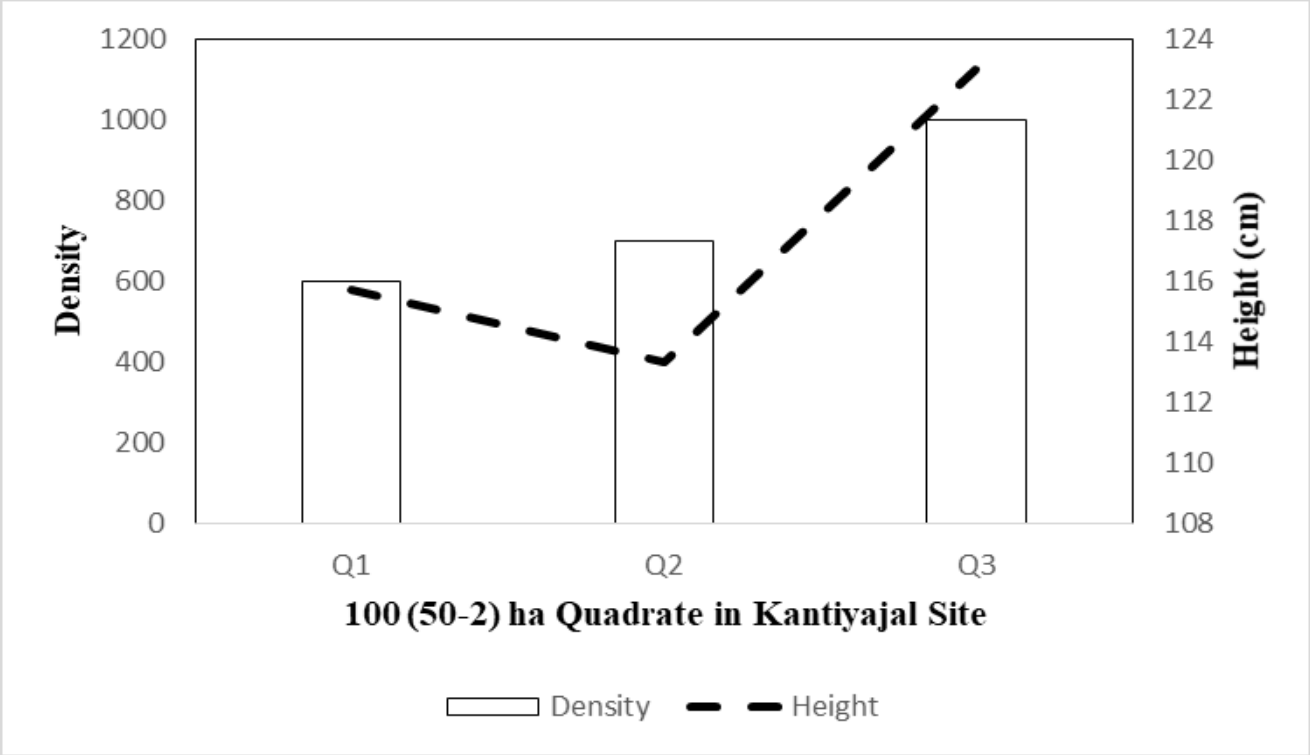

Fig.35 Details of density (No) and height of Mangrove 100 (50-2) Ha plantation area in 2021-2022 at Kantiyajal site

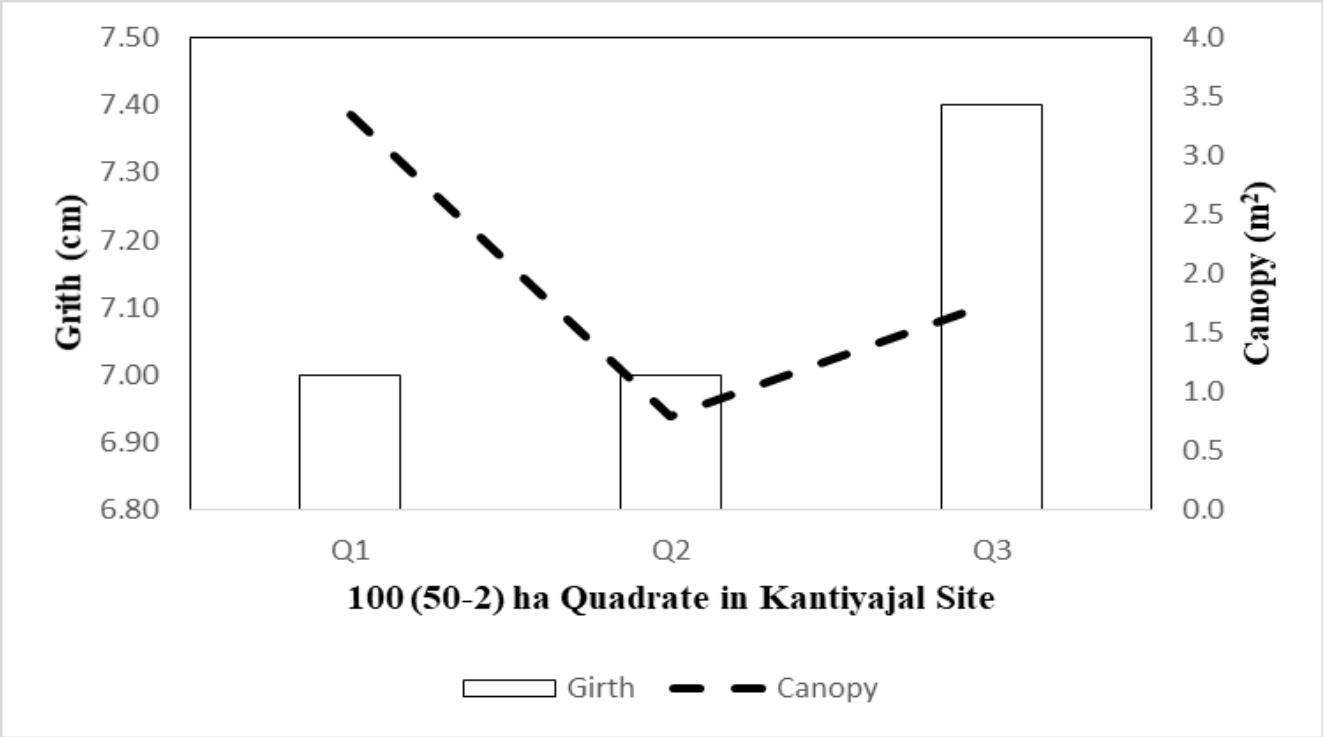

Fig.36 Details of Canopy and Basal Girth of Mangrove 100 (50-2) Ha plantation area in 2021-2022 at Kantiyajal site

7. Regeneration and recruitment class

The study conducted in various plantation blocks reveals crucial insights into the density of younger-class mangroves, particularly in their natural regeneration and recruitment phases. The findings indicate significant variations in the density of these young mangroves across different locations, highlighting both favourable and less favourable conditions for their establishment. The regeneration class, which encompasses newly established mangrove seedlings, exhibited the highest average density in the 50-hectare plantation block of Nakti Creek, with an impressive 1, 50,000 plants per hectare. This suggests highly favourable conditions for seedling establishment, potentially due to optimal salinity levels, sediment availability, and reduced anthropogenic disturbances. Conversely, the lowest density of regeneration-class mangroves was recorded in the 20-hectare plantation block of Sat-Saida Bet, where only 20,000 plants per hectare were observed. The lower density of younger-class mangroves in this particular plantation block may be influenced by multiple ecological and environmental factors. While limited seed dispersal and suboptimal hydrodynamic conditions are common constraints affecting mangrove regeneration, the structural dynamics of this block present an additional challenge to new growth. Since this plantation is relatively old, a few mature and large trees have been observed within the area. The presence of such well-established trees creates natural competition for resources such as sunlight, nutrients, and space. Larger trees tend to develop extensive root systems that dominate the nutrient supply in the soil, reducing the availability of essential elements required for the germination and survival of younger mangroves. Additionally, the shading can limit the penetration of sunlight to the forest floor which can hamper the successful establishment of younger classes' mangroves (Fig.37).

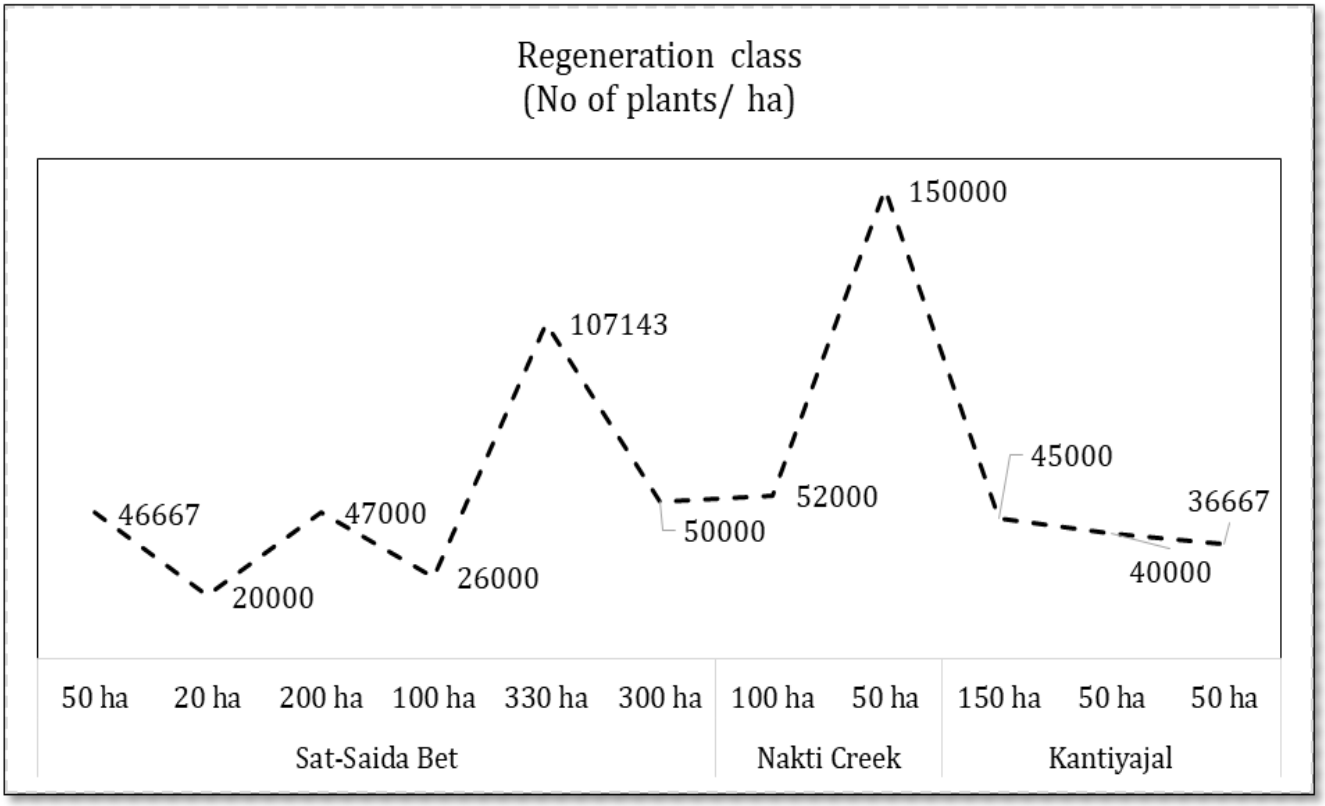

Fig. 37: Regeneration class mangroves in surveyed areas of plantations

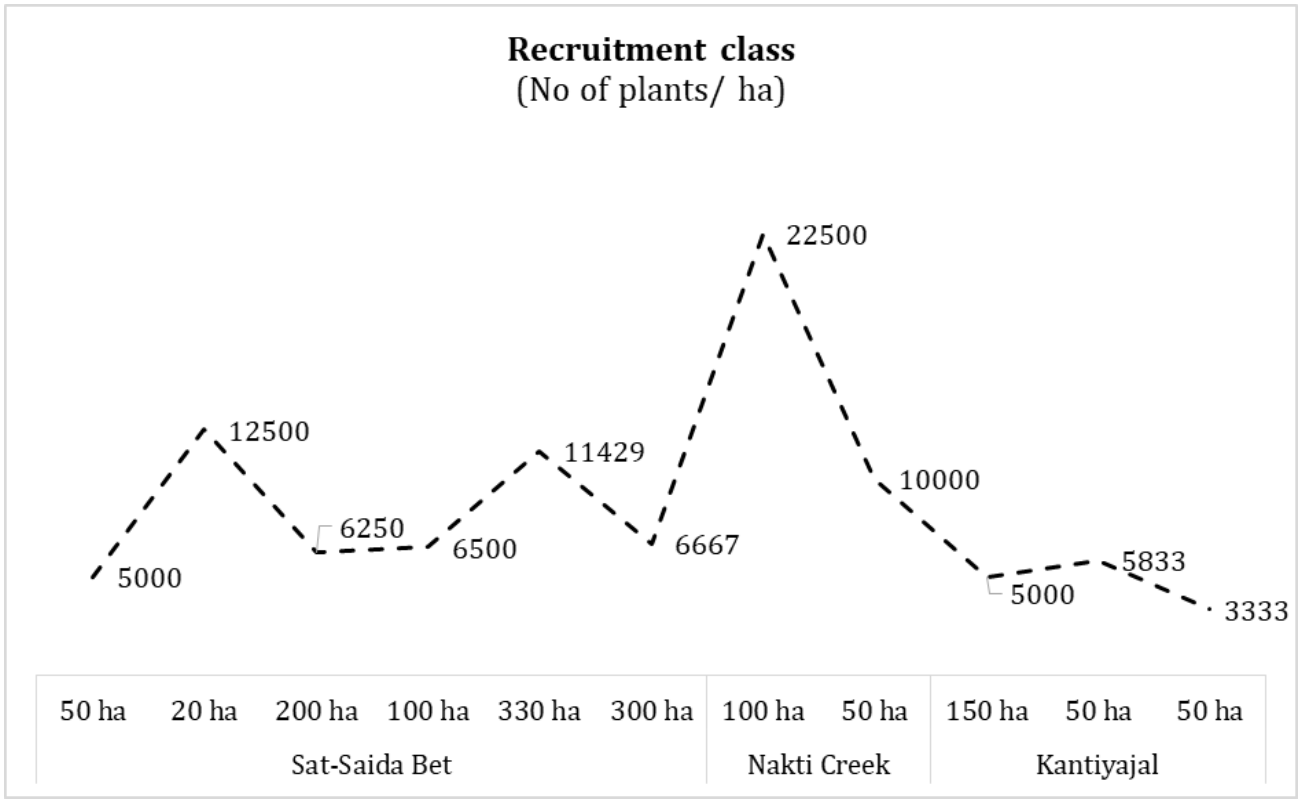

Fig. 38: Recruitment class mangroves in surveyed areas of plantations

The recruitment class, which consists of slightly older juvenile mangroves transitioning towards maturity, showed similar trends in density distribution. The highest density of 22,500 plants per hectare was recorded in the 100-hectare plantation block of Nakti Creek, reinforcing its role as a crucial site for mangrove establishment and growth. In contrast, the lowest recruitment density was observed in the 50-hectare plantation block of Kantiyajal, with only 3,333 plants per hectare. This lower density might be linked to factors such as hydrodynamic variability, nutrient availability, or mainly grazing pressures of camels in the area of plantation.

The presence of younger mangroves in these plantation blocks plays a fundamental role in ecological stabilization. These juvenile trees contribute significantly to sediment trapping and soil stabilization, reducing coastal erosion and enhancing overall shoreline resilience. Moreover, their ability to capture and retain sediments ensures the maintenance of water quality in adjacent coastal ecosystems by filtering out pollutants and excess nutrients. The ongoing regeneration and recruitment processes in these areas indicate a promising trajectory for mangrove forest development, emphasizing the importance of conservation efforts and sustainable management practices (Fig.38).

8. Soil biomass carbon

Mangrove soils are regarded as some of the most important carbon sinks, with carbon storage surpassing the biomass present above ground. These ecosystems are among the most sophisticated systems for the capture and retention of carbon because of the vast deposits of organic-rich sediments that form and the slow decomposition of matter in their waterlogged, saline and anoxic soil. The capability of mangroves to accumulate and sequester carbon in their biomass and sediments categorizes them into significant 'blue carbon' ecosystems that help slow down climate change. The carbon stock in mangrove soils is subject to change due to the presence of some, or all, species of mangrove, the age of the forest, and many soil characteristics. Through the long term capture of atmospheric carbon, mangroves play an important role in global climate regulation.

8.1 Soil biomass carbon stock potential at Sat saida Bet mangrove site

This table 3 shows data regarding soil carbon stock from two sampling blocks at three different depths in a 20-hectare *Avicennia marina* mangrove plantation at Sat Saida Bet. The soil parameters which include total organic carbon (TOC), and bulk density were measured to assess the amount of carbon stocked in the soil. Results indicate that the

carbon stock at a depth of 0-30 cm from the surface is about **29.63** (%) for the total area, which implies that the studied mangrove soils could be considered as an important carbon sink. The almost same values from different blocks and depths imply that soil conditions are relatively the same and carbon capture is efficient throughout the plantation which highlights the importance of the mangroves under climate change impact mitigation through blue carbon storage.

Table: 3 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 20 ha (*A. marina*)

Sampling Blocks	**Depth (cm)**	**TOC (%)**	**Bulk Density (g/cm^3)**	**Carbon stock (%)**	**Carbon stock in 0-30 cm (%)**
SC-1	10	0.42	1.27	5.33	30.77
	20	0.39	1.18	9.20	
	30	0.41	1.32	16.24	
SC-2	10	0.33	1.33	4.39	28.48
	20	0.33	1.32	8.71	
	30	0.41	1.25	15.38	
Average Carbon Stock (%)					**29.63**

The table 4 provides specified measurements of soil carbon from four sampling blocks (SC-3, SC-4, SC-5, and SC-6) within a 200-hectare region, with samples taken from 10, 20, and 30 cm depth intervals. For each block and depth, values are given for Total Organic Carbon, Bulk Density, Carbon Stock (%), and the estimated Carbon Stock in the top 30 cm of soil (%). Results indicate that carbon stock accumulations show increases with depth and there are distinct differences among blocks: SC-3 and SC-6 have the highest carbon stocks per hectare while SC-5 has the lowest. Average carbon stock for all the blocks is 43.78 % which suggests that relatively moderate levels of soil carbon is stored on in this 200-hectare region. The fact that these are average values points to the explanation of the local soil and environmental conditions, as well as changes and management interventions sought via spatial planning within the area facilitated CO_2 soil sequestration.

Table: 4 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 200 ha (*A. marina*)

Sampling Blocks	Depth (cm)	TOC (%)	Bulk Density (g/cm³)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
SC - 3	10	0.69	1.30	8.97	48.27
	20	0.74	1.27	18.80	
	30	0.56	1.22	20.50	
SC-4	10	0.56	1.25	7.00	44.37
	20	0.65	1.27	16.51	
	30	0.57	1.22	20.86	
SC-5	10	0.57	1.39	7.92	36.23
	20	0.50	1.35	13.50	
	30	0.35	1.41	14.81	
SC-6	10	0.65	1.33	8.65	46.15
	20	0.62	1.30	16.12	
	30	0.54	1.32	21.38	
Average Carbon Stock (%)					**43.78**

The values of soil carbon stock for 300 ha five sampling blocks (SC-7 to SC-11) at three different depths (10 cm, 20 cm, and 30 cm). Most blocks to the seem to have an increase in TOC percentage with an increase in depth, including with the carbon stock that is calculated. The values of bulk density remain fairly uniform with the exception of being between 1.18 and 1.35 g/cm³. Carbon stock over 30 cm differs between blocks with SC-11 having the highest value measured at 48.27 % and SC-7 having the lowest value at 28.31 %, measuring an average of 36.14 % across all blocks. This shows uneven distribution of carbon in soil which is important in determining the condition of the soil as well as its ability to retain carbon in the selected location (Table 5).

Table: 5 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 300 ha (*A. marina*)

Sampling Blocks	Depth (cm)	TOC (%)	Bulk Density (g/cm³)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
SC-7	10	0.24	1.32	3.17	28.31
	20	0.39	1.28	9.98	
	30	0.38	1.33	15.16	

	10	0.41	1.27	5.21	
	20	0.45	1.32	11.88	
SC-8	30	0.39	1.23	14.39	31.48
	10	0.51	1.18	6.02	
	20	0.47	1.30	12.22	
SC-9	30	0.48	1.33	19.15	37.39
	10	0.38	1.35	5.13	
	20	0.44	1.25	11.00	
SC-10	30	0.48	1.33	19.15	35.28
	10	0.50	1.28	6.40	
	20	0.60	1.33	15.96	
SC-11	30	0.68	1.27	25.91	48.27
Average Carbon Stock (%)					**36.14**

The table 6 showed soil carbon stock data 330ha for four sampling blocks (SC-12 to SC-15) with three depth increments (10 cm, 20 cm, and 30 cm). The mean carbon stock for all blocks stands at 57.54 %. These significant levels of stored carbon illustrate how important these soils are for carbon sequestration, especially in mitigating climate change through the storage of atmospheric carbon in soil. The differences among blocks and depths also suggest different inputs of organic matter, soil practices, or other environmental parameters which highlight the need for more targeted soil carbon management plans for specific locations.

Table: 6 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 330 ha (*A. marina*)

Sampling Blocks	**Depth (cm)**	**TOC (%)**	**Bulk Density (g/cm^3)**	**Carbon stock (%)**	**Carbon stock in 0-30 cm (%)**
	10	0.44	1.28	5.63	
	20	0.68	1.30	17.68	
SC-12	30	0.71	1.20	25.56	48.87
	10	0.79	1.25	9.88	
	20	0.75	1.20	18.00	
SC-13	30	0.81	1.18	28.67	56.55
	10	0.84	1.39	11.68	
	20	1.11	1.37	30.41	
SC-14	30	1.08	1.25	40.50	82.59
	10	0.50	1.25	6.25	
SC-15	20	0.50	1.28	12.80	42.16

	30	0.60	1.27	22.86	
Average Carbon Stock (%)					**57.54**

The data displays soil carbon stock quantifications for 50 Ha from two sampling blocks (SC-16 and SC-17) at three distinct depths: 10 cm, 20 cm, and 30 cm. It describes total organic carbon (TOC) percentage, bulk density, and the carbon stock values calculated for each depth. From all samples taken, average carbon stock is calculated to be 50.02 % for the top 30 cm of soil. This indicates a moderate to high amount of soil carbon storage which improves soil fertility, structure, and helps mitigate climate change. These results capture the need of careful soil management to bolster soil carbon stocks considered vital for agricultural and environmental sustainability (Table. 7).

Table: 7 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 50 ha (*A. marina*)

Sampling Blocks	**Depth (cm)**	**TOC (%)**	**Bulk Density (g/cm³)**	**Carbon stock (%)**	**Carbon stock in 0-30 cm (%)**
SC-16	10	0.72	1.32	9.50	40.2
	20	0.56	1.28	14.34	
	30	0.41	1.33	16.36	
SC-17	10	0.60	1.27	7.62	59.85
	20	0.75	1.22	18.30	
	30	0.87	1.30	33.93	
Average Carbon Stock (%)					**50.02**

An assessment of the carbon stocks on soil in the Sat Saida Bet mangrove plantation (100 ha, dominated by *Avicennia marina*) shows considerable carbon sequestration potential over three sampled blocks (SC-18, SC-19, SC-20) at 10, 20, and 30 cm depths. Soil up to30 cm in depth has an average carbon stock of 40.31 % and individual block values range from 29.88 to 46.04 %. Especially, TOC (%) in the bulk of samples increase with depth which indicates that major carbon accumulation happens across the entire soil profile. In any case, the high bulk density values also spatially imply carbon storage capacity, thus superposing the observation. In any case, the findings of the study demonstrate the

importance of mangroves in enhancing soil carbon stocks and combating climate change through blue carbon sequestration. (Table. 8).

Table: 8 Soil Carbon stock in Sat Saida Bet mangrove plantation site- 100 ha (*A. marina*)

Sampling Blocks	Depth (cm)	TOC (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
SC-18	10	0.35	1.35	4.73	29.88
	20	0.44	1.33	11.70	
	30	0.38	1.18	13.45	
SC-19	10	0.50	1.18	5.90	45.01
	20	0.56	1.30	14.56	
	30	0.62	1.32	24.55	
SC-20	10	0.53	1.32	7.00	46.04
	20	0.63	1.23	15.50	
	30	0.59	1.33	23.54	
Average Carbon Stock (%)					**40.31**

The mean carbon stock value from different sized plantations at the Sat Saida Bet mangrove site was 42.90 % at 30 cm depth with a range of 29.63 % - 57.54 % proportional to plantation area which is shown in Table 9. This difference is most likely attributed to the age of the plantations, species composition, site conditions and the management practices which are all known to influence the rate of carbon accumulation in mangrove ecosystems. Mangroves have an international reputation for their capability to store carbon in the soil and above it, and therefore play an important role in fighting climate change because they sequester huge amount of carbon and store it over long periods of time. This average figure can be used as a starting point to track carbon shifts at the site, and adds to the reasoning for conserving and managing mangrove ecosystems in the region for natural carbon emission mitigation.

Table 9 Average Carbon Stock at Sat saida Bet mangrove site

Plantation (ha)	Avg. Carbon stock 0-30 cm depth (%)
20	29.63
200	43.78
300	36.14
330	57.54
50	50.02
100	40.31
Avg.	**42.90**

8.2 Soil biomass carbon stock potential at Nakti creek mangrove site

The soil carbon stock at the Nakti creek mangrove plantation site (50 ha), dominated by *Avicennia marina* was analyzed through two sampling blocks (TC-1 and TC-2) at depths of 10 cm, 20 cm, and 30 cm. For TC-1, the carbon stock increased with depth: 12.01 % (10 cm), 18.80 % (20 cm), and 32.87 % (30 cm), totalling 63.68 (%). Similarly, TC-2 showed stocks of 9.44 % (10 cm), 17.27 % (20 cm), and 45.24 % (30 cm), totalling 71.95 (%). The average carbon stock across both blocks was 67.82 (%), for the entire 50-hectare site (Table 10).

Table: 10 Soil Carbon stock in Nakti creek mangrove plantation site- 50 ha (*A. marina*)

Sampling Blocks	Depth (cm)	TOC (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
TC-1	10	0.78	1.54	12.01	63.68
	20	0.74	1.27	18.80	
	30	0.83	1.32	32.87	
TC-2	10	0.71	1.33	9.44	71.95
	20	0.68	1.27	17.27	
	30	1.16	1.30	45.24	
Average Carbon Stock (%)					**67.82**

The present's data on soil carbon stock from different sampling blocks in a 100-hectare mangrove plantation with *Avicennia marina, Rhizophora mucronata*, and *Ceriops tagal* species. It includes total organic carbon (TOC) percentage, bulk density. TOC at three depths (10, 20, 30 cm) for each block alongside their respective carbon stock, leading up to carbon stock per hectare within 30 cm of soil, which was estimated. The results indicate variability among blocks, with TC-4 yielding the highest carbon stock at 77.64 % and TC-6 yielding the lowest at 45.1 %. Overall, the mean carbon stock across blocks stood at 57.8 %. This demonstrates the capacity of mangrove soils in relation to carbon sequestration and emphasizes the importance of the contribution of these ecosystems in climate change mitigation (Table 11).

Table: 11 Soil Carbon stock in Nakti creek mangrove plantation site- 100 ha (*A. marina*, *R. mucronata, C. tagal*)

Sampling Blocks	Depth (cm)	TOC (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
TC-3	10	0.3	1.18	3.54	
	20	0.93	1.23	22.88	
	30	0.78	1.27	29.72	56.14
TC-4	10	1.01	1.25	12.63	
	20	0.98	1.30	25.48	
	30	1.08	1.22	39.53	77.64
TC-5	10	0.75	1.18	8.85	
	20	0.72	1.25	18.00	
	30	0.87	1.32	34.45	61.3
TC-6	10	0.38	1.32	5.02	
	20	0.69	1.30	17.94	
	30	0.60	1.23	22.14	45.1
TC-7	10	0.62	1.37	8.49	
	20	0.59	1.32	15.58	
	30	0.63	1.35	25.52	49.59
Average Carbon Stock (%)					**57.8**

The mean carbon stock at Nakti creek site is calculated by taking the percentage of 30 cm depth on the soil and comparing it to the two sizes of plantations (50 ha and 100 ha) and mangrove carbon reserve. It indicates that the 50-hectares carbon reserve plantation has a higher average Carbon stock (67.82 %) compared to 100-hectare plantation's (57.8 %),

with an overall average of 62.81 % .This implies that the smaller plantations at this site store more carbon per unit area than the larger ones which can be attributed to differences in age or management practices. The study demonstrates the need for such data to optimize understanding of mangrove carbon capture (Table 12).

Table 12 Average Carbon Stock at Nakti creek mangrove site

Plantation (ha)	Avg. Carbon stock 0-30 cm depth (%)
50	67.82
100	57.8
Avg.	**62.81**

8.3 Soil biomass carbon stock potential at Kantiyajal mangrove site

The Kantiyajal mangrove plantation site (150 ha of *Avicennia marina*) exhibited considerable variation of soil carbon stock within its two sampling blocks. Block KC-1 tended to have average carbon stocks of 39.91 (%) and was gradually increasing in contribution with depth to: 5.62% (10cm), 12.51% (20cm), and 21.78% (30cm) whereas KC-2 demonstrated greater sequestration at 63.78 (%) due to deeper-layer storage (7.58% at 10cm, 18.35% at 20cm, and 37.85% at 30cm). This variability demonstrates greater carbon density of KC-2 (bulk density 1.43-1.45 g/cm^3; KC-1 1.37-1.39 g/cm^3) which is likely due to accumulation of organic matter in mangrove sediments (Table 13). The average carbon stock of the *A. marina* plantation was 51.85 (%) (150ha).

Table: 13 Soil Carbon stock in Kantiyajal mangrove plantation site- 150 ha (*A.marina*)

Sampling Blocks	Depth cm	TOC (%)	Bulk Density (g/cm^3)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
KC-1	10	0.41	1.37	5.62	39.91
	20	0.45	1.39	12.51	
	30	0.53	1.37	21.78	
KC-2	10	0.53	1.43	7.58	63.78
	20	0.66	1.39	18.35	

	30	0.87	1.45	37.85	
Average Carbon Stock (%)					**51.85**

The soil carbon stock at the Kantiyajal mangrove plantation site (150 ha), dominated by *Avicennia marina* and *Rhizophora mucronata*, was analyzed through two sampling blocks (KC-3 and KC-4) at depths of 10 cm, 20 cm, and 30 cm. For KC-3, the carbon stock increased with depth: 3.99% (10 cm), 10.01% (20 cm), and 18.23% (30 cm), totalling 32.23 (%). Similarly, KC-4 showed stocks of 6.03% (10 cm), 13.44% (20 cm), and 16.07% (30 cm), totalling 35.54 (%). The average carbon stock across both blocks was 33.88 (%), for the entire 150-hectare site (Table 14).

Table: 14 Soil Carbon stock in Kantiyajal mangrove plantation site- 150 ha (*A. marina* and *R. mucronata*)

Sampling Blocks	**Depth cm**	**TOC (%)**	**Bulk Density (g/cm^3)**	**Carbon stock (%)**	**Carbon stock in 0-30 cm (%)**
KC-3	10	0.30	1.33	3.99	32.23
	20	0.35	1.43	10.01	
	30	0.45	1.35	18.23	
KC-4	10	0.44	1.37	6.03	35.54
	20	0.47	1.43	13.44	
	30	0.38	1.41	16.07	
Average Carbon Stock (%)					**33.88**

The soil carbon stock assessment in the 50-hectare Kantiyajal mangrove plantation site dominated by *Avicennia marina* reveals notable variation across sampling blocks and soil depths. In block KC-5, soil carbon stock values increased with depth, from 3.53 % at 10 cm; 9.57% at 20 cm and 23.37 % at 30 cm, indicating substantial carbon accumulation in deeper layers. Similarly, KC-6 showed a rise from 1.89% at 10 cm; 7.23 at 20 cm and 13.97% at 30 cm. The average soil carbon stock across the site was 29.78 (%) (Table 15).

Table: 15 Soil Carbon stock in Kantiyajal mangrove plantation site- 50 ha (*A. marina*)

Sampling Blocks	Depth cm	TOC (%)	Bulk Density (g/cm³)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
KC-5	10	0.24	1.47	3.53	36.47
	20	0.33	1.45	9.57	
	30	0.53	1.47	23.37	
KC-6	10	0.14	1.35	1.89	23.09
	20	0.26	1.39	7.23	
	30	0.35	1.33	13.97	
Average Carbon Stock (%)					**29.78**

The soil carbon stock at the Kantiyajal mangrove plantation site (100 ha), dominated by *Avicennia marina*, was analyzed through two sampling blocks (KC-7 and KC-8) at depths of 10 cm, 20 cm, and 30 cm. For KC-7, the carbon stock increased with depth: 7.15% (10 cm), 15.85% (20 cm), and 25.89% (30 cm), totalling 48.89 (%). Similarly, KC-8 showed stocks of 3.72% (10 cm), 11.02% (20 cm), and 24.36% (30 cm), totalling 39.1(%). The average carbon stock across both blocks was 43.99(%), for the entire 150-hectare site (Table 16).

Table: 16 Soil Carbon stock in Kantiyajal mangrove plantation site- 100 ha (50 ha and 50 ha) (*A. marina*)

Sampling Blocks	Depth cm	TOC (%)	Bulk Density (g/cm³)	Carbon stock (%)	Carbon stock in 0-30 cm (%)
KC-7	10	0.50	1.43	7.15	48.89
	20	0.57	1.39	15.85	
	30	0.63	1.37	25.89	
KC-8	10	0.26	1.43	3.72	39.1
	20	0.38	1.45	11.02	
	30	0.56	1.45	24.36	
Average Carbon Stock (%)					**43.99**

The soil carbon stock at the Kantiyajal mangrove plantation site reflects the critical role of mangroves in carbon sequestration, with the average carbon stock at 30 cm depth (%) across different plantation areas (totalling 450 hectares) calculated to be 39.87%, based on observed values of 51.85%, 33.88%, 29.78%, and 43.99% for individual plots. This substantial soil organic carbon pool highlights the effectiveness of mangrove plantations in trapping and storing carbon, as mangrove soils are known to accumulate and retain carbon due to their ability to trap sediments and maintain anaerobic conditions that slow decomposition processes (Table 17).

Table.17 Average Carbon Stock at Kantiyajal mangrove site

Plantation (ha)	Avg. Carbon stock 0-30 cm depth (%)
150	51.85
150	33.88
50	29.78
100 (50 +50)	43.99
Avg.	**39.87**

9. Details of carbon Sequestration at the plantation sites

Each block randomly selected 10 trees that were >7 cm dbh and in good health plants. The allometric equations pertaining to *A. marina* (Vikarant et al., 2013) were used in estimating above ground biomass (AGB), below ground biomass (BGB), and tree biomass. The total tree biomass carbon was then converted into CO2 equivalent by multiplying it with a factor of 3.67 (Kauffman and Donato, 2012; Kathiresan et al., 2021). The data from 2025 from across Sat Saida Bet, Nakti Creek and Kantiyajal shows that there is a notable difference in biomass and carbon values across different hectare (HA). Sat Saida Bet tends to show greater tree biomass and carbon values as well as in larger plots like 330 HA, with CO_2 equivalents peaking at 6042.32 Mg C ha^{-1}, indicating greater carbon sequestration potential than the rest of the regions, while Nakti Creek has moderate biomass and carbon storage. Despite Nakti Creek showing the 100 HA plot having a quite high tree biomass and carbon value of 1887.81 Mg C ha^{-1}. Kantiyajal does has some blocks with high tree biomass like to 50 HA at 2849.60 Mg C ha^{-1}, but they still have lower carbon

values because it makes the area appear to contain less dense or younger vegetation (Table 17).

This finding confirms once more the spatial differences in carbon sequestration capacity across these sites and emphasizes area size and specific local ecological conditions as prime determinants of carbon storage potential in mangrove and coastal ecosystems.

Table. 17 Details of Carbon Sequestration at 1600ha mangrove plantation site

Sat Saida Bet during 2025					
Hectare (HA)	**Above Ground Biomass**	**Below Ground Biomass**	**Tree Biomass**	**Carbon values (Mg C ha^{-1})**	**CO_2 equivalent**
20 HA	3.83	2.63	6.61	3875.96	24.25
200 HA	4.99	3.30	8.50	5053.82	31.21
300 Ha	6.07	3.89	10.23	5301.18	37.54
330 Ha	4.32	2.92	7.41	6042.32	37.54
50 Ha	5.16	3.39	8.77	2849.60	27.21
100 Ha	2.88	2.06	5.04	1138.56	32.17
Average	**4.54**	**3.03**	**7.76**	**4043.57**	**31.65**
Nakti creek during 2025					
50	3.16	2.23	5.50	2904.33	20.18
100	5.66	3.67	9.57	1887.81	35.13
Average	**4.41**	**2.95**	**7.535**	**2396.07**	**27.66**
Kantiyajal during 2025					
150	3.56	2.47	6.17	1335.92	22.64
50	6.07	3.89	10.23	3627.13	37.54
100(50-2)	2.27	1.68	4.01	799.75	14.73
Average	**3.97**	**2.68**	**6.80**	**1,920.93**	**24.97**

10. Phyto-sociological observation

Halophytes are an example of a specialized plant that can live in areas with high salinity. They can be divided into three categories based on their growth conditions: obligate halophytes, which depend entirely on a saline environment; facultative halophytes which can exist in both saline non-saline environments; and habitat indifferent halophytes which have some degree of preference for their environment. In the course of the comprehensive survey, we identified four prominent species of halophytes within the designated DPA mangrove plantation sites. These were: *Salicornia brachiata, Aeluropus lagopoides, Salvadora persica,* and *Sesuvium portulacastrum*. At the plantation site, we recorded an interesting form of relationship between halophyte species and mangrove associated plants. Numerous halophyte associated species recorded for the first time during the field trips began the quest to understanding these intricate ecosystems. Also observed were mudskippers, bivalves, crabs, gastropods and many fish that contribute to the ever changing ecological relationships at the plantation sites. This abundance of both plant life and animal life is why we believe that halophytes are important for the condition of the entire ecosystem along the coast. The working commingling of halophytes and mangrove associated ecosystems forms a zone of high productivity and biodiversity.

The roots of mangrove trees house many microorganisms that aid plants in osmoregulation and dealing with both heat and salt stress. The vegetation and fauna flora of such ecosystems enables nutrient cycling to occur and supports higher trophic levels in the biological community. It also helps in the conservation of natural diversity and the stability of the environment. Furthermore, halophytes boost soil structure by capturing salts and favourable rhizobacteria, which contribute to the salt tolerance of supplementary flora. Taking care of and acclimatizing coastal areas that are abundant in these halophytes is important for the ecological sustainability of fish resources, protection of coastal zone against natural calamities, and climate mitigation through efficient carbon sequestration (Plate 14).

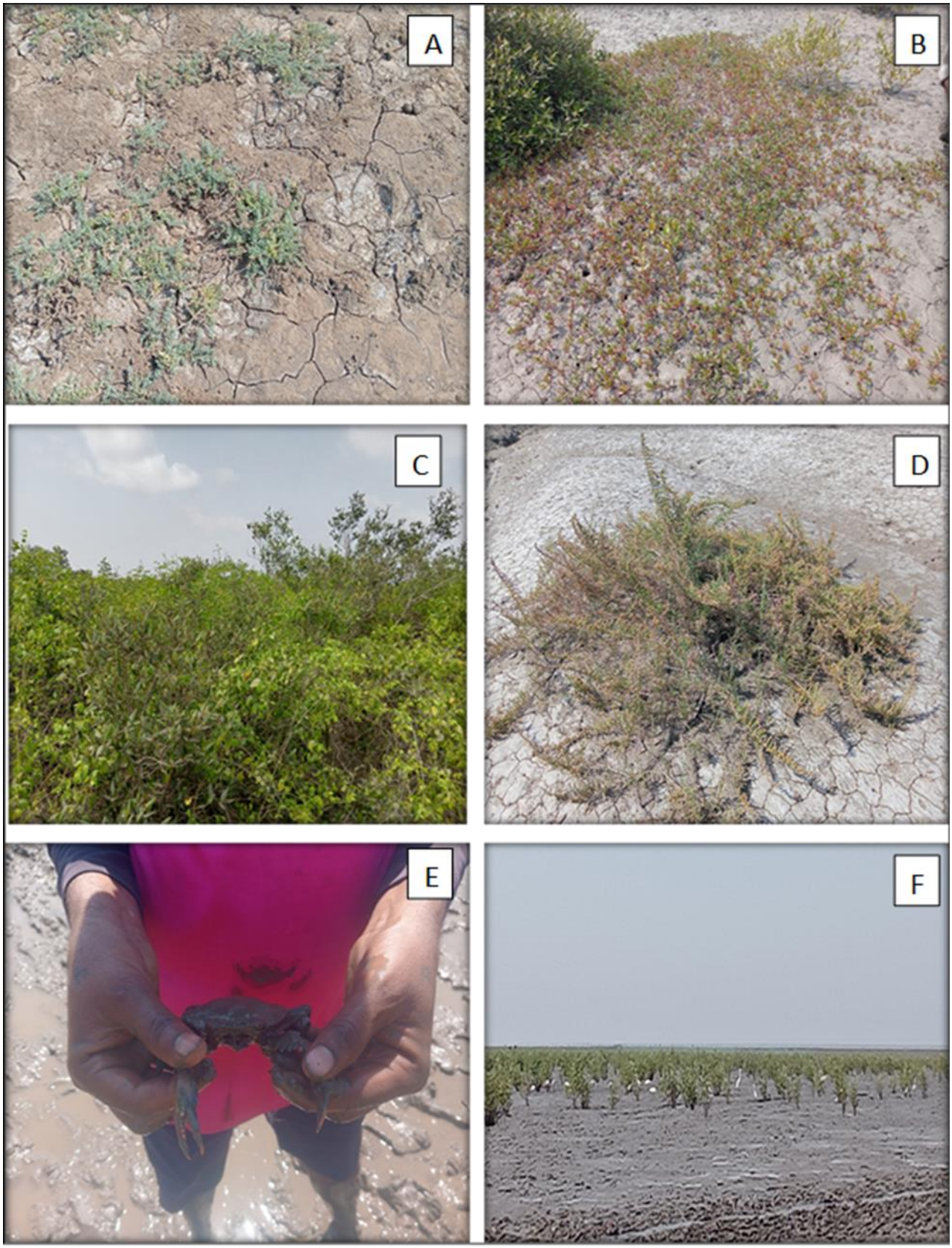

Plate 14. Mangrove associated Halophytes and fauna diversity in plantation site during a visit in 2025

[A-*Sueda* sp.; B- *Sesuvium* sp; C- *Salvadora* sp; D- *Salicornia* sp; E- Crab; F-Birds]

11. Field observation of threats for Mangroves

Plate 15 captures a coastal mudflat environment where the existing threats stress on the mangrove is most clear during the filed trip in 2025. The aforementioned plant's aerial roots suggests that this more or less eroded and unstable mangrove was subjected to tidal forces or soil erosion. The second and third image depicts dry mangrove vegetation which is indicative of an either experiencing salinity stress coupled with water logging or some unpleasant conditions that inhibit the development of a mangrove. The fourth image shows a grazing camel in what can be described as an all around difficult area of observing and holding sustained environmental control, capturing the extra attention on the stress mangroves experience in this region. Cumulatively, these evidences unveils the relative intense environmental load on mangroves like erosion, alternating human and animal interaction, salinity levels above normal and scarcity of water which deepens their fragility and lowered resilience in this habitat.

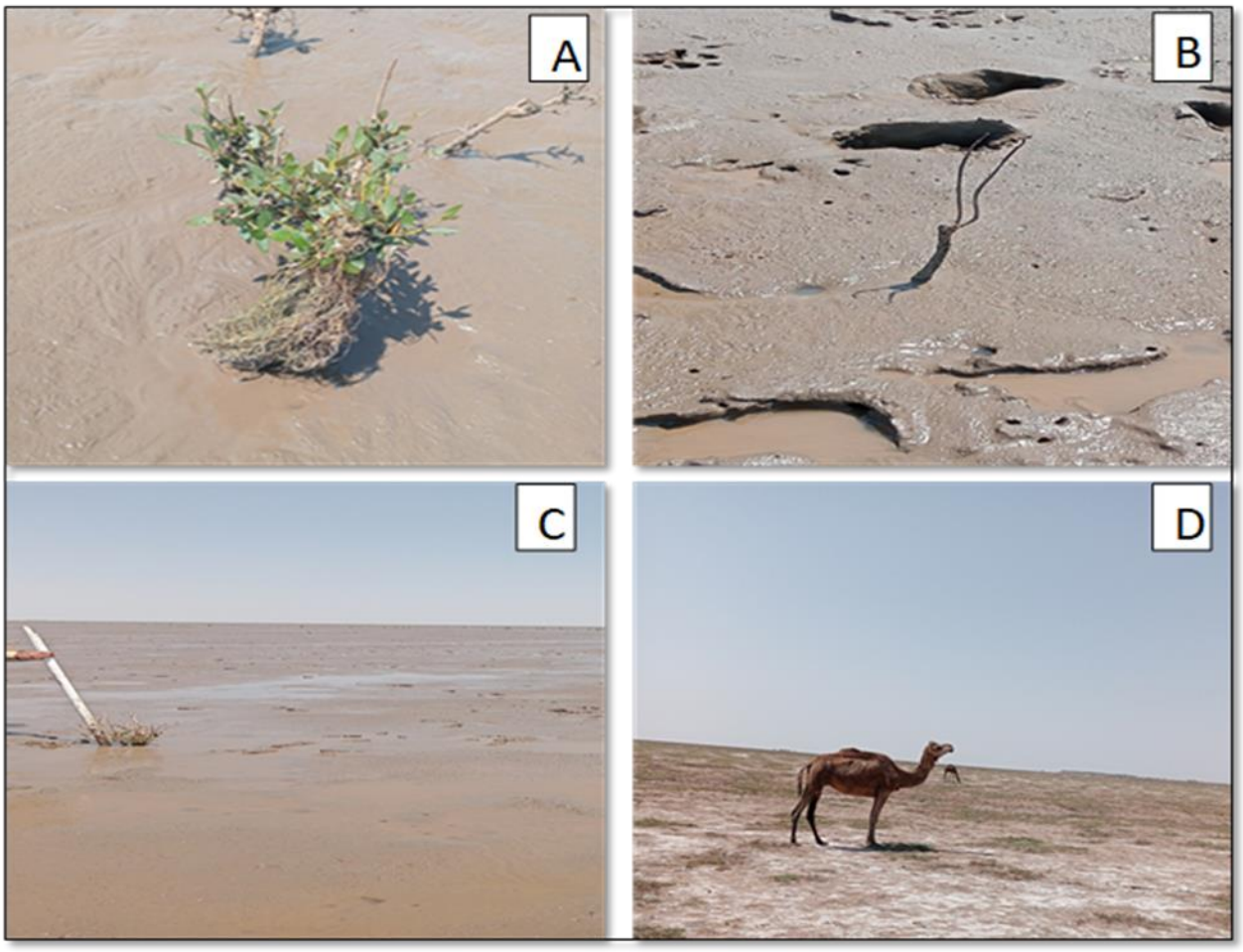

Plate 15. Mangrove Stress factors observed in plantation site during a visit in 2025.

[A-Fishing net; B- Animal foot; C- Sediment deposit; D-Camel grazing]

12. Summary and Discussion

The mangrove monitoring was conducted at sites located in Sat Saida Bet and Nakti Creek (near to Tuna village) in Kandla district as well sites located nearby Kantiyajal, Bharuch district. The sampling occurred at six plantation blocks in Sat Saida Bet, two in Nakti Creek, and five in Kantiyajal for monitoring the mangrove plantations developed over an area of total 1600 ha from 2005 to 2021. The primary objectives of this study included determination of the density and abundance of planted mangroves to estimate the carbon sequestration potential, understanding ecological concerns about the success of the plantation, and recommending appropriate conservation strategies. The sampling points are selected only where the mangroves are present inside the plantation blocks. Extensive field studies performed from February to May of 2025 revealed marked differences in the density and height growth of mangroves over the various sites. Most remarkably, carbon sequestration was the highest at Sat Saida Bet (up to 4043 Mg C ha^{-1}) while Nakti Creek exhibited the greatest concentration of carbon stock in topsoil, averaging 62.81% carbon stock. The monitoring show significant variation in mangrove density and tree height among the sites. At Sat Saida Bet, mangrove density was between 100 to 4000 individuals per hectare and the tree height was between 70 to 240 cm. Nakti Creek reported densities of 400–1,600 individuals per hectare and tree heights of 100–170 cm, while Kantiyajal showed densities of 500–1,600 individuals per hectare and tree heights of 70–140 cm. However, it should be noted that major area of Kantiyajal is empty and under various stresses on mangroves such as grazing pressure by camel, cattle etc.

Soil analysis revealed average carbon stock values (0-30 cm depth) between 39.87% and 62.81%, with Nakti Creek recording the highest percentage. However, Sat Saida Bet demonstrated the highest carbon values overall ranging from 1,920.93 to 4,043.5 Mg C ha^{-1} and also led in CO_2 equivalent values at 31.65, compared to 27.66 at Nakti Creek and 24.97 at Kantiyajal. This study looked at the importance of mangrove ecosystems as blue carbon sinks which absorb carbon dioxide more effectively. Their multifunctional roles provide coastal protection, serve as habitats for various species, sustain fisheries and tourism, aid in climate change mitigation all at the same time. They demonstrate the impact of unsustainable practices as well as habitat destruction. In turn, this creates a need for ongoing restoration and conservation efforts. This report recommends targeted multi-species planting and natural regeneration to improve sparse patches while active

long-term management strengthens resilience to ensure sustainability for these ecosystems.

Globally, mangrove rehabilitation and restoration is regarded as one of the most effective management strategies for lost or damaged mangrove forests. Many biotic and abiotic factors such as predation, seed recruitment, soil quality, colonization rates, salinity, and temperature can hamper the overall plantation during various stages of planting. Rather, mangrove restoration projects tend to set specific criteria for success.

In the port development of DPA, we notice an effort that integrates port activity with environmental protection. The monitoring results offered invaluable information with regard to the restoration of mangroves and their relation to climate change, biodiversity as well as human health. The project illustrates the necessity of strategic investment in the conservation of mangroves which aids climate change and coast protective efforts, thereby setting an ecological benchmark in port management. As a source of blue carbon, defenders of coasts and regions abundant in biodiversity, the project highlighted the ecological and economic value of mangroves. Despite the ecological and economic value, the mangroves are still facing threats of habitat loss and unregulated resource extraction, particularly in Kantiyajal site, where the main stress factor on mangrove plantation is camel grazing which is observed. In order to enhance the resilience and sustainability of the critical ecosystems within the port limits, the report recommends of sparse patches with natural regeneration and gap filling as well as constant maintenance. With this, the site selection for mangrove plantation should be done after a scientific and social study of the location.

13. Recommendations in terms of future prospects

On the basis of this study, following recommendations are suggested for current and future plantation activities. This study clearly identified that a few blocks of plantations within Sat-Saida Bet was more promising than other locations for further mangrove plantation efforts. These areas have demonstrated the suitability for expansion of mangroves. Moreover, the availability of space allows for gap-filling, which can further enhance the overall mangrove coverage. To ensure the development of the planted mangroves into a mature and thriving ecosystem, several conservation measures are recommended.

- Appropriate site selection: Identifying suitable locations for mangrove plantations is essential for their survival and growth. Factors such as soil composition, tidal

influence, and existing ecological conditions must be thoroughly assessed before selecting a site.

- Monitoring to prevent camel grazing: Continuous monitoring of existing mangrove plantations is necessary to mitigate human activities that may disrupt growth. Grazing by camel is one of main stress in the plantation area at Kantiyajal, which can cause severe damage to young mangrove plants. Implementing protective barriers, enforcing regulations, and engaging local communities in conservation efforts may help safeguard these ecosystems. Or it will better to find different area for further plantations.
- Field observation and high-resolution mapping: The use of both ground-based surveys and advanced mapping techniques is necessary for effective mangrove monitoring, conservation, and management. Field observations provide real-time insights into plant health, while high-resolution mapping helps track vegetation changes over time and detect areas requiring intervention.
- Site-specific plantation techniques: Different mangrove species thrive in varying environmental conditions. Therefore, plantation techniques must be carefully adapted to match the specific hydrogeological features of each site. This includes selecting appropriate planting depths, spacing, and protective measures to prevent high mortality rates among mangrove seedlings.
- Ensuring tidal flushing and inundation: Mangroves rely on a dynamic water exchange system for nutrients and sediment deposition. Regular tidal flushing and controlled inundation must be maintained to sustain optimal soil salinity levels, support biodiversity, and promote natural regeneration. Proper hydrological management will further strengthen the mangrove ecosystem over time.
- Utilizing local seed sources for mangrove plantation: Selecting seed sources from the nearest available areas ensures genetic compatibility with the local environment. This approach accelerates adaptation to site-specific conditions, and strengthens the resilience of the mangrove species.
- Prioritizing restoration over new plantation sites: Instead of creating entirely new plantation sites, efforts should focus on restoring existing mangrove areas that have suffered degradation.
- Preserving natural tidal hydrology and seed dispersal: Mangroves rely on tidal movements for oxygen exchange, sediment deposition, and nutrient supply.

Maintaining the natural water-borne dispersal of seeds helps facilitate regeneration and promotes species diversity.

- Awareness and outreach programs for DPA staff: Strengthening conservation efforts requires active participation from local authorities, environmental organizations, and the general public. Awareness campaigns, training workshops, and stakeholder engagement activities will help develop a collective understanding of mangrove protection. Educating DPA staff and involving communities will encourage responsible stewardship.
- Promoting multispecies plantation for greater ecological benefits: Planting multiple mangrove species fosters biodiversity and enhances ecosystem resilience. A multispecies approach improves the adaptability of the plantation, ensuring long-term sustainability and ecological balance.
- Identification 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.
- Community-based management: Engaging local communities, particularly fishermen can significantly enhance mangrove plantations. Fishermen can be key participants in community-based restoration and conservation.

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Gujarat Institute
Of Desert Ecology

Annexure B

DEENDAYAL PORT AUTHORITY
(Erstwhile: DEENDAYAL PORT TRUST)

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY
www.deendayalport.gov.in

ISO 9001-2015 &
ISO 14001-2015 Certified Port

Administrative Office Building
Post Box NO. 50
GANDHIDHAM (Kutch).
Gujarat: 370 201.
Fax: (02836) 220050
Ph.: (02836) 220038

No. Civil Engineering/EMC/820/GreenbeltDevelopmentPhaseII/2023/45 Dated: 17/07/2025

To,
The Gujarat Institute of Desert Ecology (GUIDE),
P. O. Box No. 83,
Opp. Changleshwar Temple, Mundra Road,
Bhuj (Kachchh)-370 001,
Gujarat (India).
Tel: 02832-329408, 235025.
Tele/Fax: 02832-235027.
E-mail: vijay196129@gmail.com

Kind Attention: Dr. V. Vijay Kumar, Director, M/s GUIDE, Bhuj.

Sub: Maintenance of Greenbelt Development in Deendayal Port Authority at Kandla (Phase II) for two years.

Ref.: GUIDE, Bhuj offer vide letter no. GUIDE/MAINT-DPA-GRN/412/2024-25 dated 11/12/2024.

Sir,

Your offer for the subject work submitted vide above referred letter dated 11/12/2024 (**copy attached - Annexure A**) amounting to **Rs. 53,55,900.00 + 18% GST** (Rupees Fifty-Three Lakhs Fifty-Five thousand and Nine Hundred Rupees plus eighteen percent GST only), including all terms & conditions mentioned in the proposal, has been accepted by the competent authority in Deendayal Port Authority.

2. Scope of work:

Monitoring, maintenance and watering at regular intervals (through water tanker) for a period of 2 years (2025-26 and 2026-27).

3. Obligation of Deendayal Port Authority:

Assistance regarding the statutory clearance from authorities concerned to be rendered by DPA for field visits/maintenance of plantation activities.

.....Cont.....

4.Terms of Payments:

1. 30% of the project budget should be paid to GUIDE within 30 days from the date of submission of Inception report by GUIDE.
2. 40% of the project budget should be paid to GUIDE within 15 days from the submission of progress report for the first year.
3. 20% of the project budget should be paid to GUIDE within 15 days from the submission of the mid-term progress report for the second year.
4. 10% of the project budget should be paid to GUIDE within 15 days from the submission of completion report for the second year.

Payment shall be released after successful completion of the above tasks.

5. Time period: 2 years.

6. Kindly send acknowledgment of this work order and start the work w.e.f. 21/07/2025.

Thanking you.

Yours faithfully,

XEN (EMC)
Deendayal Port Authority

Annexure C

DEENDAYAL PORT AUTHORITY

दीनदयाल पत्तन प्राधिकरण
DEENDAYAL PORT AUTHORITY

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Ph.: (02836) 220038

www.deendayalport.gov.in

Civil Engineering/Pipeline/3564/GBDinDPA&itssurrounding III/2024/ 14 Dated: 27/01/2025

To,
Gujarat Institute of Desert Ecology (GUIDE)
P.O Box No. 83
Opp Changleshwar Temple, Mundra Road,
Bhuj (Kachchh) – 370001, Gujarat(India)
Tel : 02832 – 329408, 235025
E-mail: desert_ecology@yahoo.com

Kind Attention: Dr. V.Vijay Kumar, Director, GUIDE, Bhuj

Sub: Greenbelt Development in Deendayal Port Authority (DPA) and its Surrounding Areas (Phase III) along with two years maintenance period-reg.

Ref.: GUIDE, Bhuj offer vide letter no. GUIDE/DPA/GRN-Phase-III/375/2024-25 dated 12/11/2024.

Sir,

Your offer for the subject work submitted vide above referred letter dated 12/11/2024 amounting to Rs 81,12,500/- + applicable GST (Rupees Eighty-One lakhs twelve thousand and five hundred plus applicable GST), with all terms and conditions mentioned in the offer letter, has been accepted by the competent authority in Deendayal Port Authority **(Copy of offer of GUIDE, Bhuj attached)**.

2. Scope of Work:

The activities under the greenbelt development include; inventory of suitable sites for greenbelt development in DPA, Soil and moisture conservation and management at plantation sites, selection of suitable species of plants for plantation, procurement and plantation of plant saplings and seeds {5000 Plants (Indigenous)& 200 Plants at Gopalpuri (fruit bearing/medicinal/air purifying)}(including maintenance of the same for 1st year), along with maintenance, management and monitoring of plantation, including drip/tanker water supply for a further period of 2 years.

3. Obligation of DPA:

Assistance regarding the statutory clearances from authorities concerned to be rendered by DPA for field visits/plantation activities

4. Terms and Mode of Payment:

(i) First year budget requirement of Rs 39, 32,500 Lakhs (Plus GST) . In which, 50% of the project budget to be paid to GUIDE after the submission of Inception Report by GUIDE.
(ii) 20% of the project budget to be paid to GUIDE within 15 days from the date of completion of plantation works.
(iii) 20% of the project budget to be paid to GUIDE within 15 days from the date of submission of draft report.
(iv) 10% of the project budget to be paid to GUIDE within 15 days from the date of submission of final report.
(v) Annual maintenance budget from 2nd year onwards, for a period of two years would be Rs 41.80 Lakhs (plus GST).
(vi) During the maintenance phase, 25% of the project budget to be paid to GUIDE every six months in 4 instalments with progress reports, and completion report at the end of the maintenance works.

5. Time period :

(a) Plantation of 5000 (Indigenous) Saplings at DPA site and 200 (fruit bearing/medicinal/air purifying) plants at Gopalpuri, through suitable species as per the site scenario – 1 year i.e. from 1/2/2025 to 31/1/2026.
(b) Management and Monitoring of Plantation including drip/tanker water supply at regular interval - 2 years after completion of above 1 year period i.e. from 1/2/2026 to 31/1/2028.

6. Kindly sent the acceptance of this work order & start the work w.e.f. 01/02/2025.

Thanking you.

Yours faithfully,

27/1/25

Dy. Chief Engineer & EMC(I/c)
Deendayal Port Authority

Annexure D

List of CSR Works for the year 2025(April to Till November-2025)		
Sr.No	**Name of work**	**Approved cost (Rs in Lakhs)**
1	Request for construction of relocatable of sports arena at Gandhidham Military Station,HQ 98 Artillery Brigade Military Station Gandhidham	₹ 28.00
2	Proposal for construction of Police Community Hall at Police Headquarters Shinay.Office of the Superintendent of Police, East – Kutch Gandhidham.	₹ 100.00
3	Proposal for providing AWG system at their check posts located in the Runn of Kutch,Commandant BSF Station Gandhidham	₹ 82.70
4	Proposal for providing 4000 pieces of Tripal/Tarpaulin,Matri Sena Charitable Trust	₹ 32.00
5	Proposal for Upgrading Satellite Eye Hospital at Bhuj.1.Request for financial support for the addition of cornea and retina outpatient departments (OPD), a spectacle dispensing unit, and a medicine counter as part of our OPD activities, & equipment purchase.	₹ 35.08
6	Proposal for financial assistance for purchase of C Arm and OT table to start Orthopedic at St. Joseph's Hospital Gandhidham,ST. Joseph's Hospital Trust, Gandhidham.	₹ 28.78
7	Proposed to establish a women empowerment center, through Ujjas Mahila Sangh,Gandhidham	₹ 119.48
8	CSR Grant for 'Strengthening of School Ecosystem at Primary School Level in Kachchh District,Ladies Environment Action Foundation (LEAF), Gandhinagar	₹ 50.00
9	Proposal for recharge Ponds and Solar based initiatives.Providing solar street lights, home lighting and solar lights for boats, specially targets sea farming families in the Tuna & Vandi village within Gandhidham block of Kutch district,Baif Institute for sustainable livelihoods and development, (BISLAD)Pune- Maharashtra.	₹ 30.00
10	Proposal for the Financial assistance for Ramakrishna Mission Centre for Human Excellance and Social Sciences also called 'Viveka Thirtha', New Town Kolkata. Human Excellence building ,Ramakrishna Mission, West Bengal	₹ 150.00
11	Funding for Distribute Biomass Green Cook Stove free of cost across Gujarat state.,Ramdas Athawale Foundation Ahemdabad	₹ 27.00
12	Request to Allotment of Fund for Development of School premises and providing furniture etc from CSR Fund.,Shree J.H Shukla Madhyamik Shala	₹ 25.92
13	Re-accreditation of sport academy under Khelo India Scheme.Request for Infrastructure for the proposals i) seating gallery & amenities ii) up gradation of existing hostel for elite athletes iii) surrounding road & infrastructure, etc.,Usha School Athletics, Kerala.	₹ 69.00
14	Proposal for Skill Development Training Program for Unemployed and Underprivileged Youth under CSR Initiative of Deendayal Port Authority (DPA) through Centre of Excellence in Maritime and Shipbuilding (CEMS),Mumbai	₹ 124.00
15	Submission of application along with requisite documents for construction of Kabrastan and fund for basic amenities under CSR,Etihadul Muslemin E Hind Trust, Anjar	₹ 50.00
16	Request Letter for the purchase of stainless steel Water Cooler with filter and dispenser for the school,Sunflower School, Gandhidham	₹ 3.19
17	Proposal for Placement Linked Skill and Capacity Building Training on Tourism and Hospitality Request for funding under Corporate social Responsibility (CSR) initiative,Pragati Edutech, Guwahati	₹ 50.00
18	Fund for establishment of New Facilities and upgradation of existing facilities at 'Adhar Sankul (Excluding cost of Building Construction.),'Adhar Sankul' Manav Seva Trust, Gandhidham.	₹ 75.00
19	Earnest Appeal to Contribute under CSR Activities for the construction of sainik school at silvassa in the name of NETAJI CHANDRA BOSE MILITARY ACEDEMY,VidhyaBharti Gujarat Pradesh, Ahemdabad.	₹ 445.23
20	Construction of an educational and social purpose building having 28 rooms & 2 halls.Shree Akhil Kutch Samasta Meghvanshi Gurjar Meghwal Charitable Trust, Bhuj.	₹ 75.00
21	Request to allotment of fund for development of school premises and providing furniture from CSR fund.Sunrise Global School, Gandhidham	₹ 12.60
22	Financial assistance to construction of Building Mind Power development centre for specially visually impaired children. With Equipments, Furniture CCTV, Airconditioner etc.,Shri Navchetan Adhjan Mandal, Madhapar	₹ 107.00

23	Proposal for DPA support Kutch Muslim Shifa Hospital,Muslim Shifa Medical Trust-Bhuj	₹	200.00
24	Request for help from CSR for providing Kits to the Children . List of government schools in khambhaliya taluka,for school Bags/Kits etc. They have requested for 1000 kits ,District Primary Education Officer, Devbhumi Dwarka-Khambhaliya	₹	4.00
25	Project proposal is for Education,Health and Livelihood project in kutch area Electric vehicle project for migrant community school,mobile health van project proposal, school structure project,tailoring training project, computer class for bhadreshwar centre, school-toilet-project, vermin compose unit, fisherman livelihood project.Yusuf Meherally Centre, Bhadreshwar-Kutch	₹	97.67
26	Request for renovation and construction of the shed work above G.F. slab, both side jali for shed, repairing work, painting.Missionaries of Charity, Bhachau (Mother Teresa's distitudi's home)	₹	55.00
27	River Reincarnation Project of the Bhukhi River.Krushi Research Innovation and Development Association, Mumbai (KRIDA)	₹	400.00
28	Providing Financial Assistance to R.D.S Kalavad Taluka Meghwar Seva samaj Education and Charitable Trust, Kalavad,SWA Ramji Daya Somaiya Shri Kalavad Taluka Meghwar Seva Samaj Education and Charitable trust, Kalavad	₹	75.00
29	CSR funding towards cure of Baby Aasmika Das diagnosed with Spinal Muscular Atrophy (SMA Type-1).	₹	20.00
30	CSR Funding for Providing Nutrition Kit to T.B. Patients under TB Mukat Bharat Abhiyan as Nishyray Mitra.	₹	14.02
31	Financial assistance under the CSR initiative to facilitate the urgent upgradation of the training and parade ground at the 176 BN BSF campus, Bhuj, Frontier Headquarters, Border Security Force (BSF)	₹	171.90
32	Financial assistance under the CSR initiative for Construction of a Martyr's Column at the 176 BN BSF campus, Bhuj, Frontier Headquarters, Border Security Force (BSF)	₹	32.20

Annexure E

दीनदयाल पोर्ट प्राधिकरण
DEENDAYAL PORT AUTHORITY

Office of the Dy. Chief Engineer
(EMC & I/c), Ground Floor,
Administrative Office Building
Post Box No. 50, Gandhidham–Kachchh
Email: scplkpt@gmail.com,
www.deendayalport.gov.in

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No: EG/WK/4783/VII/ /43 **Date: 04/10/2024**

To,
M/s. Precitech Laboratories Pvt. Ltd.
1st floor, Bhanujyot Complex,
Plot no. C5/27, B/h. Pachratna Complex,
Near GIDC Char Rasta,
VAPI-396195
Mail – vapi@precitechlab.com

WORK ORDER

Sub: "Strengthening of Existing Environmental Management Cell of Deendayal Port Authority: Appointment of Environment Expert for two years and further extendable for one years."

Ref: 1) Tender dated 28/12/20223 submitted by M/s Precitech Laboratories Pvt. Ltd., Vapi.
2) LOA No. EG/WK/5375/171 dated 19/09/2024.
3) Performance Guarantee submitted by M/s. Precitech Laboratories Pvt Ltd in the form of Bank Guarantee of Rs. 9,45,000.00 vide Bank Guarantee no. 1102924BG0B00238 dated 30.09.2024 issued by State Bank India, Commercial Branch, Vapi.

Sir,

Kindly refer above cited Letter of Acceptance dated 19/09/2024.

1) You shall have to provide Key Experts as per tender requirement during the entire contract period. Accordingly, you shall have to submit the qualification and experience certificates of the Key experts to be appointed at DPT, as per tender conditions for verification & approval.
2) Please submit the agreement of contract as per Tender Conditions.
3) Kindly commence the work on or before 07/10/2024.

Please note that the time period for providing Consultancy service for the subject work will be Initially for Two years and further extendable for one year on mutual consent as per tender condition.

Accordingly, a copy of Form-III is enclosed herewith for information and necessary action please.

Encl: Form – III

04/10/24
Dy. Chief Engineer (PL) & EMC (I/c),
Deendayal Port Authority

CC: 1. TPA to CE - For kind information to Chief Engineer, please.
2. RAO, DPA
3. Sr. DD (EDP) with a request to hoist this work order in website of DPA.

4. A.M.(W/A)

दीनदयाल पोर्ट प्राधिकरण
DEENDAYAL PORT AUTHORITY

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www.deendayalport.gov.in

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No: EG/WK/4783/VII/ **Date: 4/09/2024**
10

FORM – III

(Under rule 21(2) of the Contract Labour (Regulation and Abolition) Central Rules,1970; and Rules 7(3) of the Inter-State Migrant Workmen (Regulation of Employment and Conditions of Service) Central Rules, 1980)

CERTIFICATE BY PRINCIPAL EMPLOYER FOR OBTAINING LICENCE FROM ASSISTANT LABOUR COMMISSIONER (C), GOPALPURI.

Certified that:

I have engaged the applicant "Precitech Laboratories Pvt Ltd. 177, 1st floor, Bhanujyot Complex, Plot no. C5/27, B/h. Pachratna Complex,Near GIDC Char Rasta,VAPI-396195. as a contractor in my establishment for the work **"Strengthening of Existing Environmental Management Cell of Deendayal Port Authority: Appointment of Environment Expert for two years and further extendable for one years."** to be carried out for **24 months** (as per tender) and the work will be commenced on or before **07/10/2024**.

1) I undertake to be bound by all the provisions of the Contract Labour (Regulations and Abolition) Act, 1970 (37 of 1970) and the Contract Labour (Regulations and Abolition) Central Rules, 1971 The inter-State Migrant Workman (Regulation of Employment and Conditions of Service) Act, 1979 (30 of 1979) and the Inter State Migrant Workmen (Regulation of Employment and Conditions of Service) Central Rules, 1980* in so far as the provisions are applicable to me in respect of the employment of Contract Labour/inter-state migrant workmen by the applicant in my establishment.

2) The engagement of contract labour in the said work is not prohibited under sub-section (1) of section 10 of the Contract Labour (Regulation and Abolition) Act, 1970 (37 of 1970) or an award or a settlement.

04/09/24

Dy. Chief Engineer (PL) & EMC (I/c),
Deendayal Port Authority

Annexure F

CE
May posted in Civil Engineering Deptt/ Chairman's office, after obtaining & due formalities there.

Date: 25th August

To,

The Secretary,
Deendayal Port Authority,
Gandhidham, Kutch

Subject: Duty Report for the post of Chief-Manager (Environment & Safety) on contractual basis at DPA – reg.

Sir,

I Dr. Utkarsh S. Mukkannawar, have been selected and offered the position of Chief Manager (Environment & Safety) on contractual basis under professional functionaries category vide Letter No. GA/PS/4292(PF)/2025/1347 with effective from 12th August'2025.

As per terms clause no 19, I "have to report for medical examination before the Chief Medical Officer, DPA at Gopalpuri Hospital....."

Accordingly, I hereby submit and enclose my medical examination Report as clinically healthy and "FIT to Join".

Further, I hereby submit my duty report today i.e., 25th August 2025 (FN) along with duly signed acceptance copy of Offer Letter, the original copy of the medical report enclosing clinical documents and two passport size photos for your kind perusal.

Thanking you,

Yours faithfully,

25/08/25

Dr. Utkarsh Mukkannawar
Mob: 9822077507

CE
May be posted in Civil Engineering Department, after due clearance & formalities as per T&C of engagement, under intimation to GAD Pune.

10/9/2025
Secretary.

Date: 10th September 2025

To,

The Secretary,

Deendayal Port Authority,

Gandhidham, Kutch

Subject: Duty Report for the Port of Manager (Environment & Safety) on contractual basis at DPA – reg.

Sir,

I Ms. Neha Chandrashekhar Dekate, have been selected and offered the position of Manager (Environment & Safety) on contractual basis under professional functionaries' category vide letter no. GA/PS/4292 (PF)/2025/1349 with effective from 12th August'2025.

As per clause no. 19, "I have to report for medical examination before the Chief Medical Officer, DPA at Gopalpuri Hospital..... "

Accordingly, I hereby submit and enclose my medical examination report as clinically healthy and "FIT to Join".

Further, I hereby submit my duty report today i,e. 10th September 2025 (FN) along with duly signed acceptance copy of Offer letter, the original copy of the medical report enclosing clinical documents and two passport size photos for your kind perusal.

Thanking you,

Yours faithfully,

Neha Dekate

Ms. Neha Dekate
Mob: 9096069665

CG/Sr AS

may be posted in Environment Cell of Civil Engineering Deptt, subject to observance of due formalities as per terms & conditions of engagement in DPA on contract, Above.

3/9/2025
Secretary

To,

The Secretary

Administrative Building

Deendayal Port Authority

Date: 03/09/2025

SUBJECT: Duty Report for Contractual Engagement as Manager – Environment & Safety in Deendayal Port Authority (DPA)

Ref : DPA letter GA/PS/4292(PF)/2025/1348 dated 12/08/2025

Sir,

With reference to the above referred letter dated 12/08/2025 I am hereby pleased to submit my Duty Report and I confirm to join the organization with effect from today i.e.03/09/2025.

Thanking You

Yours Faithfully

Rajeshwari Sharma