RAPID ENVIRONMENT IMPACT ASSESSMENT REPORT FOR THE

DEVELOPMENT OF FISHING HARBOUR IN KALUVELI WATERS AT AZHAGANKUPPAM VILLAGE IN MARAKKANAM TALUK VILUPPURAM DISTRICT AND ALAMPARAIKUPPAM VILLAGE IN CHEYYUR TALUK, CHENGALPATTU DISTRICT, TAMIL NADU

Project Proponent

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DEPARTMENT OF FISHERIES**

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June 2020

DECLARATION BY PROJECT PROPONENT

Fisheries Department, Government of Tamil Nadu has conducted the **EIA Study on "Development of Fishing Harbour in Kaluveli Waters at Azhagankuppam Village, Marakkaram Taluk, Viluppuram District and Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu".**

The EIA report preparation has been undertaken in compliance with the EIA Notification 2006 and CRZ Notification 2011 issued by MoEF&CC. Information and content provided in the report is factually correct for the purpose and objective for such study undertaken.

We at this moment declare the ownership of contents (information and data) of the EIA/EMP Report.

For on behalf of Fisheries Department

Signature   :

Name   :

Designation   :

For Azhagankuppam   *For Alamaparaikuppam*

DECLARATION BY EIA CONSULTANT

EIA Study on "Development of Fishing Harbour in Kaluveli Waters at Azhagankuppam Village, Marakkaram Taluk, Viluppuram District and Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu".

*This EIA report has been prepared by **Cholamandalam MS Risk Services Limited (CMSRSL)** in-line with CRZ Notification, 2011, EIA Notification 2006 and their amendments.*

*This work has been undertaken in accordance with **ISO 9001:2008 Quality Management System** with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our General Terms & Conditions of Business and taking account of the resources devoted to it by agreement with the client.*

We disclaim any responsibility to the client and others in respect of any matters outside the scope of the above.

Further, this report is confidential to the client and the use of this report by unauthorized third parties without written authorization from CMSRSL shall be at their own risk.

For and on behalf of *Cholamandalam MS Risk Services Limited*

Approved by   : **N V Subba Rao**

Sign   :
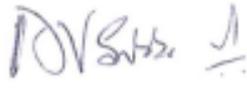
Designation   : Chief Executive

GOVERNMENT OF TAMILNADU
DEPARTMENT OF FISHERIES

Development of Fishing Harbour in Kaluveli Waters at Azhagankuppam Village, Marakkaram Taluk, Viluppuram District and Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu

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DECLARATION BY EIA CONSULTANT

Declaration by Experts contributing to the EIA study for "Development of Fishing Harbour in Kaluveli Waters at Azhagankuppam Village, Marakkaram Taluk, Viluppuram District and Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu".

I, hereby, certify that I was part of the EIA team in the following capacity that developed the above EIA.

Sector as per NABET Scheme	*33*	*Ports, harbours, break waters and dredging*
Sector as per EIA Notification	*7 (e)*	*Ports, harbours*

EIA Coordinator: In-House

Name: **Mr. V.S. Bhaskar**

Signature:

Date: 04 June 2020

Period of Involvement: May 2019 to December 2019

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Functional Area Experts

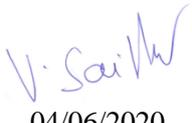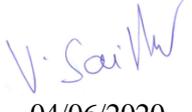| S. No	Functional Areas	Name of the Expert/s	Involvement (Period and Task)	Signature
1	AP- Air Pollution Monitoring, Prevention & Control (Category - A)	Mr. V S Bhaskar	**Period :** May 2019 to June 2020 **Task:** Developed Dust Control and Mitigation Plan during Construction Phase and Fugitive Dust Emission Control during Cargo Transportation	V. Sai 04/06/2020
2	WP- Water Pollution Monitoring Prevention & Control (Category - A)	Mr. V S Bhaskar	**Period :** May 2019 to June 2020 **Task:** Finalization of water sampling locations, characterization. Identification of Potential during construction and developed management plan to prevent contamination of water during coal transportation	V. Sai 04/06/2020
3	SE Socio-Economics (Category - A)	Mr. Karthick C S	**Period :** May 2019 to June 2020 **Task:** Conducted primary socio-economic survey, identification of social impact due to proposed project, preparation of mitigation plan, and development of CSR plan.	04/06/2020

S. No	Functional Areas	Name of the Expert/s	Involvement (Period and Task)	Signature
4	EB Ecology and Biodiversity (Category - A)	Dr. T. Balakrishnan	**Period :** May 2019 to June 2020 **Task :** Primary Survey of Terrestrial Flora and Fauna, Marine Biological Sampling. Identifiation and Analysis of Phytoplankton, Zooplankton and benthos. Identification of Nesting/breeding grounds of reptiles, mammals and avifauna including rare/threatended/endangered/ endemic species and their habitat within the study area. Impact assessment and environmental management plan for Mangroves Conservation, Habitat Conservation Measures.	04/06/2020
5	AQ Meteorology, Air Quality Modelling & Prediction (Category - A)	Mr. V S Bhaskar	**Period :** May 2019 to June 2020 **Task:** Design of Ambient Air Quality Monitoring Network. Primary Air Quality data Analysis and identification of impacts.	04/06/2020
6	NV Noise & Vibration (Category - A)	Mr. V S Bhaskar	**Period :** May 2019 to June 2020 **Task:** Identification of Noise Monitoring Locations. Noise Mitigation measures during construction and operation phase.	04/06/2020
7	LU Land Use (Category - A)	Mr. T. P. Natesan	**Period :** May 2019 to June 2020 **Task:** Preparation of land use land cover maps for the study area using GIS/ related tools followed by ground truth verification.	04/06/2020

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GOVERNMENT OF TAMILNADU
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1 INTRODUCTION

1.1 About Tamil Nadu Fisheries Department

Fisheries is one of the major food production sectors in the State of Tamil Nadu that supports the livelihood of the coastal fisherfolks. The state of Tamil Nadu is one of the foremost states in India that exhibits a steady increase in fish catch. Recognizing its importance, the Government of Tamil Nadu has committed itself towards development of infrastructures that support fisheries as well as the livelihood of the coastal community who depend on fishing. The Tamil Nadu Fisheries Department, that was established in the year 1907, is actively engaged in conserving the fishery wealth of the state, diversifying fishing methods at sea and inland, and strengthen the infrastructure for fish landing, processing and marketing. Also, it promotes sustainable fisheries throughout the state of Tamil Nadu and creates direct and indirect employment in the fishing sector. The Department of Fisheries has planned to develop fishing infrastructures in the form of fishing harbours, fish landing centres, and fish landing points across the 14 coastal districts of Tamil Nadu, inclusive of the recently formed Chengalpattu District, with the total fishing infrastructures accounting to 301 (**Figure 1-1**).

Figure 1-1 Fishery Infrastructure in Tamil Nadu
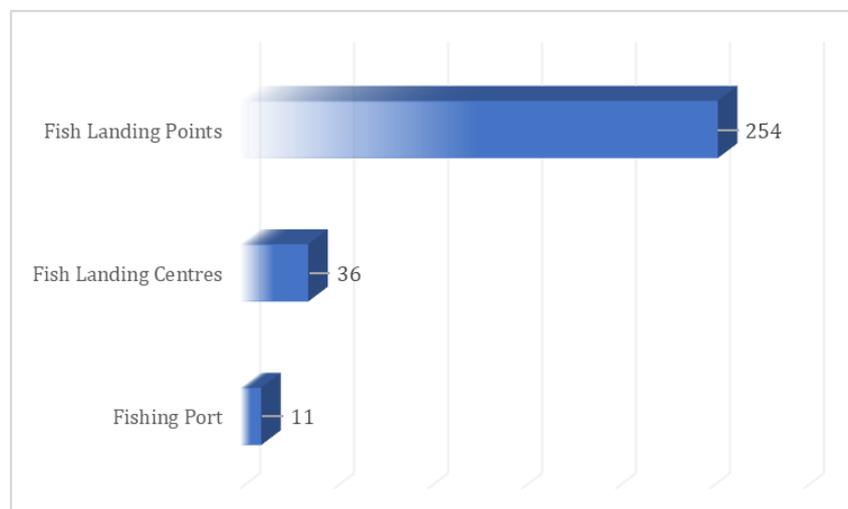
The infrastructures would suffice the need of about 608 marine fishing villages that houses a population of 10,06,567. Currently the Dept. of Fisheries has developed 11 fishing harbours and 35 fish landing centres.

1.2 Background of the Harbours in Kaluveli Waters

With the increasing fish catch along the coast of Tamil Nadu, there appears to be a lack of infrastructure for landing the fish catch and further processing, especially in the districts of

Chengalpattu and Villupuram. The nearest fishing harbors, with an established infrastructure, proximal to the above stated two districts are Chennai and Puducherry (**Figure 1-2**). The lack of fishery infrastructure in either districts has led to migration of the major fish catch of the districts to Chennai or Puducherry causing overcrowding and overloading of fish catch which in turn resulting in low quality fish production. An establishment of a well-structured fishing harbor with sufficient supporting facilities would ease the burden on other fishing harbor which would lead to the production of good quality and hygienic fish catch to the market. Also, the migration of fish catch to the existing fishing harbor has reduced the economic contribution of the districts to the State's overall GDP. This will increase the quality and standards of the Tamilnadu fishes in the world market.

In this regard, the Government of Tamilnadu (GoT) intends to develop a modern fishing harbor with all supportive amenities in Kaluveli waters at SFNo-23/1, Azhagankuppam Village in Marakkanam taluk of Viluppuram District and Alamparaikuppam Village in Cheyyur Taluk of Chengalpattu District. Both the fishing harbours have been notified as a site for development of fish landing point in the Tamil Nadu Gazette published on July 8, 2015 under the 'Tamil Nadu Marine Fishing Regulation Act, 1983 (Tamil Nadu Act 8 of 1983). The gazette notification is given in **Annexure I**. The location notified for the fishing harbor development on Azhagankuppam of Viluppuram District and Alamparaikuppam of Chengalpattu District is earmarked in the geo co-ordinate 12°14'50.66" N & 79°59'31.97" E and 12°16'1.00"N & 80° 0'44.00"E, respectively.

The proposed sites are located on the northers and southern banks of the Kaluveli Estuary. The proposed fishing harbours are Greenfield projects which envisages the development of supporting infrastructures to cater the handling, processing and storing of fish catches. The development of the said fishing harbours have been proposed to handle total fish quantity of 24,000 Tonnes Per Annum (TPA) with each fishing harbor accounting to 12,000 TPA.

Figure 1-2 Location of existing fishing harbor along the coast of Tamilnadu
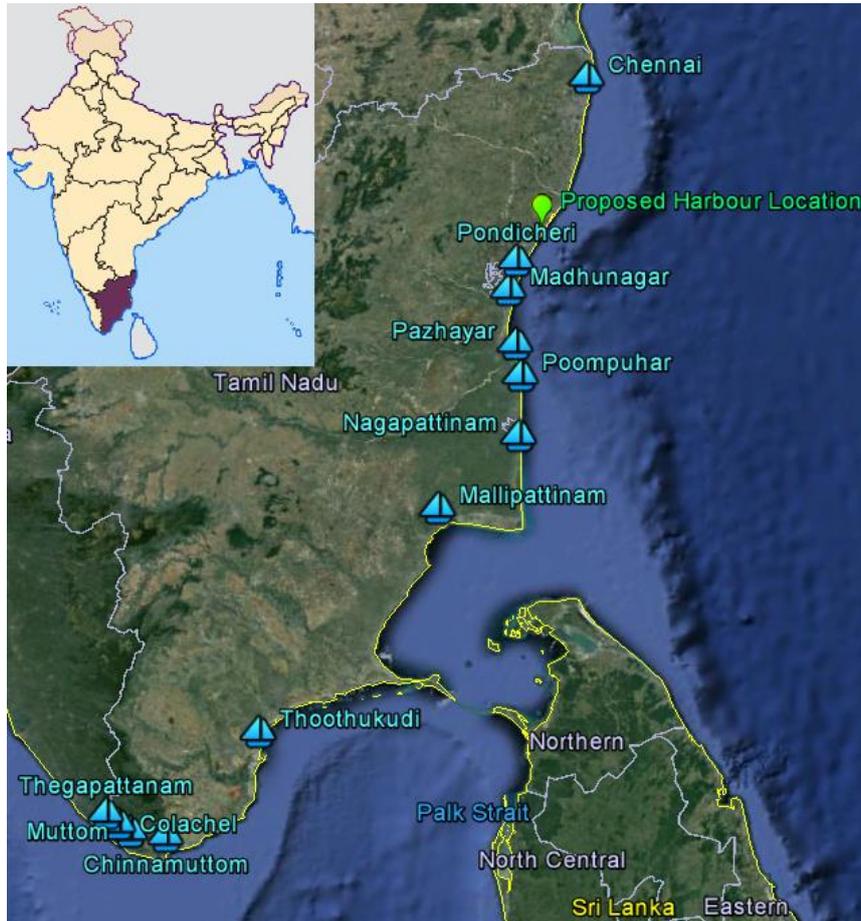
1.3   Need for the Fishing Harbors

The fishery sector of the nation has a significant contribution to the nation's Gross Domestic Product (GDP). It contributes about 5.23% to the GDP of the agriculture sector and 0.19% to the total GDP of the country. India contributes about 6.3% of the global fish production and 5% of the global fish trade. During the year 2016-17, the total fish production of the country was 11.41 million metric tonnes which has contributed to 1% of the total GDP of the country making India as the second largest producer of the fish in the entire world. Tamil Nadu ranks 4th in fish production of the country with an estimated production of 7.12 Lakh tones during the year 2017-18. By exporting marine products, Government of Tamil Nadu earned a foreign exchange of Rs.4342 Cr during 2016-17.

The current per capita consumption of fish in Tamilnadu is 9.83 Kg against the recommended requirement of 11.6 Kg. With the increase in demand for fish, there is a huge demand for augmenting the overall production of the state substantially from all the available fishery resources.

The proposed harbours will improve the socio-economic status of the fisher folk/entrepreneurs and will create employment opportunities to the local fisher folk in and around the fishing villages of Viluppuram and Chengalpattu districts. The proposed harbours will act as a natural fishing harbours with a larger area for accommodating higher number of fishing boats. Since the proposed harbors is well connected to the capital city by road and to the airport and sea ports, they would facilitate easy and quick transport of fish catches.

The proposed fusing harbours will also benefit the local fishermen, state and nation by,

- Bridging the gap between the current per capita fish consumption and recommended requirement.
- Contributing to the state's total fish production which will aid the nation's GDP.
- Increasing the monetary value of the fish catch in the global market.
- Aiding safe berthing of fishing vessels during adverse weather conditions.
- Safe storage of fishing accessories such as nets, floats, engines etc.

1.4   Regulatory Requirements

The proposed developments fall under sector 7(e) as per the schedule of EIA Notification, 2006 (S.O.1533 (E), dated the 14th September, 2006) for development of Ports and Harbours. And, the total fish handling capacity of each of the proposed fishing harbours at Azhagankuppam and Alamparaikuppam being 12,000 TPA, which is more than 10,000TPA, they are classified as Category B project which mandates obtaining prior environmental clearance from the State Environmental Impact Assessment Authority (SEIAA).

Further, the proposed project being located in the Coastal Regulation Zone (CRZ) as per the Coastal Regulation Zone Notification 2011 it requires prior CRZ Clearance from the Tamil Nadu State Coastal Zone Management Authority (TNSCZMA) under the following clauses of the Notification

Section 3 clause (i) subclause (a) *those directly related to waterfront or directly needing foreshore facilities*;

Section 3 clause (iv) subclause (a) *Land reclamation, bunding, or disturbing the natural course of seawater required for setting up construction or modernisation or expansion of foreshore facilities like ports, harbours, jetties, wharves, quays, slipways, bridges, sealink, road on stilts, and such as meant for defence and security purpose and for other facilities that are essential for activities permissible under the notification.*

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Section 4 clause (i) subclause (f) *construction and operation for ports and harbours, jetties, wharves, quays, slipways, ship construction yards, breakwaters, groynes, erosion control measures.*

Section 8. Sub-section III clause (iii) subclause (l) *facilities required for local fishing communities such as fish drying yards, auction halls, net mending yards, traditional boat building yards, ice plant, ice crushing units, fish curing facilities and the like.*

1.5 Site Conditions

The sites for the proposed fishing harbour at Azhagankuppam, Village of Villupuram Dist., and Alamparaikuppam Village of Chengalpattu Dist. are located at 12°14'50.66" N & 79°59'31.97" E in Survey No-23/1 and 12°15'40.40"N & 80°0'10.37"E in Survey No-49/2, respectively. The location map is shown in **Figure 1-3**. The project sites are located at about 89 km from Chennai and 44 km from Puducherry. The project site can be identified from the Survey of India (SoI) toposheets no D44U3, D44T16 & D44T15 prepared by Survey of India and the location map of the proposed project site is shown in **Figure 1-4**.

As per the EIA notification 2006, it is mandatory to study the environment conditions around the 10 Km radius of the project site boundary. Areas that are ecologically sensitive near the project site are mangroves along the banks of Kaluveli Waters (Backwaters). Alamparai Fort, an Archeological Survey of India (ASI) notified monument is present more than 2 km away from the project site. The marine water present in the study area is Bay of Bengal. The nearest railway station is Acharapakkam at an aerial distance of 25.5 Km from the project site. The nearest airport is Chennai International Airport about 80 km aerial distance and Puducherry Airport 42 Km aerial distance from the project site. The proposed site along with the study area within 10 Km has been represented on the toposheets shown in **Figure 1-3**.

Figure 1-3 Location of the Proposed Sites
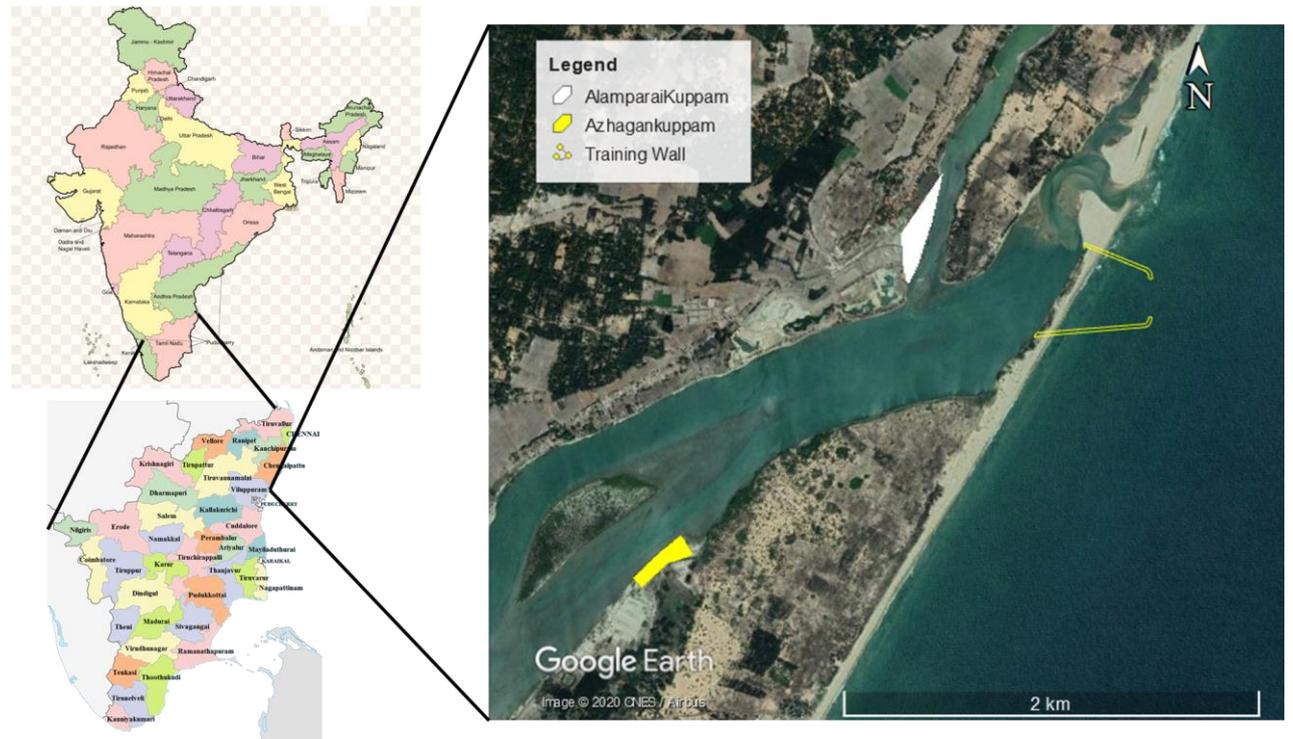
Figure 1-4 Topographical representation of the Study area
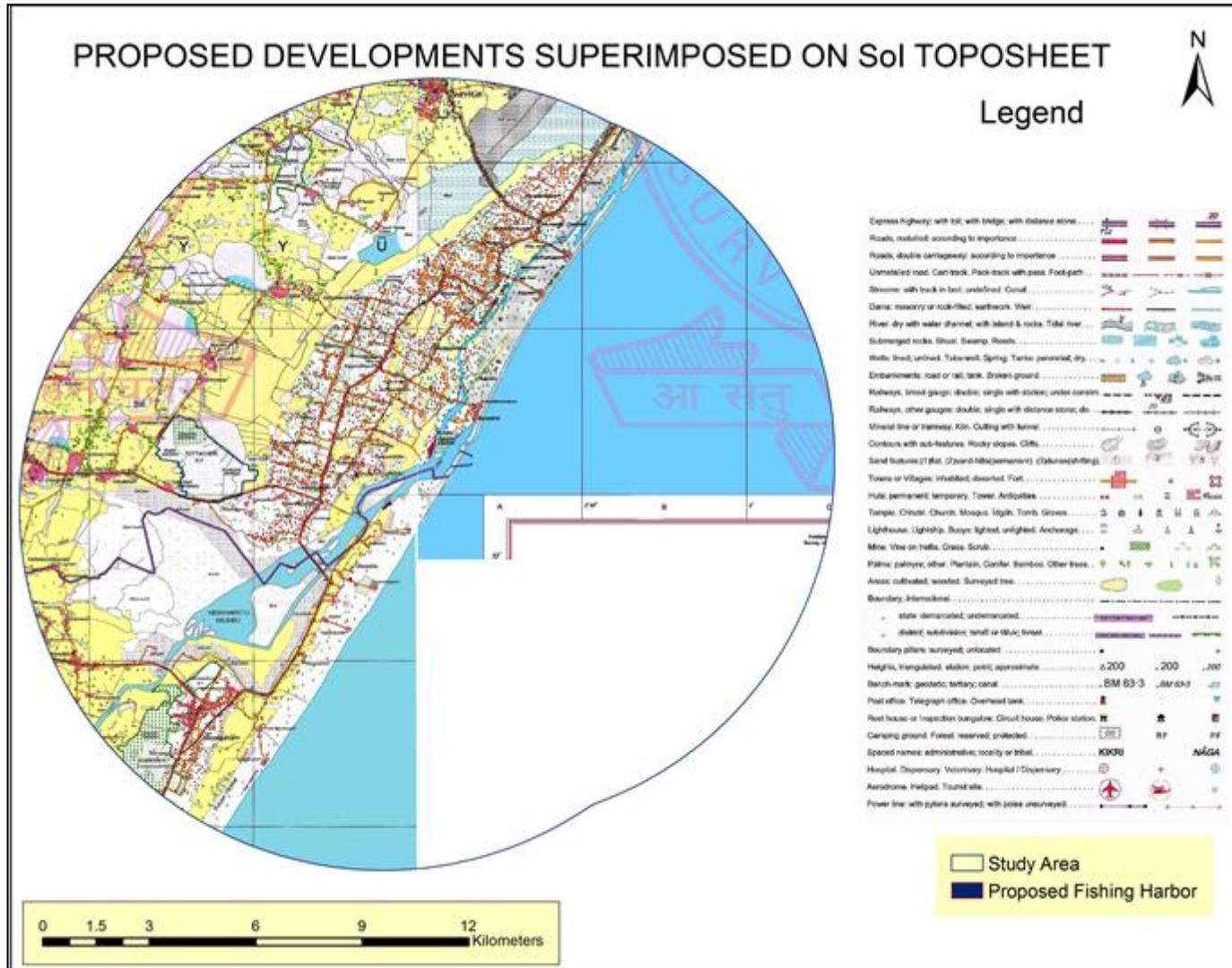
Table 1-1 Environmental Setting of Study Area

S. No.	Particulars	Details (Aerial distance (within 15 km.) Proposed project location boundary)
1	Project Location	Azhagankuppam Village, Viluppuram District, Tamilnadu. Alamparaikuppam Village, Chengalpattu District, Tamil Nadu
2	Site Coordinates	Latitude: 12°14'50.66" N; Longitude: 79°59'31.97" E Latitude: 12°15'40.40" N; Longitude: 80°0'10.37" E
3	Nearest Railway Station	Acharapakkam Railway Station *Road Distance- 36 Km* *Aerial Distance- 25.5 Km*
4	Nearest Airport	Puducherry *Road Distance- 48 Km* *Aerial Distance- 40 Km*
5	Nearest Sea Port	Chennai Port
6	Village/Major Town	Marakkanam & Edaikazhinadu.
7	Inland, coastal, marine or underground waters	Bay of Bengal – East of proposed fishing harbor.
8	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value	Alamparai Fort. (*Aerial Distance – 0.55 Km*)
9	Areas which are important or sensitive for ecological reason	Tottencheri R.F. Sitharkadu R.F. Marakkanam R.F. Agaram R.F.
10	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration	Nil.
11	State, National boundaries	Nil.
12	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas	Kadapakkam- Alamparaikuppam Road leading to State Highway 49. *Aerial Distance – 1.43 Km NE.*
13	Densely populated or built-up area	Azhagankuppam – *0.9 Km SE.* Alamparaikuppam – *0.75 Km NE.*

1.6 Methodology of EIA

M/s DHI Water Environments Pvt. Ltd contracted M/s Cholamandalam MS Risk Services Limited, a NABET accredited EIA consultant organization (accredited to undertake EIA studies for Ports and Harbors as per the NABET accreditation scheme), to undertake the

Environmental Impact Assessment (EIA) study. A copy of the latest accreditation status is presented in **Annexure II**.

The EIA study for the proposed project was carried out based on the standard ToR issued by SEAC, the baseline environmental monitoring was conducted. The baseline study was done from 18th October 2019 to 11th November 2019.

The monitoring studies in the study area were conducted to assess the baseline environmental conditions with respect to quality of air, soil, noise, groundwater, surface water and marine waters, sediment etc. Sampling and Analysis studies were undertaken by NABL accredited laboratory and the respective accreditation certificate is attached as **Annexure III**. The primary data obtained from the laboratory were validated with the secondary data collected for the study area from the authentic sources.

As a part of the EIA study, the anticipated positive and the negative impacts on the environment due to the proposed project activities have been assessed and their corresponding Environment Management Plan (EMP) is developed to reduce the magnitude of impacts.

1.7   Structure of EIA/EMP

The EIA / EMP report for the proposed project has been organized as per Appendix-III of EIA Notification, 2006 which describes the Generic Structure of Environmental Impact Assessment Document.

Chapter 1 – Introduction Presents the background and need for study, along with the brief description of nature, size and location of the project as well as its importance to the region and country.

Chapter 2 – Project Description - Describes the details on the size, location of the project including project layout, technology and process involved, proposed schedule for approval and implementation etc.

Chapter 3 – Baseline Environment - Presents the baseline environmental conditions of both the marine and the terrestrial components inclusive of land use & land cover along with the base maps of all the components, socio-economic condition of the study area.

Chapter 4 – Impact Prediction - Presents the anticipated positive and negative environmental impacts due to the proposed project, its construction and operational activities. The

significance of the impacts are analyzed in order to provide the mitigation measures so as to reduce the impacts of the environment.

Chapter 5 – Analysis of Alternative - The alternative site and technology that may be used for the proposed development are included.

Chapter 6 – Environmental Monitoring Program - Presents Environment Monitoring Plan for the study area.

Chapter 7 – Additional Studies – Presents the details of additional studies such as Risk Assessment, Cumulative Impact Assessment, CRZ study and Disaster Management Plan.

Chapter 8 – Project Benefits - Presents the details of the Project benefits such as the improvements in physical infrastructure, social infrastructure and employment potential.

Chapter 9 – Environmental Management Plan - Presents the effectiveness of the mitigation measures in terms of EMP by monitoring the environmental components during construction and operation phases of the project.

Chapter 10 – Summary and Conclusions – Presents the overall justification and summary of the impacts and mitigations that has to be implemented.

2 PROJECT DESCRIPTION

2.1 General Description of the Proposed Project

The proposed fishing harbors at Azhagankuppam is located at latitude 12°14'50.66" and Longitude 79°59'31.97" in Survey No-23/1 of Marakkanam revenue village in Marakkanam taluk of Viluppuram district at Villupuram district, and the one at Alamparaikuppam is located at latitude 12°15'40.40"N and Longitude 80° 0'10.37" at Chengalpattu district in the state of Tamilnadu. The proposed harbor is a natural harbor type as it is strategically located in the western branch of the main estuary (Kaluveli waters) which is a shadow region experiencing very minimal wave current. The Kaluveli estuary is connected with Kaliveli Lake which is one of the largest lakes in the peninsular India. The proposed fishing harbor at Azhagankuppam will spread across an area of 3.23 Ha, in the 6 Ha land and Alamparaikuppam spreads across an area of 3.43 Ha, in the 5 Ha land, with both the lands belonging to the Fisheries Department, which includes intertidal area. The project does not involve acquisition of land or resettlement of people. The nearest town to the project site is Edaikazhinadu which lies at a distance of 5.6 km and 3 km from Azhagankuppam and Alamparaikuppam respectively.

Both fishing harbors have been proposed to handle an annual fish catch of 12,000 Tonnes. To accommodate the said quantity, land side infrastructure facilities such as auction hall, net mending shed, gear room, power room, sloping yard, administration building, fresh water sump, electrical control room & electrical generator room, water supply and drainage, overhead tank of capacity 50,000 litres, Sewage treatment plant of capacity 15 KLD, solid waste collection area, parking area, security room, toilet blocks, ice plant and cold storage rooms, radio/ telephone communication, two lane internal roads of 1.5 Km length with walkway on either side and compound wall around the periphery are proposed. Water front infrastructure facilities such as diaphragm wall, training wall, slipway, capital dredging and reclamation are proposed as part of the developments. The layout of the two proposed fishing harbour at Azhagankuppam and Alamparaikuppam is illustrated in **Figure 2-1** and **Figure 2-2** respectively.

Figure 2-1 Layout of the Proposed Fishing Harbor at Azhagankuppam village

Figure 2-2 Layout of the Proposed Fishing Harbor at Alamparaikuppam village
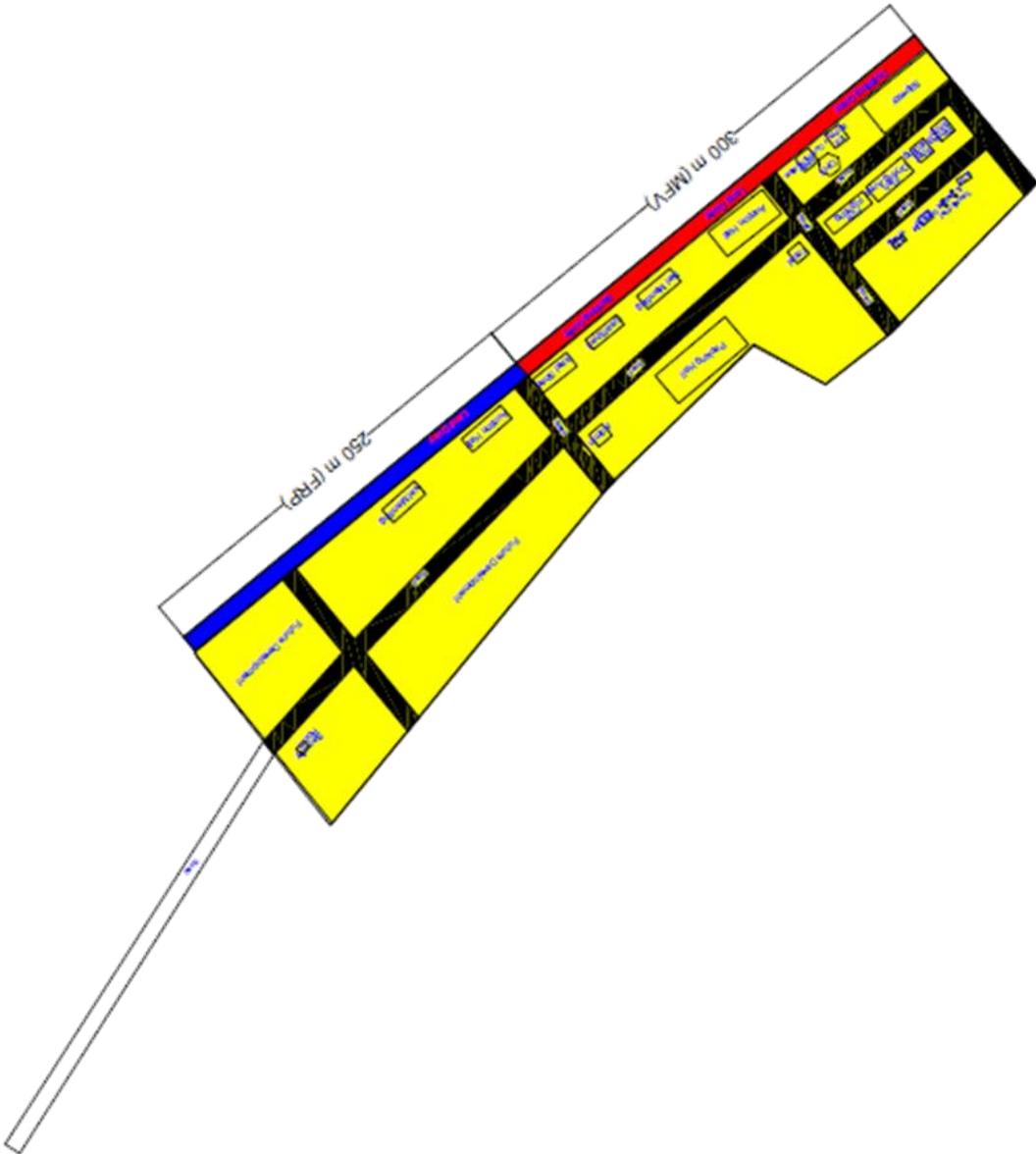
2.2 Infrastructural Requirements

The two fishing harbours proposed at Azhagankuppam and Alamparaikuppam have been designed with similar infrastructures with only minor variations in dimensions and utilities. THe following sub-sections details on the infrastructural development proposed for either sites for a fully functional fishing harbour.

The proposed project does not involve development of any external roads. However, internal roads are proposed as part of the harbor development to aid smooth flow of traffic within the harbor.

2.2.1 Site Connectivity

Although the proposed project is a Greenfield development, the project site is easily accessible by road. The detailed connectivity to the site is discussed in the following sections.

2.2.1.1 Road Connectivity

Azhagankuppam: A single lane road along the eastern side of the estuary is proposed to connect the project site to Thazhangadu Village, which is further connected to the east coast road (SH-49).

Alamparaikuppam: An existing single lane road (Canal Bank road) connects the project site to Kadapakkam, a residential area. However, the single lane road would be widened 5m on either side (10m overall) into a two lane road for a stretch of 215 m until Kadapakkam; the village road from Kadapakkam further connected to the east coast road (SH-49).

The SH-49 connects the project site to Chennai via Kalpakkam, Mahabalipuram and Kovalam. The site is connected to Puducherry by SH-49 via Marakkanam, Koonimedu and Bommayapalayam.

2.2.1.2 Rail Connectivity

The nearest railway station to either locations is Acharapakkam located at a distance of 25.5 Km, which is connected to Melmaruvathur and Tindivanam, the major towns in Villupuram district.

2.2.2 Land Requirement

The proposed fishing harbors will be developed by reclaiming the existing intertidal area which is currently occupied by salt affected land. Filling for reclamation will be met from the dredged

sediments that is proposed as part of the development. The land on which the two harbours have been proposed is owned by Government of Tamilnadu for the Department of Fisheries. And therefore, no acquisition of land is required for the current proposals.

Azhagankuppam: The fishing harbour proposed at Azhagankuppam spreads over an area of 3.23 Ha, which will be developed in the 6 Ha land owned by the Department of Fisheries.

Alamparaikuppam: The fishing harbour proposed at Alamparaikuppam spreads over an area of 3.43 Ha, which will be developed in the 5 Ha land owned by the Department of Fisheries.

2.3 Proposed Infrastructural Developments

To address the need of handling 12,000 TPA of fish catch at either fishing harbours, basic developmental activities such as dredging to facilitate the berthing and safe navigation of fishing vessels and supporting infrastructure facilities such as internal roads, various types of building blocks and drainage facilities are proposed. The following subsections would detail the activities to be undertaken and the proposed developments.

2.3.1 Navigation Channel

As the two proposed fishing harbours would be developed in the backwaters of Kaluveli, a permanent approach channel for the vessel navigation, the clearing of the sand bar between the Kaluveli Waters and the sea is proposed by dredging. An area of 5 Ha of the sandbar would be dredged to maintain a water depth of -2.5m from CD. It is estimated that a volume of 0.4 M.Cum of dredge sediment would be generated during the development of the navigation channel.

2.3.2 Navigation Basin

Besides the development of navigation channel into Kaluveli Waters, the development of the navigation basin within Kaluveli Waters is also proposed in order to facilitate the navigation of vessels to the fishing harbours at Azhagankuppam and Alamparaikuppam. This would require capital dredging to maintain a water depth of -2.5 m from CD for berthing and safe navigation of fishing vessels. To attain such depth, it is expected that 0.4 M.Cu.m of dredge sediment would be generated for each fishing harbour accounting to a total volume of 0.8 M.Cum of dredge sediment.

2.3.3 Training Wall

To prevent the sedimentation of the Navigation channel, two training walls have been proposed on the northern and southern side of the channel. The length of the training wall on the northern side of the channel is 400m and the one to the southern side is 600m.

2.3.4 Diaphragm Wall

Diaphragm wall along the harbor boundary will be constructed retain the soil from shearing and to provide a structural platform for docking of fishing vessel. At either harbours a diaphragm wall of length 550m has been proposed, of which 300m of the wall would be used to dock mechanized boats and 250m for motorized boats.

2.3.5 Reclamation

The dredged sediment would be utilized to reclaim the intertidal area and rising of low areas. The dredged sediments will be screened and tested for suitability for filling. An area of 3.23 ha and 3.43 of intertidal area at Azhagankuppam and Alamaparaikuppam, respectively, would be reclaimed at both sites for the development purpose.

2.3.6 Internal Roads

It is proposed to develop several segments of two-lane internal roads of total length 1.5 Km within the two harbor facilities to aid free movement of vehicles. The proposed road width would be 10 m with sidewalk on the either sides for person on foot.

2.3.7 Associated Facilities

For supporting the efficient handling of fish catch, associated facilities such as auction hall, Ice plant and cold storage rooms, net mending shed, gear room, radio/telephone communication, power room, sloping yard, administration and bank building, electrical control room with generators, security room, compound wall around the periphery and parking area are proposed at both fishing harbours.

2.3.8 Greenbelt Development

Greeneries and landscaping in front of the main gate and other areas are proposed as part the development. The total area that is designated for greenbelt development is 0.1 Ha. The greenbelt would be developed in consultation with the forest department and priority would be given to species native to the region.

2.4 Utilities

Utilities refer to the electricity power and the water required by the harbor for its operation along with the waste management measures.

2.4.1 Sewage Treatment Plant & Drainage

A modular Sewage Treatment Plant of 15 KLD capacity that functions on activated sludge process is proposed at both harbours. The STP would treat the waste water generated from the handling of daily fish catch. Sewage from various units, including standalone toilets, will be routed to the STP by dedicated drains. Storm water drains will be developed within both the harbor facility to collect the rain water and route them to a collection tank and routed to the STP as well.

2.4.2 Water Requirement

An overhead tank of capacity 50KL is proposed for the two harbours, to meet the fresh water requirement within the harbours. The water would be sourced from approved sources and be treated in a water treatment plant whose operating capacity would be 1000 litre/hour. A water sump of capacity 50KL is also proposed as part of the development to store treated fresh water.

2.4.3 Power Requirement

The power demand during the construction and operation phase would be 15 KV & 75 KV. The required power will be drawn from TNEB. DGs will be kept in standby to fulfill the power supply in the event of power failure.

2.5 Employment Generation

The proposed project is expected to generate a total employment of 700 during construction and operation phase. The detailed breakup of the generated employment opportunities are given in **Table 2-1**.

Table 2-1 Employment Generation

Phase of Operation	Permanent Employees	Temporary Employees
Construction Phase	150	150
Operation Phase	300	100

2.6 Project cost estimation

The total cost for the development of fishing harbors at Azhagankuppam of Viluppuram district and Alamparaikuppam of Chengalpattu district amounts to Rs.235 Crores.

2.7 Time Schedule

The proposed developments are expected to be completed in 18 months after obtaining prior environmental and CRZ clearances.

3 BASELINE ENVIRONMENTAL CONDITION OF THE STUDY AREA

3.1 General

In order to understand the existing environmental conditions, environmental aspects like Air Environment, Noise Environment, Water Environment, Marine Environment, Biological Environment and Socio-Economic Environment needs to be monitored and analyzed. For this purpose, baseline monitoring study is conducted; for one season terrestrial environment and one season marine environment within the 10km study area. Monitoring was done for a period of one month. The study area represents the details of the environment in 10 km radius from the boundary of the proposed project site.

The proposed activities are majorly present in the marine environment and tidal influences waters of Kaluveli, hence more importance is given to Marine Environment. Terrestrial monitoring has been conducted for analyzing Ambient Air Quality (AAQ), ambient noise, surface water quality, ground water quality and soil quality. Marine monitoring has been conducted for analyzing the quality of marine water, marine sediment, phytoplankton, zooplankton and benthic communities. All the samples have been analyzed for the parameters as per the prescribed standards and guidelines. The baseline of the study area is detailed w.r.t the primary and the secondary information collected for the two districts, Villupuram and Chengalpattu, in which the projects have been proposed. As Chengalpattu District was recently formed by the Govt. of Tamil Nadu in the 2019, the secondary information for Chengalpattu District would be detailed for Kancheepuram District. The following sections describes the baseline information of the study area.

3.2 Geographical Features

Geographical Features are the natural or man-made features on earth where the natural features include the geology, terrain type (topography), water bodies, soil type/classification, vegetative cover, and the man-made features include settlements, and other modified land use. Studying the geographical features of the proposed project stretch would provide us with the understanding of the environmental conditions of the region, and the area in specific.

3.2.1 Geomorphology

Viluppuram Dist.: The residual hills and denudational hills are common in Tirukoilur, Kallakurichi and Gingee taluks. Structural hills are noticed in the western part of the district. The shallow pediments and buried pediments are common in the central part of the district. Coastalareas are having older and younger flood plains and also beach landforms at places. The ground slope is gentle towards coast. The valley fill near Viluppuram is thick, which forms main ground water discharge zone. Lineaments are restricted to parts of Kallakurichi and Sankarapuram areas and productive fractures are noticed in select pockets. The crystalline sedimentary contact fault is having sympathetic fractures in hard rocks but mostly they are dry fractures.[1]

Kancheepuram Dist.: The prominent geomorphic units identified in the district through interpretation of satellite imagery are i) Chingleput-Tirukkalukkunram Surface (Erosional) ii) Palar Surface (fluvial and iii) Mamallapuram (Mahabalipuram) surface (Marina) etc. The elevation of the area ranges from 100 m amsl in the west to a sea level in the east. The major part of the area is characterised by an undulating topography with innumerable depressions, which are used as irrigation tanks. Three beach terraces ranging in elevation between 4 mark the coastal tract and 12 m with broad inter terrace depressions. The coastal plain displays a fairly low level or gently rolling surface and only slightly elevated above the local water surfaces on rivers. The straight trend of the coastline is a result of development of a vast alluvial plain. There are a number of sand dunes in the coastal tract. The coastal landforms include estuarine tidal, mud flats or lagoons and salt marsh etc.[2]

3.2.2 Land Use Land Cover

To determine the existing land use pattern of the study area covering 10 Km radius from the project site, Land Use and Land cover study was conducted for Level-I classification. The study was conducted by sourcing recent satellite imagery and data.

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[1] District Groundwater Brochure, Villupuram district, Tamil Nadu, 2009.
[2] District Groundwater Brochure, Kancheepuram district, Tamil Nadu, 2007

The procured satellite imageries were geo-referenced and enhanced by stacking and sharpening for arriving various land pattern of the study area. Based on the site morphology, land use classifications were identified as per guidelines and discussed in the following sections.

3.2.2.1 Methodology

General – The land use/land cover map is prepared by adopting the interpretation techniques of the image in conjunction with collateral data such as topographical maps and census records. Image classification can be done by using visual interpretation techniques and digital classification using any of the image processing software.

Present Study - For the present study, ERDAS and ArcMap software were used for image preprocessing, rectification, enhancements and classifying the satellite data for preparation of land use land cover map and assessing land use land cover pattern and land developmental activities.

The imagery was interpreted initially based on the secondary data available and image characteristics. Ground verification was done to check each class of land use/land cover spread over the entire study area and final land use/land cover analysis was made after necessary corrections. Flowchart showing the methodology adopted is presented in **Figure 3-1**.

Satellite Data – Landsat-8 multispectral data of was utilized for the present study and shown in **Figure 3-2**. The rectification of imagery was carried out to bring the digital imagery information on the earth co-ordinate system by means of ground control point (GCP) assignments from Survey of India (SoI) toposheets. Details of the acquired satellite images are shown in **Table 3-1**.

Table 3-1 Details of Satellite Map

S.No.	Satellite	Scale	Path & Row	SOI Toposheet No.	Date of Pass
1	Landsat-8	1:50,000	142&52	D44U3, D44T16 & D44T15	10.11.2019

Figure 3-1 Methodology Chart
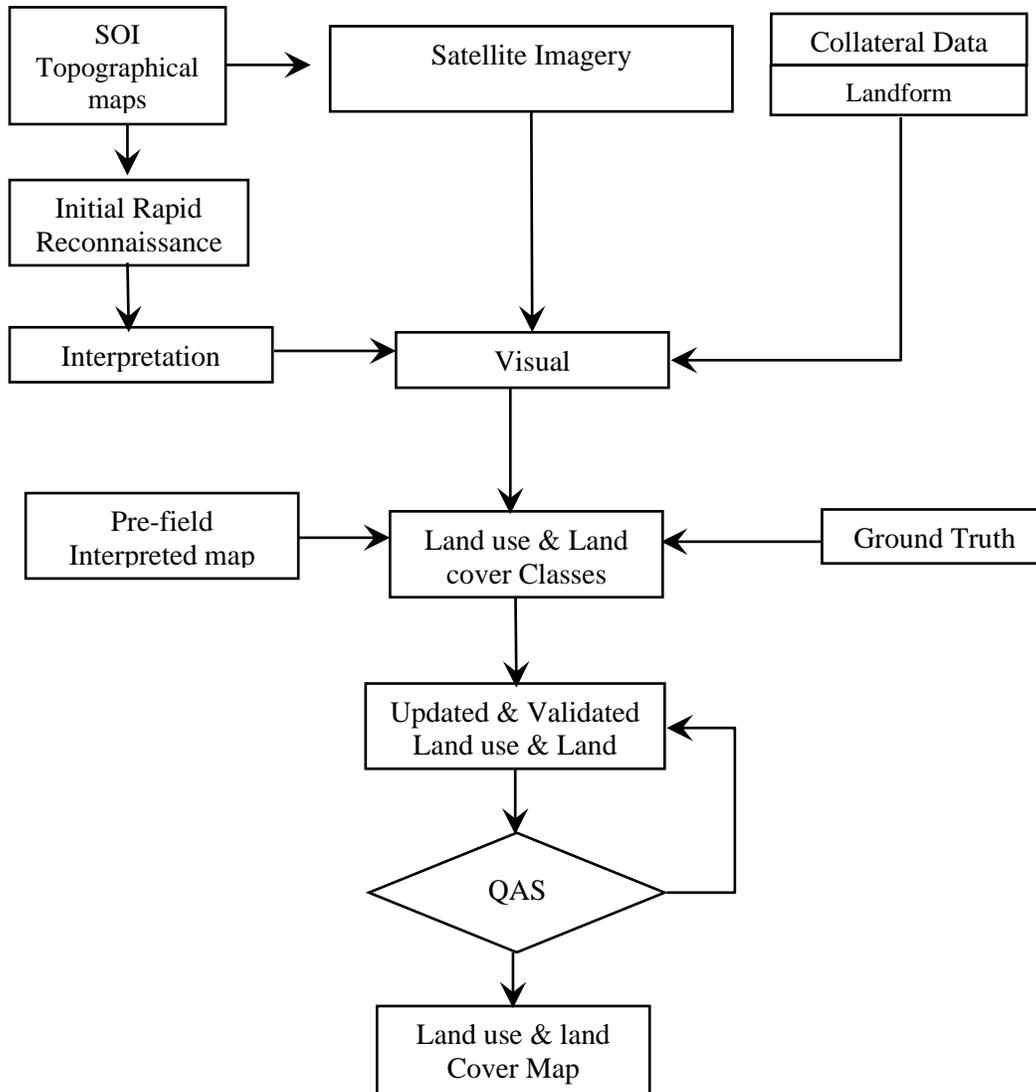
```
┌──────────────┐        ┌──────────────────┐        ┌──────────────────┐
│ SOI          │───────▶│ Satellite Imagery│        │ Collateral Data  │
│ Topographical│        │                  │        ├──────────────────┤
│ maps         │        └──────────────────┘        │ Landform         │
└──────────────┘                 │                   └──────────────────┘
       │                         │                            │
       ▼                         │                            │
┌──────────────┐                 │                            │
│ Initial Rapid│                 │                            │
│ Reconnaissance│                │                            │
└──────────────┘                 │                            │
       │                         ▼                            │
       ▼                 ┌──────────────┐                     │
┌──────────────┐         │    Visual    │◀────────────────────┘
│Interpretation│────────▶│              │
└──────────────┘         └──────────────┘
                                 │
                                 ▼
┌──────────────┐         ┌──────────────┐         ┌──────────────┐
│ Pre-field    │────────▶│ Land use &Land│◀───────│ Ground Truth │
│Interpreted map│        │ cover Classes│         └──────────────┘
└──────────────┘         └──────────────┘
                                 │
                                 ▼
                         ┌──────────────┐
                         │Updated &Validated│◀──┐
                         │Land use & Land │    │
                         └──────────────┘    │
                                 │            │
                                 ▼            │
                            ╱─────────╲       │
                           ╱    QAS    ╲──────┘
                            ╲─────────╱
                                 │
                                 ▼
                         ┌──────────────┐
                         │Land use & land│
                         │ Cover Map    │
                         └──────────────┘
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Figure 3-2 Satellite image showing 10 Km Study area of the project site
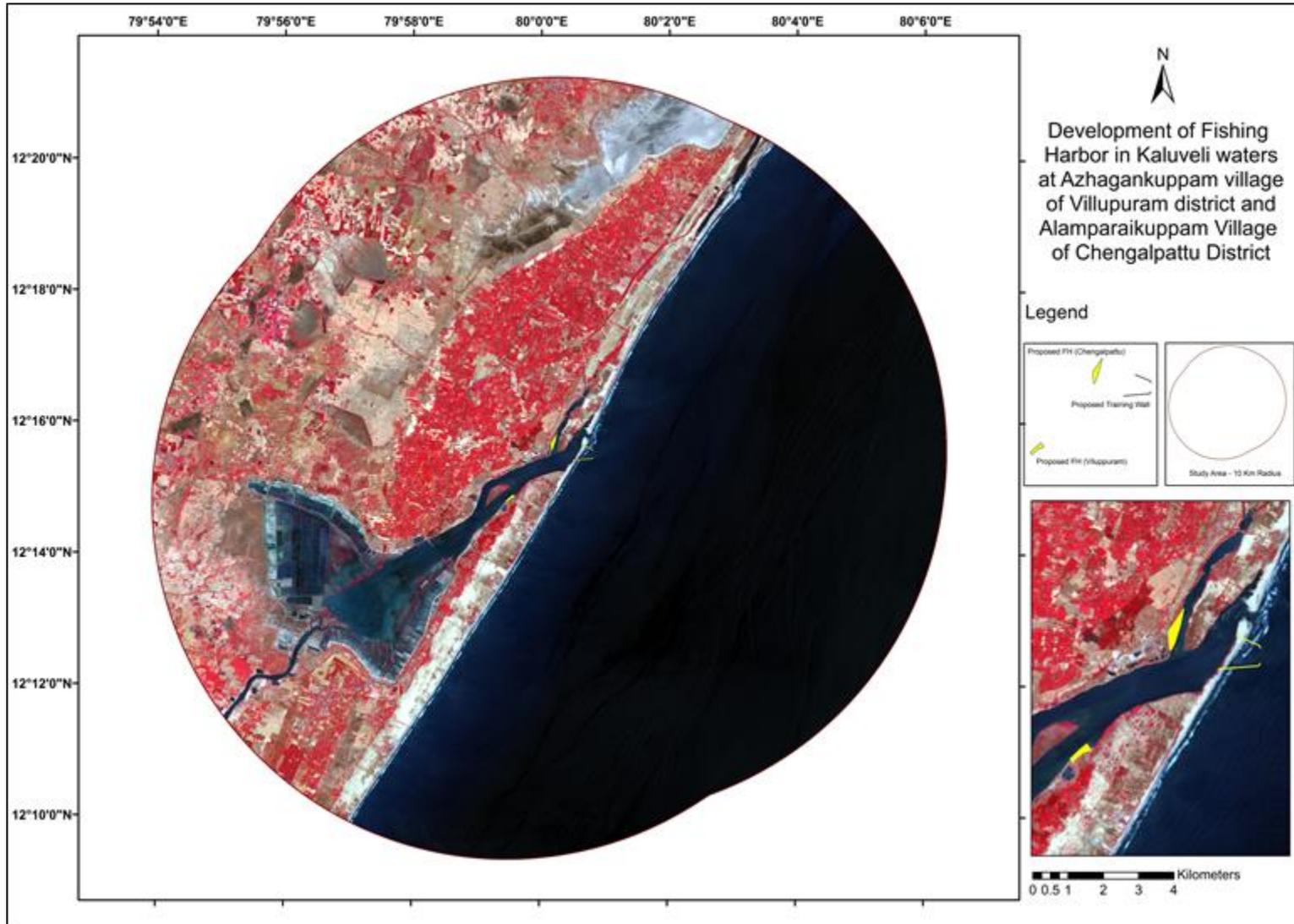
To determine the existing land use pattern of the study area covering 10 Km radius, the land use and land cover study was conducted for Level-I classifications. The level-I classification map prepared is presented in **Figure 3-3**. The land use breakup of the study area has been given in

Table 3-2. The distribution of LULC features within the study are is given in **Figure 3-4**.

3.2.2.2 Observations of Level-I Land Use Land Cover Map

The major part of the study area is covered by agricultural practice. About (7078.85 Ha) 36.31 % of the land area is covered by agricultural fields.

The second major land cover identified from the study is Land with/without Scrub which accounts to (3365.14 Ha) 17.26 % of the total land area.

Naturally growing trees and shrubs which are classified under vegetation spans over an area of 2916.6 Ha which is 14.96 % of the total land area.

Wastelands in the study are spread across a total area of 2472.8 Ha which is 12.68 % of the total land area. Wasteland includes land area that are designated for aquaculture, salt pan and other salt exposed area unfit for crop cultivation.

About 1640.2 Ha (8.41 %) of the land area is covered by sand.

Seasonal water bodies and tidal influenced water bodies within the study area accounts to a total area of 960.25 Ha which is 4.93% of the total study area.

Reserve forest in the study area was identified from the Survey of India (SoI) toposheets. The reserve forests that are identified in the study area are Thottencheri R.F., Sitharkadu R.F., Marakkanam R.F. and Agaram R.F. The total area of the reserve forest in the study area is 554.8 Ha which is 2.85 % of the total land area.

Built-up land which includes residential settlements and commercial structures are the least covered land use classification identified within the study area which has a total area of 507.67 Ha (2.6%).

Table 3-2 Land Use breakup of the Study area

Level-I Classification	Area in Ha.	Area (%)
Agricultural Land	6868.8	34.23
Alamparai Fort	7.8	0.04
Builtup Land	681.3	3.40
Land with/without Scrub	4276.0	21.31
Reserve Forest	614.0	3.06
Sandy Area	1640.3	8.18
Vegetation	2933.5	14.62
Wasteland	2058.7	10.26
Waterbody	983.7	4.90
Total	**20064.1**	**100**

Figure 3-3 Land Use Map of the 10 Km Study Area
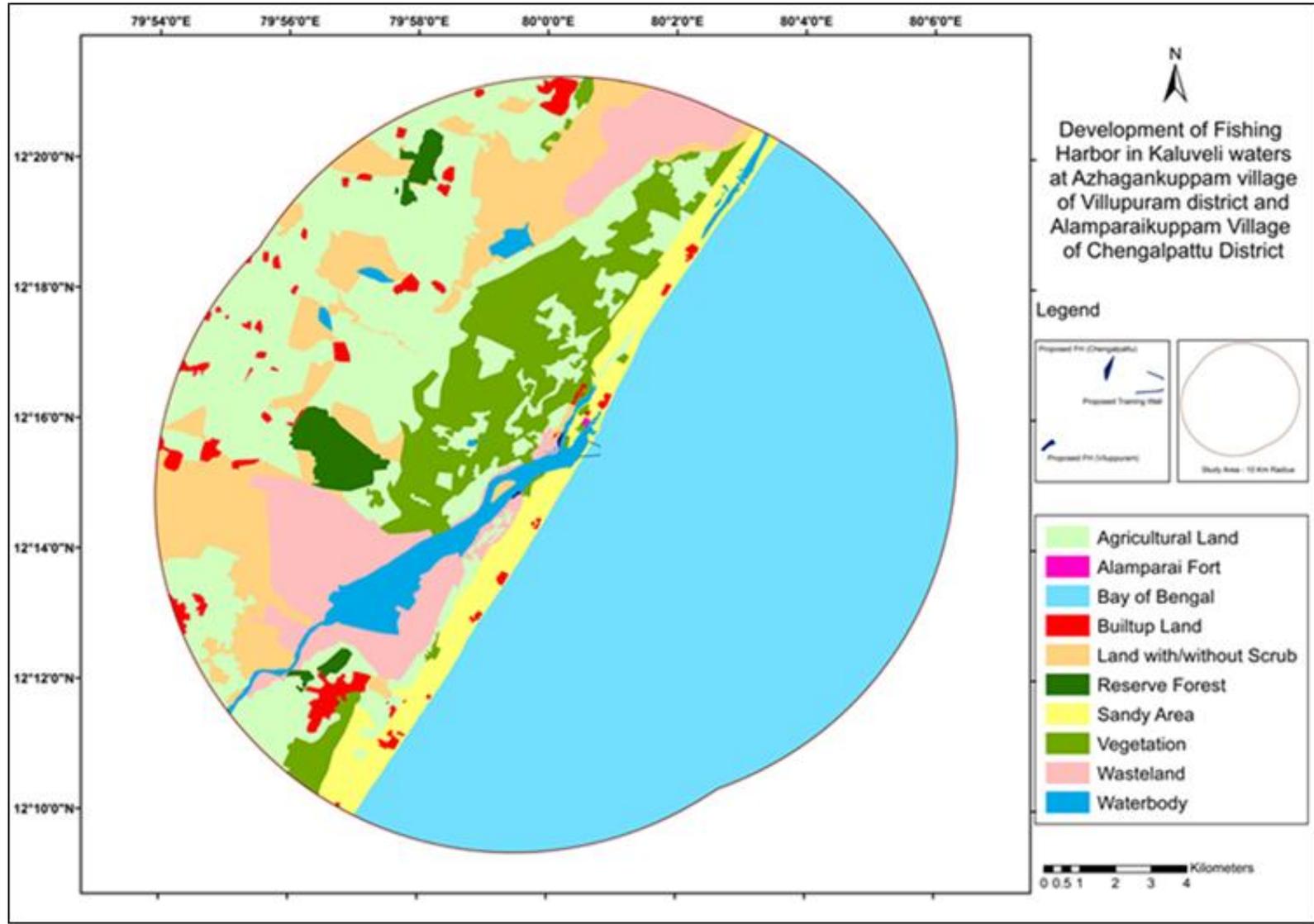
Figure 3-4 Percentage of Land Use Distribution of the Study area
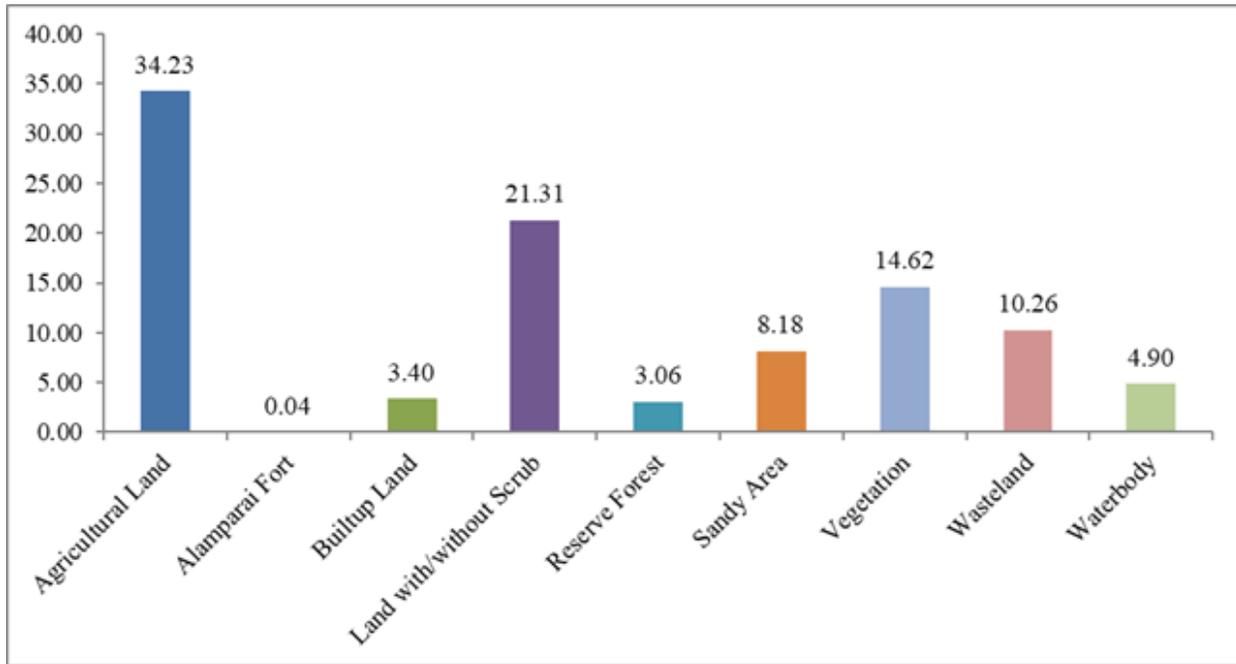
3.2.3   Soil

Viluppuram Dist.: The soils in the district are mostly forest soils and red soil. Alluvial soils are found in eastern side bordering coast. Black soils are confined to low ground in select pockets in Vanur taluk. Surface soil Samples collected at a depth of 0-0.15m from northern Villupuram district, Tamil Nadu. The available content in soil samples varied from 1.25-198.75 mg/kg with mean value of 48.64 mg/kg. The DTPA extractable micronutrients were also evaluated. The iron and zinc concentration varied from 0.22-39.40 mg/kg and 0.19-4.94 mg/kg respectively. Manganese was found to be ranging from 0.10-9.38 mg/kg. Copper and hot water soluble boron varied from 0.1-4.48 mg/kg and 0.3-4.5 mg/kg respectively. About 1.17% surface soil samples were found to be deficient in sulphur, 84% in DTPA-Zn, 39.8% in DTPA-Cu, 50.1% in DTPA-Mn and 53.4% in DTPA-Fe. About 87.2% soil samples were found to have contained high levels of available boron. Sulphur concentration was reported to be highest for 66.97 mg/kg in Melmalayanur block.[3]

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[3]Kaleeswari, R.K., 2012. Assessment of sulphur and micronutrients status in soils of northern Villupuram district, Tamil Nadu using GIS technique. *Agropedology*, *22*(2), pp.96-102.

Kancheepuram Dist.: Soils have been classified into 1) clayey soil, 2) red sandy or red loamy soil 3) Red sandy brown clayey soil and 4) Alluvial soil. Of the above soils brown clayey soil is the most predominant, covering more than 71 percent of the areal extent of Kancheepuram district. Alluvial soils are found on the banks of Palar, Cheyyar and other rivers. The river alluvium is transported and is seen in coastal area of this district. Sandy coastal alluvial (arenacious soil) occurs along the seacoast as a narrow belt.

3.2.3.1 Quality of soil in study area

In and around Viluppuram district, the physicochemical and other characteristics of soil have been analysed in the study area. Detailed soil sampling was performed at 8 locations in and around the study area. The sampling locations are chosen within the 10Km radius of the project site. The details of the sampling locations are given in the **Table 3-3** and in **Figure 3-5**. The present study of soil sampling and quality assessment shows the baseline conditions of the soil in the study and the results are compared with the standard soil classification (**Table 3-4**).

Table 3-3 Geo coordinates for soil sampling locations

S.No	Station	Location Name	Site Coordinate
1	S-1	Azhakan Kuppan Road	12°14'45.324"N 79°59'30.159"E
2	S-2	Kadapakkam Project Site	12°15'46.73"N & 80°0'8.461"E
3	S-3	Vilambur	12°17'29.81"N 79°59'45.969"E
4	S-4	Vedal Village	12°17'54.898"N 79°58'30.292"E
5	S-5	Nallur	12°15'52.124"N 79°58'11.495"E
6	S-6	Kadukalur	12°17'12.659"N 79°56'40.936"E
7	S-7	Jhangal Village	12°15'14.575"N 79°56'10.134"E
8	S-8	Karipalayam	12°11'46.952"N 79°57'2.587"E

Figure 3-5 Soil Sampling Locations within 10km Study Area (Viluppuram)
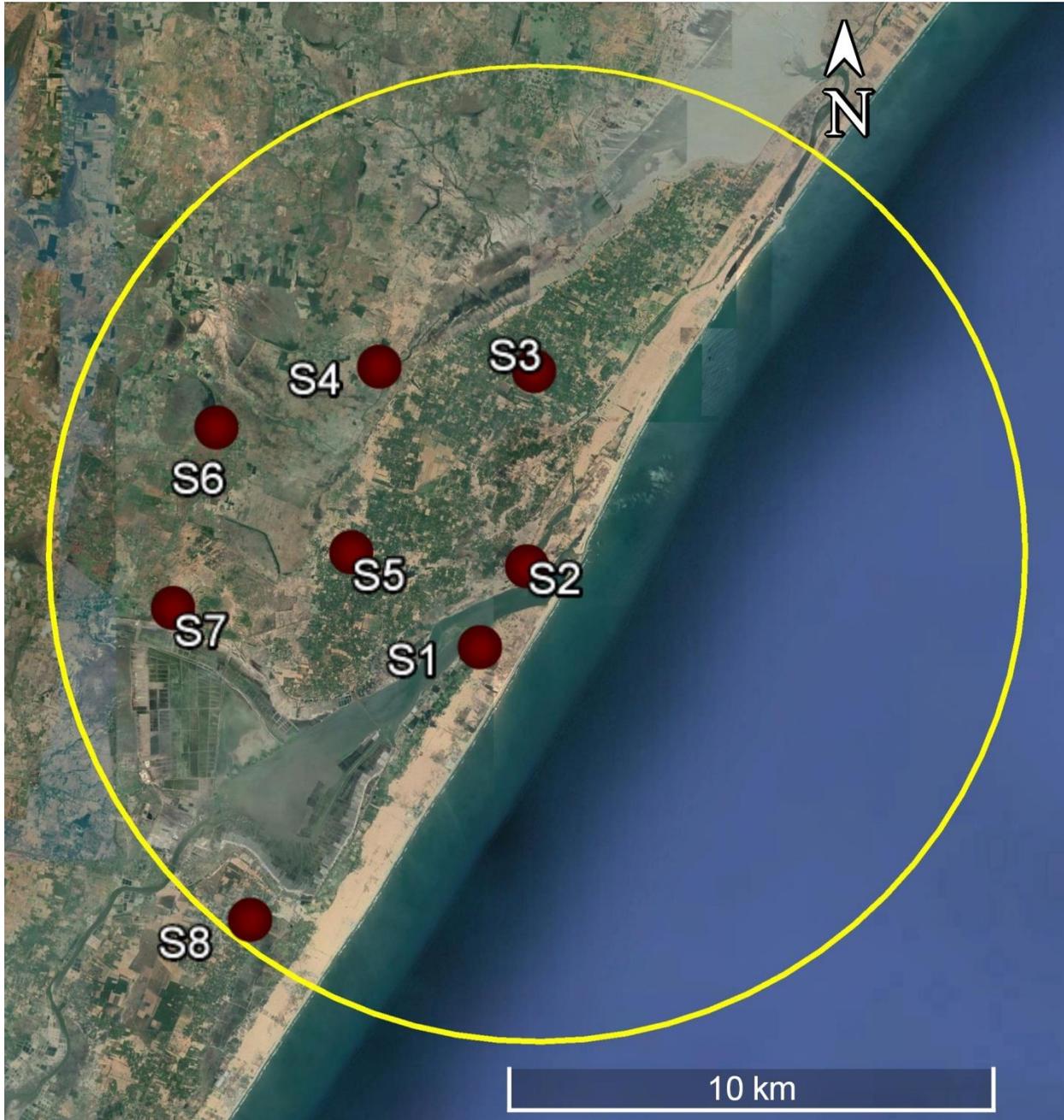
Table 3-4 Soil Quality of Study area

S.NO	PARAMETERS	UNITS	S1	S2	S3	S4	S5	S6	S7	S8
	Texture									
	Sand	%	76.3	68.4	29.5	33.1	38.2	19.3	79.2	28.4
	Silt	%	13.6	5.2	47.2	53.4	50.7	37.2	13.8	50.4
	Clay	%	10.0	26.4	23.3	13.5	11.1	43.5	7.04	21.2
	pH	-	6.4	8.0	6.8	6.4	6.9	7.6	5.6	5.1
	Moisture	%	8.62	14.22	6.32	6.52	4.66	12.71	4.06	4.72
	Conductivity	µs/cm	417	826	321	662	337	481	108	316
	Specific gravity	g/cm^3	1.74	1.62	1.68	1.36	1.62	1.50	1.36	1.48
	Porosity	%	24	26	36	32	32	38	26	34
	Sodium as Na	mg/kg	48.4	4645	36.8	884	41.6	207	12.5	36.9
	Available Nitrogen	mg/kg	126	142	396	410	328	412	138	378
	Nitrate Nitrogen	mg/kg	21.4	28.7	36.2	41.7	41.82	36.7	17.6	32.4
	Available Phosphorus as P	mg/kg	62.4	67.2	74.2	88	111	50.2	48.2	67.1
	Calcium as Ca	mg/kg	16	80	40	26	46	62	12	36
	Magnesium as Mg	mg/kg	20	292	24	34	14	22	18	16
	Acidity as CaCO$_3$	mg/kg	12	Nil	8	10	6	3	21	28
	Alkalinity as CaCO$_3$	mg/kg	96	214	104	306	118	134	68	50
	SulphateSulphur as S	mg/kg	8.8	6.5	13.4	14.4	18.3	22.1	17.4	39.3
	Boron as B	mg/kg	1.3	0.8	0.6	0.4	0.8	0.4	1.6	0.7
	Total Organic Carbon	%	0.17	0.12	0.26	0.24	0.22	0.36	0.18	0.33
	Chloride as Cl	mg/kg	49	244	52	66	73	24	62	42
	Sodium Absorption Ratio	-	5.8	10.2	6.1	7.2	6.7	5.4	7.8	4.8
	Bulk Density	g/cm^3	1.74	1.62	1.68	1.36	1.62	1.50	1.36	1.48
	Water Holding Capacity	%	12.6	13.9	17.8	20.9	16.4	18.1	12.3	17.2
	Available Potassium	mg/kg	149	820	84.4	153	182	542	63.6	123
	Iron as Fe	%	0.18	0.41	0.25	0.35	0.21	1.22	0.06	0.19
	Manganese as Mn	mg/kg	15.59	48.65	29.46	42.66	22.20	47.63	14.74	42.20
	Zinc as Zn	mg/kg	12.72	14.97	22.35	18.88	8.46	36.34	7.23	9.65
	Copper as Cu	mg/kg	BDL(DL:3.0)	3.34	3.55	4.46	5.64	39.35	BDL(DL:3.0)	4.60

Note: All the Poly Aromatic Hydrocarbons (PAHs), Cadmium, Chromium, Lead, Mercury and Molybdenum were found be below the detectable limit,

3.2.4 Soil Analysis Result

The pH of all the collected soil samples was found to be varying from 5.1-8. Slightly acidic pH (5.1) was observed for location 8 and location 2 had pH of 8. The pH in the range from 5-8 is considered good for the growth of plants. Sample 1, 2 and 7 contained more amount of Sand (as are located close to the sea) content ranging from 86-79%. Sample 3, 4, 5 and 8 were found to have more concentration of silt, ranging from 47-53.4%. Sample 6 was found to have more percentage of clay about 43.5%. The moisture content ranged from 4.06-14.22%. Maximum moisture content was observed for sample location 2 and minimum was observed for sample 7. The porosity of the samples was found to be ranging from 24-38%. Highest porosity was found for location 6 and lowest for location 1. The water holding capacity of the samples was found to be ranging from 12.3-20.9%. The bulk density occurred between 1.36-1.74 g/cm^3. The specific gravity of the samples was found to be ranging from1.36-1.74 g/cm^3. The electrical conductivity was found to be ranging from 108-826 µs/cm. the maximum value of electrical conductivity was observed for sample location 2. The value of EC shows that the soil is found to be non-saline in nature as the EC is below 2000 µS/cm. The concentration of total organic carbon was found to be ranging from 0.12-0.36%. The sodium absorption ratio occurred from 4.8-10.2.

Calcium concentration for all the samples was found to be ranging from 12-80 mg/kg. The highest concentration of calcium occurred for sample 2. Magnesium concentration ranged from 14-292 mg/kg. Location 5 showed lowest concentration and Location 2 showed the highest. Sodium concentration as Na was found to be ranging from 12.5-4645 mg/kg. Highest sodium concentration was observed for location 2 and lowest was observed for location 7. Soil S2 and S4 are considered to be sodic soils as the concentration of sodium is more than 500 mg/kg more than which the soils are found to be sodic as per Handbook of Agriculture, Indian Council of Agriculture Research. It could be due to the fact that the sample S2 was collected near creek and therefore could be saline in nature which might result in increase in concentration of mineral nutrients in the soil.

The acidity as CaCO$_3$ ranged from 3-28 mg/kg. The concentration was found to be nil or sample location 2. Alkalinity as CaCO$_3$ was found to b ranging from 50-306 mg/kg. Highest concentration was observed for location 4 and lowest was observed for location 8.

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The concentration of available nitrogen ranged from 126-412 mg/kg. Highest concentration was observed for location 6 and lowest was observed for location 1. Nitrate nitrogen concentration ranged from 17.6-41.82mg/kg. Available Phosphorus ranged from 48.2-111 mg/kg. Highest salinity was observed for Sample location 5 and lowest for observed for location 7. The concentration of sulphate ranged from 6.5-39.3 mg/kg. Highest concentration was observed for location 8 and lowest was observed for location 2. Available Potassium ranged from 63.6-820 mg/kg. The samples S2 and S6 have the exceeding concentrations of potassium as per range given by Handbook of Agriculture, Indian Council of Agriculture Research. This could be due to close proximity to salt pans. Highest salinity was observed for Sample location 2 and lowest for observed for location 7. The concentration of chlorides was found to be ranging from 24-244mg/kg. Highest concentration was observed for location 2.

The iron concentration was found to be between 0.06-1.22 percent. The concentration of manganese ranged from 14.74 mg/kg for location 7 to 48.65 mg/kg for location 2. The concentration of copper was found to be ranging from 3.34-39.35 mg/kg. The highest concentration was observed for location 6. The concentration of zinc was found to be 7.23-36.34 mg/kg.

The concentration of lead, cadmium, chromium, molybdenum and mercury was found to be below detectable limits. The concentration of PAH was also found to be below detectable limits (DL: 0.5). The test reports of the soil assessment are given in **Annexure IV**.

3.2.5 Hydrogeology

Viluppuram Dist.:Villupuram district is underlain by crystalline metamorphic complex in the western part of the district and sedimentary tract in eastern side (Plate-II). The thickness of sediments exceeds 600m near southern part of the district. Groundwater occurs under phreatic and semi–confined conditions in consolidated formations, which comprises weathered and fractured granites, gneisses and charnockites whereas in unconsolidated sedimentary rocks the groundwater occurs in phreatic, semi-confined conditions in Vanur sandstone, Kadapperi kuppam formation and Turuvai limestone. The district is having rocky outcrops in major part of Kallakurichi, Sankarapuram and Tirukoilur taluks.

The weathering is highly erratic and the depth of abstraction structures is controlled by the intensity of weathering and fracturing. The depth of wells varies from 6.64 to 17 m bgl and water levels in observation wells tapping shallow aquifers varied from 0.74 to 9.7 m bgl

during pre-monsoon (May 2006) and it varies from 0.7 to 4.45 m bgl during post monsoon (January 2007). During pre-monsoon, the depth to water levels in the range of >2 to 5 m bgl in major part of the district, in the range of >5 -10 m bgl in western and southeastern parts of the district and range of 0-2 m bgl were recorded in two isolated pockets (Plate –III). During post monsoon the depth to water levels range of >2 to 5 m bgl exists in major part of the district, range of 0 - 2 m bgl prevails in central and northeastern parts of the district and range of >5 - 10 m bgl were recorded in two isolated pockets in the southwestern and north western parts of the district (Plate –IV). The depth to piezometric surface ranged from 2.8 to 11.25 m bgl during Pre monsoon and 0.5 to 6.35 m bgl during post monsoon.

Figure 3-6 Figure showing Hydrogeology of Viluppuram District

The ground water is being developed my means of dug wells, bore wells and tube wells. The diameter of the well is in the range of 7 to 10 m and depth of dug wells range from 15 to 18 m bgl depending on the weathered thickness and joints. The dug wells yield up to 1 lps in summer months and few wells remains dry. The yield is adequate for irrigation for one or two crops in monsoon period. The yield of bore wells in favorable locations vary from <1 to 6 lps. The valley fills, intersection of lineaments, particularly, in the western part along the foot hills of Kalrayan hills are reported to have potential pockets suitable for dug wells and bore

wells. The area of contact between crystalline and sedimentary formations has variable yield prospects. The cretaceous formations are very compact and yield prospects are low. The dug wells of 6 m diameter and 10 m bgl depth in sandy tracts give about 3.5 lps. The yield of tube wells in the sedimentary formation ranges from 2.4 to 37 lps.

Figure 3-7 Depth to water level

Pre-Monsoon

Post-Monsoon
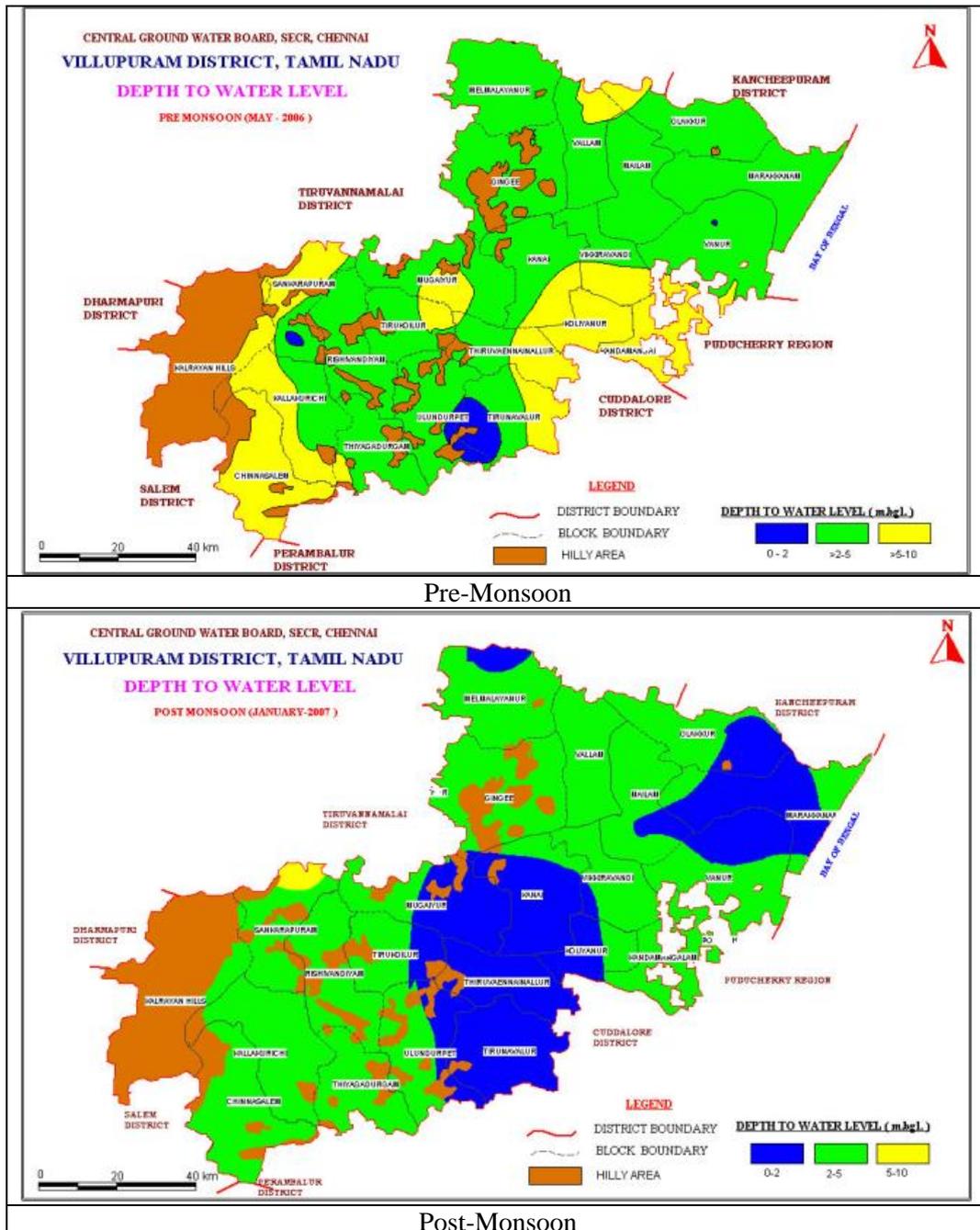
Long Term Fluctuation (1998-2007)

The long –term water level fluctuation for the period of (1998-2007) indicates rise in water level in the range of 0.003 to 0.63 m/year whereas the fall in the water level ranges between 0.014 and 0.31 m /year.

Kancheepuram Dist.: The district is underlain by both sedimentary and fissured formations. The important aquifer system in the district are constituted by 1) unconsolidated and semi consolidated formations and 2) weathered, fissured and fractured crystalline rocks.

Figure 3-8 Figure showing Hydrogeology of Kancheepuram District
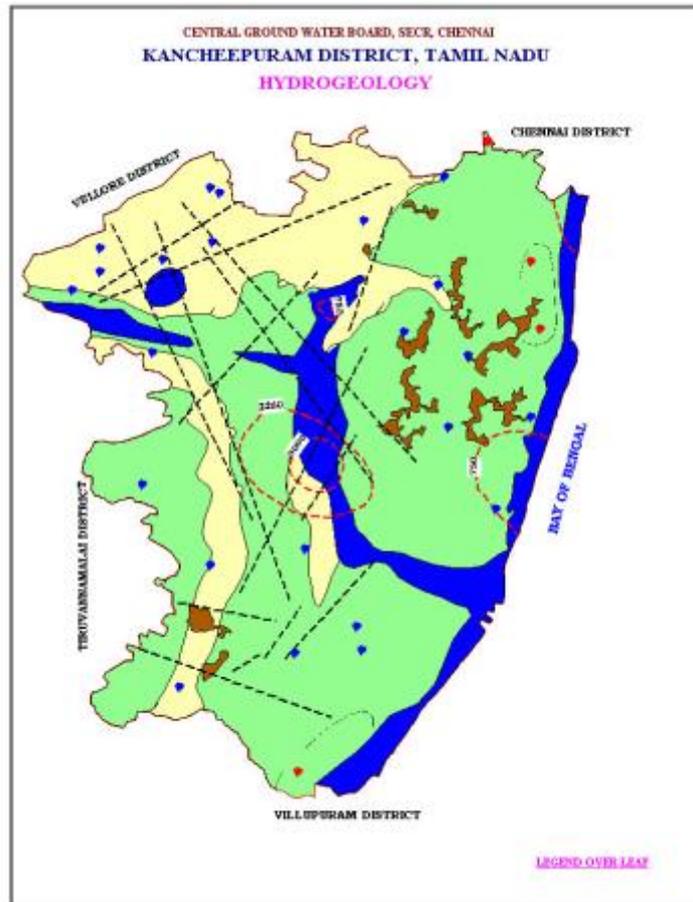
Figure 3-9 Depth to water level

Pre-Monsoon	Post-Monsoon
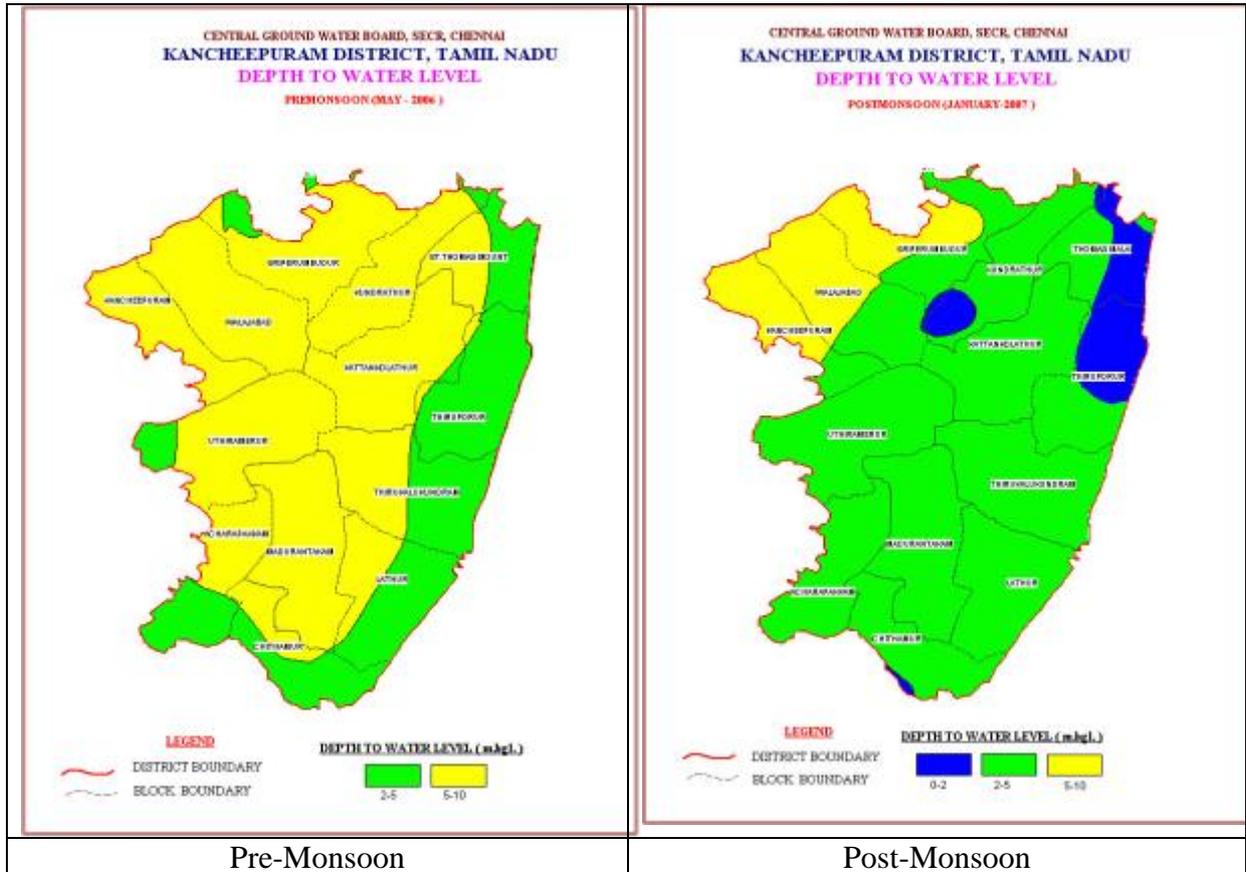
Long Term Fluctuation (1998-2007)

The long-term water level fluctuation for the period 1998-2007 indicates rise in water level in the area 0.0289 -0.3433 m/year. The fall in water level ranges between 0.0089 to 0.3279 m/year.

3.2.5.1 Ground Water Quality as in literature

Villupuram Dist.: Ground water in phreatic aquifers in Villupuram district is, in general, colorless, odorless and slightly alkaline in nature. The specific electrical conductance of ground water in phreatic zone (µS/cm at 250 C) during May 2006 was in the range of 770 to 3650 in the district. Conductance below 750 has been observed only in select pockets of the district. It is observed that the ground water is suitable for drinking and domestic uses in respect of all the constituents except total hardness and nitrate. In about 40% of samples, nitrate concentration is above permissible limits of 100 mg/l. The incidence of high total hardness is attributed to the composition of litho units constituting the aquifers in the district, whereas nitrate pollution is most likely due to use of fertilizers and other improper waste

disposal. Sodium Adoption Ratio values range from 1.7 to 4.4 with an average value of 3.25 in the district. This implies that no alkali hazard is anticipated to crops.

Kancheepuram Dist.: Ground water in phreatic aquifers in Kancheepuram in general, is colourless, odourless and slightly alkaline in nature. The specific electrical conductance of ground water in phreatic zone (in Microsiemens at 25°C) during May 2006 was in the range of 240 to 4220 in the district. It is between 750 and 2250 µS/cm at 25°C in the major part of the district. [4]Conductance below750 µS/cm has been observed in ground water in parts of Chunampet, Mahabalipuram and Oragadam, where conductance exceeding 2250 µS/cm has been observed in Melmukuttu road. It is observed that the ground water is suitable for drinking and domestic uses in respect of all the constituents except total hardness and nitrate. The Total Hardness as CaCO3 is observed to be in excess of permissible limits of 7% sample analysed whereas Nitrate is found in excess of 45 mgl/l in about 25 percent samples. The incidence of high total hardness is attributed to the composition of lithounits constituting the aquifers in the district, whereas the Nitrate pollution is most likely due to the use of pesticides and fertilizers for agriculture. With regard to irrigation suitability based on specific electrical conductance and Sodium Adsorption Ratio (SAR), it is observed that the ground water in the phreatic zone may cause high to very high salinity hazard and medium to high alkali hazard when used for irrigation. Proper soil management strategies are to be adopted in the major part of the district while using ground water for irrigation.

Around 30 groundwater samples were collected from open and bore wells during January 2010 for physico-chemical analysis. The pH of the samples ranged from 6.2-7.8. The EC varied from 161-3695. TDS values ranged from 98-2610 mg/L. Ca, Mg, Na and K were found to be ranging from 5-160 mg/L, 2-86 mg/L, 12-510 mg/L,1-30 mg/L respectively. The HCO_3 ranged from 32-432 mg/L and Cl ranged from 11-941 mg/L. The SO_4 was found to be ranging from 8-228 mg/L.[5]

3.2.5.2 Ground Water Sampling

In order to assess the quality of water environment; surface water and ground water samples were collected within the 10Km radius of the project site. It includes 8 ground water samples

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[4] *District Groundwater Brochure, Kancheepuram District, CGWB, South eastern Coastal Region, Chennai, 2007.*

[5] *Sridhar, S.G.D., Kanagaraj, G., Mahalingam, S. and Amaladas, P., 2013. Hydrochemical analysis of Groundwater between Sadras and Chinnakuppam, Kancheepuram District, Tamil Nadu, India. Journal of Academia and Industrial Research, 2(3), pp.160-166.*

and 5 surface water samples out of 8 locations. Samples were collected based upon the guidelines issued by CPCB. The collected samples were tested and compared with the water quality standards (IS: 10500:2012) to assess the physicochemical properties of various parameters. The details of the ground water sampling locations are shown in **Table 3-5**. The water quality monitoring stations are shown in **Figure 3-10.** The summary of the results are given in **Table 3-6**and the lab analysis test report is given in **Annexure V**. Groundwater sampling photos within the study area is shown in Figure. A total of 46 parameters were tested, among which 14 were found to be below detectable limits in all the locations, these parameters are not presented in the results table.

Table 3-5 Geo coordinates for groundwater sampling locations

S.No	Station	Location Name	Site Coordinate
1	GW-1	Kadapakkam Project Site	12°15'46.729"N
			80°0'8.462"E
2	GW -2	Panaiyur Village	12°19'7.822"N
			80°1'50.008"E
3	GW -3	Vedal Village	12°18'3.591"N
			79°58'13.33"E
4	GW -4	Kadukalur	12°17'4.593"N
			79°56'50.155"E
5	GW -5	Nallur	12°15'52.105"N
			79°58'11.666"E
6	GW -6	Thangal Village	12°15'15.693"N
			79°56'10.826"E
7	GW -7	Kolathur	12°11'45.005"N
			79°56'45.99"E
8	GW -8	Marakkanam Village	12°11'55.35"N
			79°57'5.996"E

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Figure 3-10 Groundwater Sampling Locations within 10km Study Area
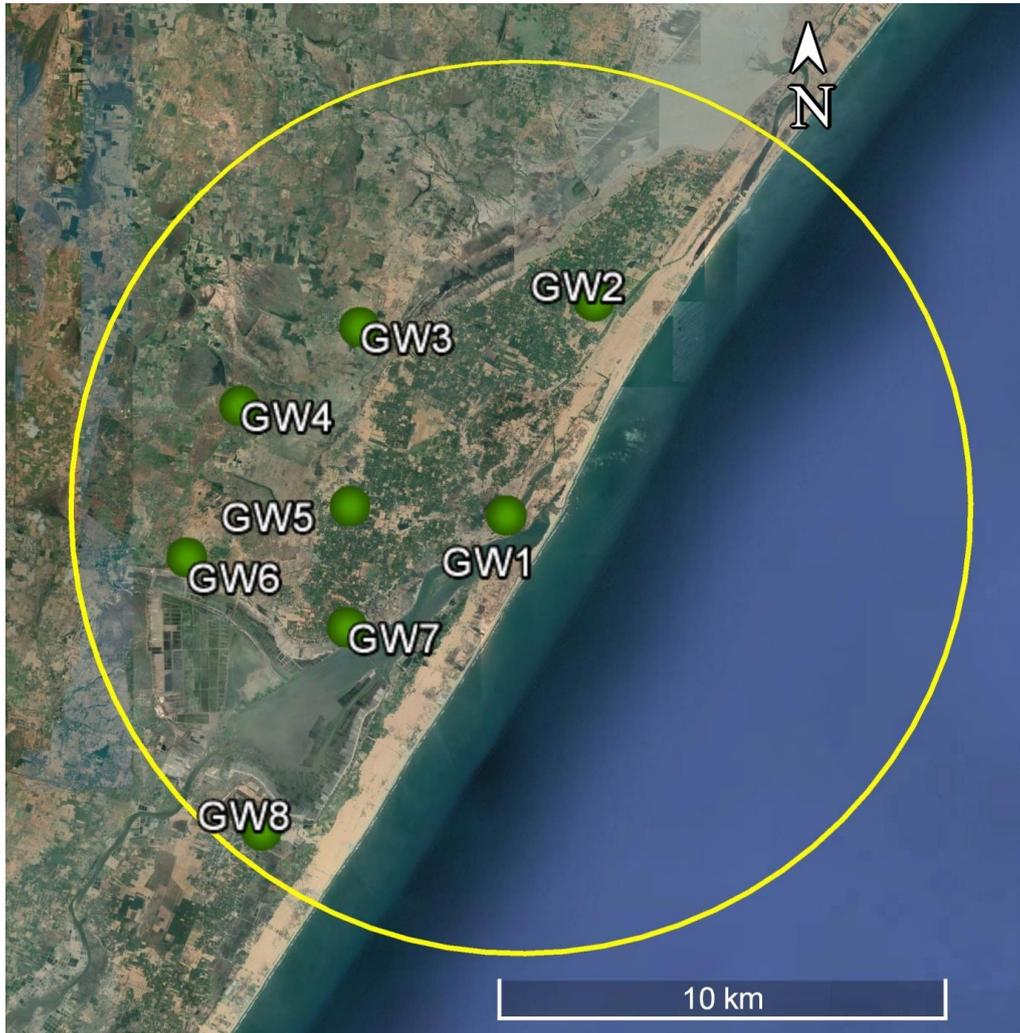
Table 3-6 Groundwater quality of study area

S.NO	PARAMETERS	UNITS	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8
1	Colour	HU	10	5	5	2	20	2	2	2
2	Odour	-	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	-	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable
4	Turbidity	NTU	69	14	2	2	77	8	5	3
5	pH @ 25°C	-	7.1	5.6	7.7	7.1	6.5	7.8	5.7	6.7
6	Conductivity @ 25°C	µs/cm	8654	287	2668	2912	204	737	457	635
7	Total Hardness as $CaCO_3$	mg/l	1753	32	776	767	34	122	35	70
8	Iron as Fe	mg/l	20.1	4.17	0.3	0.14	4.97	0.17	5.9	0.27
9	Chloride as Cl^-	mg/l	2730	70	783	612	15	131	97	79
10	Oil & Grease	mg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
11	Fluoride as F	mg/l	0.44	0.12	0.16	0.22	BDL(DL:0.1)	0.14	BDL(DL:0.1)	BDL(DL:0.1)
12	Total Dissolved Solids	mg/l	5380	186	1570	1810	142	410	270	380
13	Total Suspended Solids	mg/l	38	4	21	3	14	2	3	8
14	P. Alkalinity as $CaCO_3$	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
15	M-Alkalinity as $CaCO_3$	mg/l	280	13	172	484	34	86	15	146
16	Total Alkalinity as $CaCO_3$	mg/l	280	13	172	484	34	86	15	146
17	Calcium as Ca	mg/l	360	8	151	164	10	34	9	20
18	Sodium as Na	mg/l	1162	39.5	271	248	13.8	88.3	64.7	71.9
19	Potassium as K	mg/l	34.2	3.1	7.3	122	8.1	8.2	4.36	56.6
20	Magnesium as Mg	mg/l	208	3	97	87	2	9	3	5
21	Sulphate as SO_4	mg/l	620	9.4	104	159	18.2	45.9	29.8	29.4
22	Nitrate as NO_3	mg/l	1.4	0.3	0.81	0.98	0.18	0.46	0.38	0.43
23	Dissolved Oxygen	mg/l	6.9	7.0	6.8	7.0	6.7	6.9	6.5	6.8
24	Silica as SiO_2	mg/l	51.1	30	32.6	86.8	45	21.7	31.9	6.07
25	Biochemical Oxygen Demand (BOD) 3 days @ 27°C	mg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
26	Chemical Oxygen Demand (COD)	mg/l	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4
27	Salinity	ppt	5.38	0.18	1.57	1.8	0.14	0.41	0.27	0.38
28	Copper as Cu	mg/l	0.31	BDL (DL:0.02)	0.18	0.16	BDL(DL:0.02)	BDL (DL:0.02)	BDL (DL:0.02)	BDL(DL:0.02)
29	Manganese as Mn	mg/l	1.21	BDL (DL:0.01)	0.05	0.03	0.02	BDL (DL:0.01)	BDL (DL:0.01)	BDL(DL:0.01)
30	Zinc as Zn	mg/l	0.09	BDL(DL:0.08)	BDL(DL:0.08)	BDL(DL:0.08)	BDL(DL:0.08)	BDL(DL:0.08)	BDL(DL:0.08)	BDL(DL:0.08)
31	Total Coliform	MPN/100 ml	30	<2	4	2	90	11	17	13

3.2.5.3 Groundwater Quality

The pH of all the collected ground water samples was found to be varying from 5.6-7.8. PH value of 5.6 was observed for location 2. As per IS 10500 on drinking water specification, the pH of drinking water should be in range from 6.5-8.5.The color ranged between 2-20 HU. Highest value was observed for GW-5. For all the set of samples, the odor was found to be unobjectionable. The taste of water for all the samples was found to be disagreeable.

Turbidity of the samples was found to be ranging from 2-77 NTU. Highest turbidity was observed for location GW5.As per IS 10500 on drinking water specification, the permissible limit for drinking water is 5 NTU. The high turbidity rates for GW1 and GW5 could be due to the fact that sample GW1 lies very close to coast which might result in turbid waters. Total suspended solids ranged from 2-38mg/L with location GW 1 having the highest concentration. Total hardness was found to be ranging from 32-1753mg/L. Lowest concentration occurred for location GW-2 and highest occurred for GW-1. As the sample location GW1 lies in close proximity to sea, the salinity ingress could be one of the reasons for increase concentrations for total hardness. Calcium concentration for all the samples was found to be ranging from 8-360 mg/L. The highest concentration of calcium occurred for sample GW-1 and lowest for GW-2. Magnesium concentration ranged from 2-208 mg/L. GW-5 showed lowest concentration and GW-1 showed the highest. Total Alkalinity concentration as $CaCO_3$ was found to be ranging from 13-484mg/L. Highest alkalinity concentration was observed for location GW-4 and lowest for GW-2. M-Alkalinity concentration as $CaCO_3$ was found to be ranging from 13-484mg/L. P-Alkalinity was found to be nil in all the samples.

The concentration of chlorides ranged from 15-2730 mg/L. Highest concentration was observed for location GW-1(due to salinity ingress) and lowest was observed for location GW-5. Sodium concentration ranged from 13.8-1162 mg/L. Highest concentration was observed for location GW-1 and lowest was observed for location GW-5. Potassium was found to be ranging from 3.1-122 mg/L. Lowest concentration was observed for GW-2 and highest for GW-4. Salinity was found to be ranging from 0.14-5.38 ppt. Highest salinity was observed for Sample location GW-1 and lowest for GW-5. Total dissolved solids ranged from 142-5380 mg/L. Highest concentration of Total dissolved solids was observed for Sample location GW-1 and lowest for

GW-5. Location GW1 is not suited for drinking water as per drinking water standards IS 10500 as per which the permissible limit for drinking water should not be more than 2000 mg/L. The conductivity of the ground water samples ranged from 204 µs/cm for GW-5 location and 8654 µs/cm for location GW-1.

Dissolved oxygen ranged from 6.5-7 mg/L. Lowest dissolved oxygen concentration was observed for GW-7 and highest was observed for GW-2,4. The concentration of COD was found to be less than 4 mg/L for all the set of samples. The BOD (at 27 °C for 3 days) was found to be less than 2 for all the set of 8 samples.

Nitrate occurred in the range from 0.18-1.4mg/L. The concentration of sulphate was found to be ranging from 9.4-620 mg/L. Lowest concentration was observed for location GW-2 and highest was observed for GW-1. The concentration of fluoride ranged from 0.12-0.44 mg/L. For samples 5, 7 and 8, the fluoride was found to be below detectable limit.

The iron concentration was found to be between 0.14-20.1 mg/L, location GW-1 showed the highest concentration due to close proximity to the sea. The concentration of copper was found to be ranging from 0.16-0.31 mg/L for sample 1, 3 and 4. For all the remaining samples, the concentration was found to be below detectable limits (DL: 0.02) The concentration of manganese ranged from 0.02-1.21 for samples 1, 3, 4 and 5. The permissible limit for manganese as per IS 10500 is 0.3 mg/L. For all other samples the concentration of Manganese was found to be below detectable limits (DL: 0.01). The concentration of silica ranged from 6.07-86.8 mg/L. Highest concentration was observed for location GW-4 and lowest for GW-8. The concentration of zinc was found to be below detectable limits (DL: 0.08) for all the samples except for samples 1, for which it was observed to be 0.09 mg/L.

The concentration of oil and grease was found to be less than 2 mg/L for all the set of samples. The total coliform was found to be ranging from 2-90 MPN/100ml. Highest Total Coliform was observed for sample GW-5 and for sample GW-2, it was less than 2 MPN/100 ml.

The concentration of lead, cadmium, total chromium, boron, total arsenic, selenium, nickel, aluminum and mercury was found to be below detectable limits. The concentration of phenolic compounds (DL: 0.001 mg/L), cyanide (DL: 0.01 mg/L) and anionic detergent as MBAS (DL:

0.1 mg/L) was found to be below detectable limits. Total residual chlorine was also found to be below detectable limit (DL: 0.1mg/L)

3.2.6 Drainage

Viluppuram Dist.: The Ponnaiyar, the Malattar and the Gadilam are the major rivers which drain into the district. The Ponnaiyar River flows from northwest to east in the district. The Manimukta nadi originates in Kalrayan hills and drains the southern part of the district. The Pambaiyar and the Varaganadhi originate in the uplands of the district and join Bay of Bengal. The Varaganadhi is also known as the Gingee River and drains the parts of Gingee and Vanur taluks of this district. The Malattar and Gadilam rivers also originate in the uplands within the district and flow eastwards to Cuddalore district. All the rivers are ephemeral in nature and carry only floodwater during monsoon period. The drainage pattern is mostly parallel to sub parallel and drainage density is very low. There are small reservoirs across rivers namely Gomukha, Vedur and Mahanathur[6].

Kancheepuram Dist.: The two important rivers of the district are Palar and Cheyyar. The drainage pattern in general is sub-dendritic and radial. All the rivers are seasonal and carry substantial flows during monsoon period. River Palar originates from Western Ghats in Karnataka state, and discharges in Bay of Bengal near Pudupattinam. River Cheyyar originates from the Jawadu Hills of Tiruvannamalai district. It has a northeasterly flow in Kancheepuram district and confluences with the Palar near Pazhaiyaseevaram. Other seasonal river like Korattalaiar and Tandiar drain this district partly on the northern and southern part respectively[7].

3.2.6.1 Surface Water Sampling

The surface water samples have been collected from 5 out of 8 locations within the 10 km radius of the study area which were tested and analysed for various parameters. Surface water cannot be collected from 3 locations due to unavailability. The results of analysis are compared with the drinking water standards (IS 10500:2012). The sampling co-ordinates of the surface water are given in **Table 3-7** and the locations marked in Google Earth are shown in **Figure 3-11 .** The summary of the analysed Surface water results are shown in **Table 3-8**. The results of the surface

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[6] *District Groundwater Brochure, Villupuram District, CGWB, South eastern Coastal Region, Chennai, 2009*
[7] *District Groundwater Brochure, Kancheepuram District, CGWB, South eastern Coastal Region, Chennai, 2007*

water samples are attached as **Annexure VI.** A total of 46 parameters were tested, among which 13 were found to be below detectable limits in all the locations, these parameters are not presented in the results table.

Table 3-7 Geo coordinates of surface water samples

S.No	Station	Location Name	Site Coordinate
2	SW -2	Thazhuthalikuppam Village Road	12°18'50.209"N
			80°1'58.973"E
4	SW -4	Kadukalur Village	12°17'23.480"N
			79°56'37.691"E
5	SW -5	Chunambedu Village	12°15'20.482"N
			79°54'52.213"E
6	SW -6	Thangal Village	12°15'3.897"N
			79°56'11.638"E
8	SW -8	Karipalayam	12°11'36.186"N
			79°57'2.093"E

Figure 3-11 Study area map showing 10 km radius around study area

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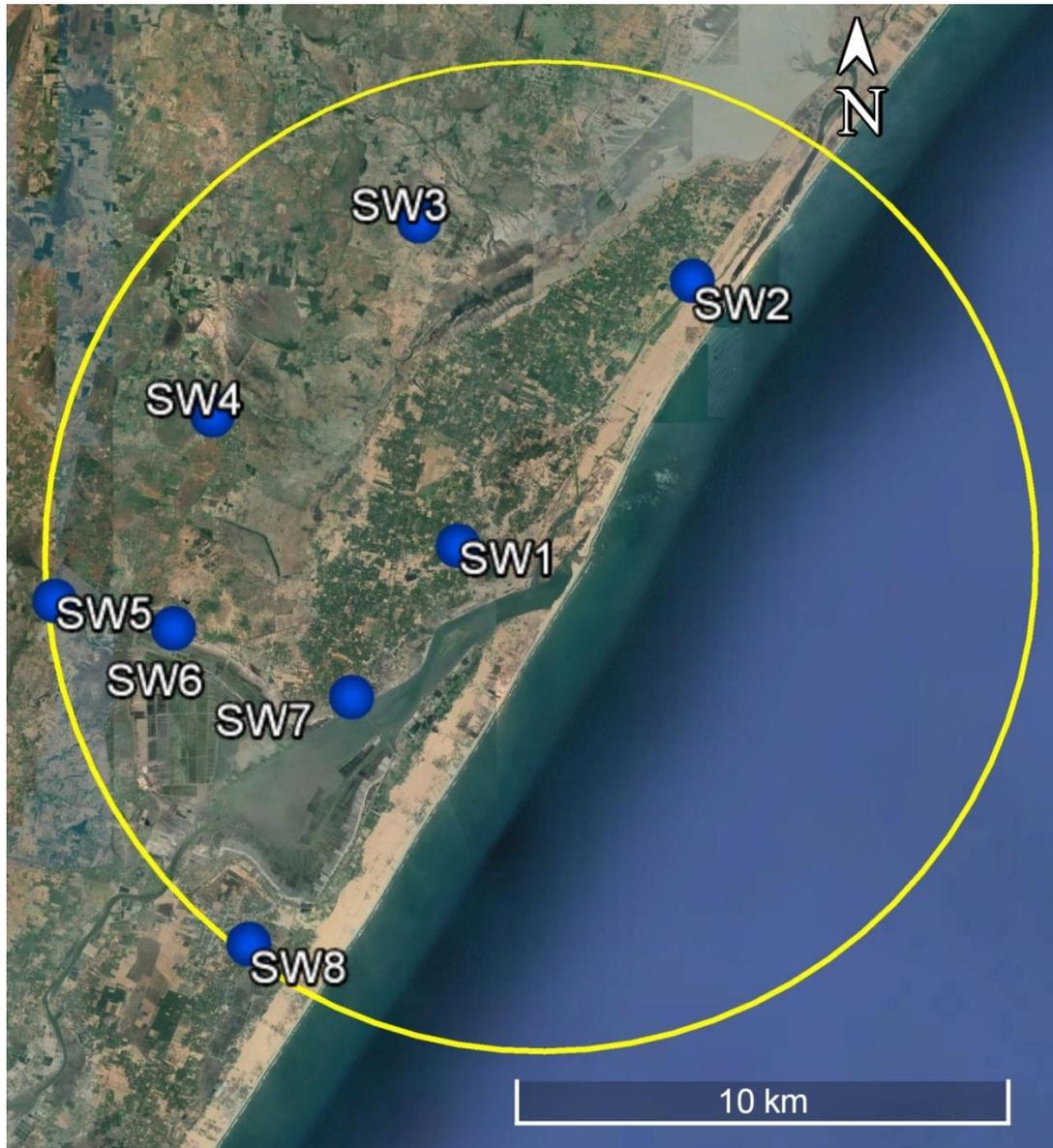
Table 3-8 Surface water quality of study area

S.NO	PARAMETERS	UNITS	SW2	SW4	SW5	SW6	SW8
1	Colour	HU	10	10	10	2	5
2	Odour	-	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
3	Taste	-	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable
4	Turbidity	NTU	32	22	14	2	11
5	pH @ 25°C	-	7.0	8.2	6.9	7.3	3
6	Conductivity @ 25°C	µs/cm	350	258	250	112610	3256
7	Total Hardness as $CaCO_3$	mg/l	37	41	50	15100	1684
8	Iron as Fe	mg/l	1.86	4.6	8.84	7.6	8.52
9	Chloride as Cl⁻	mg/l	91	9	29	37000	289
10	Oil & Grease	mg/l	< 2	< 2	< 2	< 2	< 2
11	Fluoride as F	mg/l	0.13	0.14	0.15	1.43	0.24
12	Total Dissolved Solids	mg/l	240	160	148	66996	2430
13	Total Suspended Solids	mg/l	32	21	23	459	35
14	P. Alkalinity as $CaCO_3$	mg/l	Nil	4	Nil	Nil	Nil
15	M-Alkalinity as $CaCO_3$	mg/l	26	37	73	44	Nil
16	Total Alkalinity as $CaCO_3$	mg/l	26	41	73	44	Nil
17	Calcium as Ca	mg/l	6	8	15	500	316
18	Sodium as Na	mg/l	50.4	5.9	26.8	20055	138
19	Potassium as K	mg/l	6.1	4.3	7.8	765	22.6
20	Magnesium as Mg	mg/l	6	5	3	3400	218
21	Sulphate as SO_4	mg/l	7.5	4.7	4.2	5205	1373
22	Nitrate as NO_3	mg/l	0.29	0.16	0.34	9.8	1.1
23	Dissolved Oxygen	mg/l	6.5	6.6	6.7	7.0	6.8
24	Silica as SiO_2	mg/l	49.3	83.9	5.14	1.09	57.6
25	Biochemical Oxygen Demand (BOD) 3 days @ 27°C	mg/l	< 2	< 2	< 2	< 2	< 2
26	Chemical Oxygen Demand (COD)	mg/l	< 4	< 4	< 4	< 4	< 4
27	Salinity	ppt	0.24	0.16	0.14	66.9	2.43
28	Copper as Cu	mg/l	BDL(DL:0.02)	BDL (DL:0.02)	BDL (DL:0.02)	1.14	0.28
29	Manganese as Mn	mg/l	0.08	0.07	0.05	0.14	4.49
30	Lead as Pb		BDL(DL:0.005)	BDL(DL:0.005)	BDL(DL:0.005)	0.51	BDL(DL:0.005)
31	Zinc as Zn	mg/l	BDL(DL:0.08)	BDL(DL:0.08)	BDL(DL:0.08)	0.11	BDL(DL:0.08)
32	Total Coliform	MPN/100 ml	170	90	110	21	50

3.2.7   Surface Water Quality

The surface water sampling was done for location 2, 4, 5, 6 and 8. The pH of all the collected surface water samples was found to be varying from 3-8.2. pH value of 3 was observed for location 8 and location SW4 had pH value of 8.2 was observed. As per IS: 2296-1982, the pH value should not be less than 6.5, therefore, the location 8 surface water is considered unfit for consumption. The color ranged between 2-10 HU. Highest value was observed for SW-2, 4, 5. For all the set of samples, the odor was found to be unobjectionable. The taste of water for all the samples was found to be disagreeable.

Turbidity of the samples was found to be ranging from 2-32 NTU. Highest turbidity was observed for location SW2. Total suspended solids ranged from 21-459 mg/L with location SW 6 having the highest concentration and SW 4 having lowest concentration. Total hardness was found to be ranging from 37-15100 mg/L. Lowest concentration occurred for location SW-2 and highest occurred for SW-6. Calcium concentration for all the samples was found to be ranging from 6-500 mg/L. The highest concentration of calcium occurred for sample SW-6 and lowest for SW-2. Magnesium concentration ranged from 3-3400 mg/L. SW-6 showed the highest concentration. Total Alkalinity concentration as $CaCO_3$ was found to be ranging from 26-73 mg/L. Highest alkalinity concentration was observed for location SW-5. Total alkalinity was found to be nil for sample 8. M-Alkalinity concentration as $CaCO_3$ was found to be ranging from 26-73 mg/L. P-Alkalinity was found to be nil in all the samples except for sample 4 for which the concentration was 4 mg/L.

The concentration of chlorides ranged from 9-37000 mg/L. Highest concentration was observed for location SW-6 and lowest was observed for location SW-4. As per IS: 2296-1982, the maximum tolerance limit for chlorides concentration in surface water should not be more than 600mg/L. One of the reasons for increased chlorides could be due to the presence of aquaculture ponds nearby. Sodium concentration ranged from 5.9-20055 mg/L. Highest concentration was observed for location SW-6 and lowest was observed for location SW-4. Potassium was found to be ranging from 4.3-765 mg/L. Highest concentration was observed for location SW-6 and lowest was observed for location SW-4. Salinity was found to be ranging from 0.14-66.9 ppt. Highest salinity was observed for Sample location SW-6 and lowest for SW-5. Total dissolved solids ranged from 148-66996 mg/L. Highest concentration of Total dissolved solids was observed for Sample location SW-6 and lowest for SW-5. The excessively high values for SW-6 could be due the presence of aquaculture ponds and salt

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pans in the nearby area. As per IS: 2296-1982, the maximum tolerance limit for TDS concentration in surface water should not be more than 1500mg/L. The conductivity of the surface water samples ranged from 250 µs/cm for SW-5 location to 112610 µs/cm for location SW-6.

Dissolved oxygen ranged from 6.5-7 mg/L. The concentration of COD was found to be less than 4 mg/L for all the set of samples. The BOD (at 27 °C for 3 days) was found to be less than 2 for all the set of 8 samples.

Nitrate occurred in the range from 0.16-9.8 mg/L. Highest concentration was observed for location SW-6. The concentration of sulphate was found to be ranging from 4.2-5205 mg/L. Lowest concentration was observed for location SW-5 and highest was observed for SW-6. The concentration for SW6 exceeded the IS: 2296-1982, limit of maximum 400 mg/L. The concentration of fluoride ranged from 0.13-1.43 mg/L. For samples SW-6, the fluoride concentration was found to be highest.

Iron concentration occurred from 1.86- 8.84 mg/L for all the set of samples, where highest concentration occurred for sample 5. The concentration of copper was found to be ranging from 0.28 mg/L for SW-8 and 1.14 mg/L for GW-6. For sample 2,4,5 the concentration was found to be below detectable limits (DL: 0.02 mg/L). The concentration of manganese ranged from 0.05 -4.49 mg/L. The concentration of silica ranged from 1.09-83.9 mg/L. Highest concentration was observed for location SW-4 and lowest for SW-6. The concentration of zinc was found to be below detectable limits (DL: 0.08) for all the samples except for SW-6, for which it was observed to be 0.11 mg/L. The concentration of lead was found to be below detectable limits (DL: 0.005) for all the samples except for SW-6, for which it was observed to be 0.51 mg/L which was higher than IS: 2296-1982 of 0.1 mg/L.

The concentration of oil and grease was found to be less than 2 mg/L for all the set of samples. The total coliform was found to be ranging from 21-170 MPN/100ml. Highest Total Coliform was observed for sample SW-2 and lowest for sample SW-6.

The concentration of lead, cadmium, total chromium, boron, total arsenic, selenium, nickel, aluminum and mercury was found to be below detectable limits. The concentration of phenolic compounds (DL: 0.001 mg/L), cyanide (DL: 0.01 mg/L) and anionic detergent as MBAS (DL: 0.1 mg/L) was found to be below detectable limits. Total residual chlorine was also found to be below detectable limit (DL: 0.1mg/L).

3.3   Meteorological Information

The long-term meteorological data from the "Climatological Normals" published by Indian Meteorological Department (IMD) was referred for understanding the historical trend of meteorology in the study area. The nearest IMD observatory for the project site is located at Pondicherry (11°55' N, 79°50'E). The consolidated 30 years (1971 2000) Climatological data for Pondicherry Observatory is presented in **Table 3-9** and **Table 3-10.**

3.3.1   Ambient Temperature

Viluppuram Dist.: The area falls under tropical climate with temperature in the summer months of March to May. The average temperature varies from 26 °C to 410 °C. The humidity is also high in theorder of 80%. The wind speed is high during the months of July and August. The windspeed ranges from 7.4 to 12.6 km/hr, which increases from 100 to 120 km/hr during cyclone period.

Kancheepuram Dist.: Kancheepuram district generally experiences hot and humid climatic conditions. The minimum and maximum temperature are 20°C & 37°C. The daytime heat is oppressive and the temperature is as high as 43°C.

As per the IMD data, during the months of January to May there is continuous increase in the ambient temperatures. May is the hottest month of the year with mean maximum and minimum temperatures of 39.1°C and 23.8 °C respectively. With the arrival of monsoon, the temperature begins to drop and was recorded as 31.3 °C in the month of December. January is the coldest month of the year with highest and lowest temperatures of 30.3 °C and 20.0 °C respectively. The annual average temperature was found to be 39.9 °C (max.) and 19.2 °C (min.).

Table 3-9 IMD - Climatology Table for Pondicherry Observatory

Month	Temperatures (ºC)				Humidity (%)	Rainfall (mm)				Mean Wind Speed (kmph)
	Mean		Extremes			Monthly Total	No. of Rainy Days	Heaviest Rainfall in 24hrs	Date and Year	
	Highest	Lowest	Highest	Lowest						
Jan	30	20	33.5	15.1	82 78	12.3	0.9	80	41,985	13.2
Feb	31.3	20.3	34.5	16.5	80 78	22.2	0.9	68.6	61,984	13.3
Mar	32.9	21.7	35	19.5	78 76	19.3	0.8	134.5	91,971	13.3
Apr	34.9	23.5	38	21.9	76 76	7.8	0.4	71	131,996	14.9
May	39.1	23.8	43	21.3	72 75	48.6	1.9	183	71,981	13.9
Jun	38.9	23.9	42.5	21.5	70 70	48	2.8	106.8	51,985	11.7
Jul	37.6	23	45.5	18.9	74 73	89.5	5.3	140	281,981	10.4
Aug	36.7	22.7	39	20.4	76 73	132.3	6.7	118.6	161,997	10.6
Sep	35.7	22.8	39	20.5	77 76	132.8	6.5	107	171,979	11
Oct	34.4	22.5	36.5	18.8	80 77	273.9	10.3	167	231,990	10.3
Nov	32.6	21.3	35	19.5	82 79	350	11.8	319.2	41,978	11.9
Dec	31.3	20.3	37.3	16.5	83 79	217.3	6.8	178	211,994	13.7

Month	Temperatures (ºC)				Humidity (%)	Rainfall (mm)				Mean Wind Speed (kmph)
	Mean		Extremes			Monthly Total	No. of Rainy Days	Heaviest Rainfall in 24hrs	Date and Year	
	Highest	Lowest	Highest	Lowest						
Annual Total / Mean	39.3	19.2	45.5	15.1	77 76	1354	55	319.2	4	12.4

Table 3-10IMD – Climatological Table for Pondicherry Observatory

Month	No. of days with wind speed (kmph)				Percentage no. of days wind from								
	62 or more	20-61	Jan-19	0	N	NE	E	SE	S	SW	W	NW	Calm
Jan	0	0	31	0	12	28	0	3	0	5	1	51	0
	0	10	21	0	2	61	2	13	0	1	0	21	0
Feb	0	0	28	0	6	23	1	13	1	8	3	44	1
	0	11	17	0	0	39	3	37	1	4	0	16	0
Mar	0	0	31	0	2	15	0	23	2	21	6	30	1
	0	13	18	0	0	21	2	60	1	7	0	9	0
Apr	0	1	29	29	0	5	0	45	9	28	4	9	0
	0	15	15	0	0	6	0	78	1	12	0	3	0
May	0	1	30	0	1	2	0	32	8	37	9	11	0
	0	12	19	0	0	4	0	70	5	16	1	4	0
Jun	0	0	30	0	0	2	0	16	3	54	12	13	0
	0	9	21	0	0	5	0	52	4	28	4	7	0
Jul	0	0	31	0	1	2	0	15	1	54	12	14	1
	0	8	23	0	0	4	0	55	3	29	3	6	0
Aug	0	0	31	0	0	2	0	12	1	53	12	20	0
	0	7	24	0	0	5	0	53	4	26	4	8	0
Sep	0	0	30	0	1	3	0	20	3	43	8		
	0	8	22	0	0	7	0	60	3	22	1	21	1

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Month	No. of days with wind speed (kmph)				Percentage no. of days wind from								
	62 or more	20-61	Jan-19	0	N	NE	E	SE	S	SW	W	NW	Calm
Oct	0	0	31	0	4	13	1	13	1	31	6	30	1
	0	8	23	0	1	24	2	41	2	14	1	14	1
Nov	0	1	29	0	8	26	0	8	1	10	2	44	1
	0	9	21	0	3	45	2	21	0	5	0	24	0
Dec	0	1	30	0	11	33	0	7	0	5	0	44	0
	0	13	18	0	1	56	2	15	0	4	0	22	0
	0	5	358	2	4	13	0	17	3	28	6	28	1
Annual Total/ Mean	0	124	240	1	1	23	1	46	2	14	1	12	0

*Source: Climatological Report published by Indian Meteorological Department, Pondicherry, Tamil Nadu (**30 Years Data: 1971 to 2000**)*

3.3.2 Rainfall

This region receives rainfall mainly from south-east monsoon (Jun - Sep) which spread over period of 55 days. As per Climatological Tables, precipitation occurs mainly during the months of May to December. November is the wettest month in year as it receives rainfall of around 350 mm during a period of 11.8 days. Northeast monsoon provides with little rains during October to November. The average yearly rainfall was reported to be 1354 mm.

Viluppuram Dist.: The district receives rainfall from southwest monsoon (June – September), northeast monsoon (October – December) and non-monsoon periods (January – May). The rainfall is generally heavy during low-pressure depressions and cyclones during the northeast monsoon period. The normal annual rainfall is 1119.8 mm (1901-1980) and the higher is towards coast. The annual rainfall data of Viluppuram district, Tamil Nadu for previous 5 years (2014-2018); as published by Rainfall Statistics under Indian Meteorological Department, is presented in

Table 3-11.

Kancheepuram Dist.: The district receives the rain under the influence of both southeast and northeast monsoons. Most of the precipitation occurs in the form of cyclonic storm caused due to the depressions in Bay of Bengal chiefly during northeast monsoon period. The southwest monsoon rainfall is highly erratic and summer rains are negligible.The normal annual rainfall over the district varies from 1105 mm to 1214mm. It is the minimum in the western and northwestern parts of the district around Uttiramerur (1105 mm) and it is the maximum around Kovalam (1214.2 mm). The annual rainfall data of Viluppuram district, Tamil Nadu for the year 2006; as published by Rainfall Statistics under Indian Meteorological Department, is presented in **Table 3-12**.

Table 3-11 Rainfall Data -Viluppuram District during the Year 2016 in mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
2014	0.5	3.4	0.0	0.0	35.7	117.6	50.9	130.9	130.6	196.3	135.0	106.9
2015	1.7	0.0	0.0	49.5	45.4	32.2	102.2	140.4	70.3	179.8	1061.3	574
2016	0.4	0.0	0.0	0.0	173.2	81.6	76.6	112.7	213.3	28.6	26.1	280
2017	16.4	0.1	0.0	0.0	14.4	67.8	98.8	228.6	98.7	287.6	335.7	49.3
2018	2.6	1.8	7.9	0.4	6.2	51.1	64.8	189.7	91.4	133.0	241.1	43

Table 3-12 Rainfall Data -Kancheepuram District during the Year 2016 in mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEP	OCT	NOV	DEC
2014	0.5	3.4	0.0	0.0	35.7	117.6	50.9	130.9	130.6	196.3	135.0	106.9
2015	1.7	0.0	0.0	49.5	45.4	32.2	102.2	140.4	70.3	179.8	1061.3	574
2016	0.4	0.0	0.0	0.0	173.2	81.6	76.6	112.7	213.3	28.6	26.1	280
2017	16.4	0.1	0.0	0.0	14.4	67.8	98.8	228.6	98.7	287.6	335.7	49.3
2018	2.6	1.8	7.9	0.4	6.2	51.1	64.8	189.7	91.4	133.0	241.1	43

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3.3.3   Relative Humidity

Viluppuram Dist.: The district's relative humidity is higher during morning than evening due to sea-breeze and land breeze effect. The climate in the study area is humid due to the vicinity of the sea. The highest humidity of 83% occurs during the month of December at morning. The lowest relative humidity of 70% occurs during the month of June at evening.

Kancheepuram Dist.: High relative humidity between 58 and 84% prevail throughout the year in Kancheepuram district. Relative humidity is maximum in the morning and minimum in the evening. Higher rates of relative humidity are observed between November and January i.e., 83 to 84%. In the months of June, the humidity is lower i.e., around 58%. Average relative humidity in the morning and evening 74 and 64%.

3.3.4   Wind Speed

An automatic weather station operated by the Indian Meteorological Department is used to give representative wind speed and wind direction for this region. The automatic weather station is located at 11°55' N, and 79°50'E, 6m above mean sea level with observations from 1971 to 2000. Wind speed between the ranges of 1-19 kmph was recorded for 257 days in morning and 246 days in the evening of the year while wind speed between 20-61 kmph was recorded for 97 days in the morning and 112 days in the evening of the year, and it was observed as calm in the 11 days in morning and 7 days in the evening of the days. The annual wind rose plot of Pondicherry region plotted with 30 years average data by IMD is shown in **Figure 3-12.**

Figure 3-12 Pondicherry Annual Wind Rose Plot IMD data
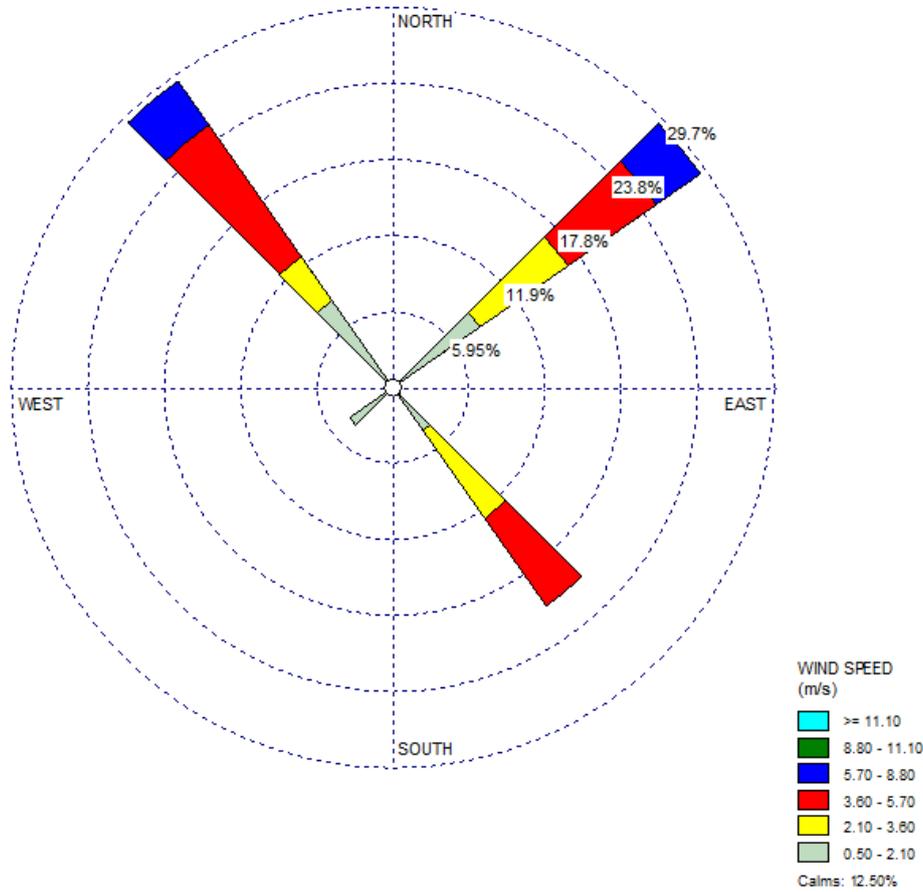
3.3.5 Baseline Ambient Air Quality

The background ambient air quality of the study area has been analyzed by collecting 8 samples in various locations within the study area and the collected samples were analyzed for various parameters which were then compared with NAAQ standards, as per CPCB guideline. AAQ monitoring station photographs are presented in **Figure 3-13.** The sampling co-ordinates of the AAQ monitoring locations are given in **Table 3-13**and the sampling locations represented on Google Map shown in **Figure -3-14.** Locations for AAQ monitoring were based on strategic placement, covering the entire study area and important locations.

The results of the analyzed AAQ within the study area are represented in **Table 3-14.**A total of 12 parameters were tested, among which 6 were found to be below detectable limits in all the locations, these parameters are not presented in the results table.

Figure 3-13 AAQ Monitoring Site Photographs

AAQ monitoring stations are set up at 8 locations (upwind, downwind & crosswind) considering the historical wind pattern (December). Monitoring stations have been fixed on the basis of the site conditions. The background ambient air quality (PM_{10}, $PM_{2.5}$, SO_2, NO_2, ozone, ammonia etc) of the study area are collected from these locations as per CPCB guidelines, NAAQ of 2009. The collected samples were sent to NABL accredited laboratory on periodic basis for analysis. Noise monitoring will be done during the upcoming stages of the baseline monitoring period, with monitoring stations locations same as AAQ stations.

The details of the 8 ambient air quality monitoring station within the 10Km study area are presented in **Table 3-13.**

Table 3-13 Air and Noise Monitoring Locations

S.No	Station	Name of the Location	Latitude	Longitude
	Air			
1	AAQ-1	Kadapakkam Project Site	12°15'46.729"N	80°0'8.462"E
2	AAQ-2	Azhakan Kuppam Village	12°14'25.632"N	79°59'47.645"E
3	AAQ-3	Vembanur Village	12°16'0.736"N	79°59'8.197"E
4	AAQ-4	Kadapakkam Village	12°17'28.631"N	79°59'46.926"E
5	AAQ-5	Thalangadu Village	12°11'45.005"N	79°56'45.99"E
6	AAQ-6	Thailangadu Village	12°15'54.703"N	79°56'3.717"E
7	AAQ-7	Marakkanam Village	12°11'55.412"N	79°57'6.784"E
8	AAQ-8	Muthalayar kuppam Village	12°19'12.361"N	80°01'38.549"E

Figure -3-14 AAQ Monitoring Locations

Table 3-14 Hours Average Ambient Air Quality Monitoring Results

SL.NO	Parameters	Units	NAAQS*	AAQ1		AAQ2		AAQ3		AAQ4		AAQ5		AAQ6		AAQ7		AAQ8	
				min	max	Min	max	min	max	Min	max	min	max	min	max	min	max	min	max
1	Particulate Matter (PM$_{2.5}$)	µg/m^3	60	18.6	25.4	10.2	21.1	10.1	15.1	16.2	24	21.7	29.1	10.0	13.2	22.4	27.5	23.1	32.4
2	Particulate Matter (PM$_{10}$)	µg/m^3	100	40.1	54.1	32.5	44.7	28.7	35.8	38.7	53.4	45.6	65.4	26.5	34.8	48.5	60.1	52.1	68.5
3	Sulphur Dioxide (SO$_2$)	µg/m^3	80	3.2	5.8	BDL(DL:3.0)				3.8	5.8	5.2	9.6	BDL(DL :3.0)		6.2	9.2	5.5	12.6
4	Oxides Of Nitrogen (NO$_2$)	µg/m^3	80	7.6	13.1	4.6	9.7	3.5	6.7	5.6	12.7	10.4	20.4	4.1	4.8	13	18.5	11.2	28.7
5	Ozone (O$_3$)	µg/m^3	180	8.7	10.5	BDL(DL:5.0)				6.5	8.5	8.7	22.1	BDL(DL:5.0)		9.2	17.1	9.5	23.8
6	Carbon Monoxide (CO)	mg/m^3	4	BDL(DL:1.15)															
7	Ammonia (NH$_3$)	µg/m^3	400	BDL(DL:5.0)	5.8	BDL(DL:5.0)						5.6	16.7	BDL(DL:5.0)		6.2	10.2	7.8	18.6

3.3.5.1 Observations on Ambient Air quality of the study area:

Particulate matter is the freely suspended solid particles in the air. In general, due to the close proximity to the sea, there is a general increase in PM concentration due to sea salt. PM10 is the particulate matter with 10 µm or less in aerodynamic diameter. From the results presented in the **Table 3-14**, it can be observed that the pollutant concentration at all locations was found to be lesser when compared to ambient National Ambient Air Quality Standards (NAAQS) as prescribed by CPCB. The average PM_{10} values were found to be ranging from 26.5 µg/m^3 to 68.5µg/m^{3}at all locations which is much lower than the NAAQS standard of 100 µg/m^3. The average $PM_{2.5}$ values were found to be ranging from 10 µg/m^3 to 32.4 µg/m^3 which was found to be lower than the standard value of 60 µg/m^3.

Sulphur Dioxide values were found to be ranging from 3.2-12.6 µg/m^3 which was much lesser than the ambient National Ambient Air Quality Standards (NAAQS) as prescribed by CPCB, indicating that there is not much pollution of air due to vehicular and industrial emissions in the project site. The maximum SO_2 concentration was found at location 8 which was 12.6 µg/m^3. For locations 2, 3 and 6 the SO_2 concentration was found to be below detectable limits which could be due to the occurrence of rain right before the measurement of air quality. The NO_2 concentration was found to be within the range from 3.5-28.7µg/m^3. The NO_2 concentration was much lower than the standard limit of 80 µg/m^3. The maximum NO_2 concentration was found at location 8 which was 28.7 µg/m^3. Ozone pollution which is the product of photo-catalytic reaction at ground level is a serious threat to human health and other living things. The ozone concentration varied from 6.5-23.8µg/m^3 which is found to be way less than the standards. Maximum ozone concentration was observed for AAQ-8. Ät locations AAQ2 and AAQ 3, the concentration was found to be below detectable limits. The concentration of ammonia was found to be very low ranging from 5.6-18.6 µg/m^3. At location, 2, 3, 4 and 6 the concentration of ammonia was found to be below detectable limits.

Carbon monoxide was found to be below detectable limits for all the eight locations. Toxic heavy metals like lead, arsenic, nickel, VOCs (Volatile Organic Compounds) like benzene and PAHs (Poly aromatic hydrocarbons) like benzo(a)pyrene were found to be below the detectable limits indicating their absence in the ambient air. The test reports of the air quality assessment are given in **Annexure VII**.

3.3.6 Noise Environment

The noise level varies in different ambience and location, as residential area would have lower noise levels when compared to an industrial area. The government has set noise level standards for various areas during both day and night times. AAQ and Noise were monitored in the same locations. The study area being located in a rural area majorly comprises of residential areas.

The measurements were carried out at each location during the study period for 24 hrs on hourly basis. A digital noise level meter was used to record the noise levels. Day time is considered from 06:00 hrs to 22:00 hrs and night from 22:00 hrs to 06:00 hrs. Noise monitoring locations in the study are same as in **Table 3-13. Figure -3-14**shows the sampling locations in the map**. Figure 3-13**shows the photograph taken during baseline monitoring.

Table 3-15 Noise Monitoring Results and Standards

Locations	Description	Day Time (Leq)	Standards Day Time (Leq)	Night time (Leq)	Standards Night Time (Leq)
N-1	Industrial Area	42.4	75	34.1	70
N-2	Residential Area	40.2	55	33.1	45
N - 3	Residential Area	36.3	55	32.1	45
N - 4	Residential Area	47.9	55	34.8	45
N-5	Residential Area	53.8	55	44.3	45
N-6	Residential Area	38.6	55	33.3	45
N-7	Residential Area	56.1	55	48.4	45
N-8	Residential Area	53.5	55	44.3	45

The measured noise levels have been compared with the standard specified in Schedule III, Rule 3 of Environmental Protection Rules. Based on the recorded noise levels the minimum and maximum noise levels for day and night at all eight locations are presented in the **Table 3-15**. From the **Table 3-15**, it can be observed that Location 7 (N-7) had the noise values slightly higher than the standard values for both day and night. During day it was found to be 56.1 dB (A) Leq and during night it was found to be 48.4 dB (A) Leq. For all the other monitoring locations during day and night, the noise levels in the area did not exceed the

permissible limit during both day and night time, as prescribed by NAAQ Standards in respect of Noise as prescribed the CPCB. The test reports of the noise assessment are given in **Annexure VIII**.

3.4 Marine Environment

3.4.1 Tides

The information on tidal levels off Cuddalore (Lat. 11˚ 43' N, Long. 79˚ 45' 30'' E) as mentioned on the Naval Hydrographic Chart 3003, with reference to the datum of soundings, is given in **Table 3-16**

Table 3-16 Tide Level off Cuddalore Coast

Tidal levels w.r.t CD in (m)				
MHWS	**MHWN**	**MSL**	**MLWN**	**MLWS**
1.0m	0.8m	0.7m	0.6m	0.4m

3.4.2 Wave

The wave rose for the study area for significant wave height and peak wave period was prepared from the met ocean data. It was observed that the predominant wave direction is south and is represented in **Figure 3-15**.

Figure 3-15 Annual waves rose (left): significant wave height; (right): peak wave period
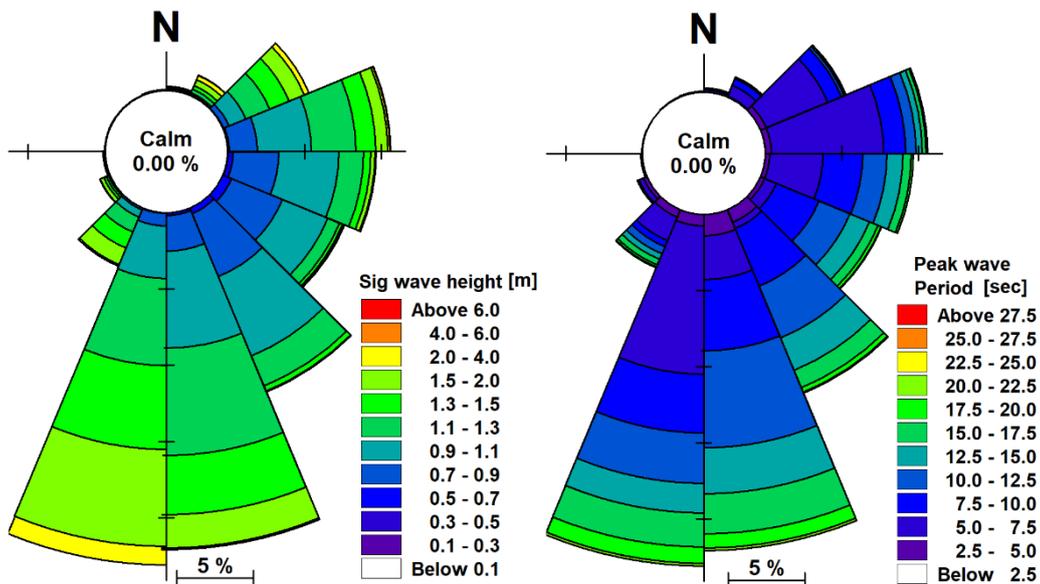
3.4.3 Current

Secondary current data collected from a drifting buoy shows that the coast of Villupuram and Kancheepuram experiences a maximum current speed of 1.8 m/s and a minimum current speed of 0.02 m/s.

3.4.4 Marine Water Quality

3.4.4.1 Marine Water Sampling

Assessment of marine water quality was made by collecting marine water samples (both at surface and bottom) from 8 locations within the 10Km study area around the project site. The collected marine water was securely stored and assessed in the lab for various parameters.

Table 3-17 Details of Marine Water sampling location within the study area

Sr.No	Station Code	Latitude	Longitude
1	MS-1	12.259341°N	80.004041°E
2	MS-2	12.265406°N	80.005567°E
3	MS-3	12.247266°N	79.990151°E
4	MS-4	12.236057°N	79.976801°E
5	MS-5	12.219893°N	79.956083°E
6	MS-6	12.221011°N	79.997330°E
7	MS-7	12.229920°N	80.047387°E
8	MS-8	12.274702°N	80.029086°E

The summary results of the physicochemical parameters of the collected marine water samples are presented in **Table 3-18**(Surface Water) and **Table 3-19**(Bottom Water). Google Earth imagery indicating marine water sampling stations are shown in **Figure 3-16.**

A total of 32 parameters were tested, among which 8 were found to be below detectable limits in all the locations for surface water, these parameters are not presented in the results table Marine water sampling collection photographs are presented in **Figure 3-17.**

Figure 3-16 Marine Water Sampling Locations
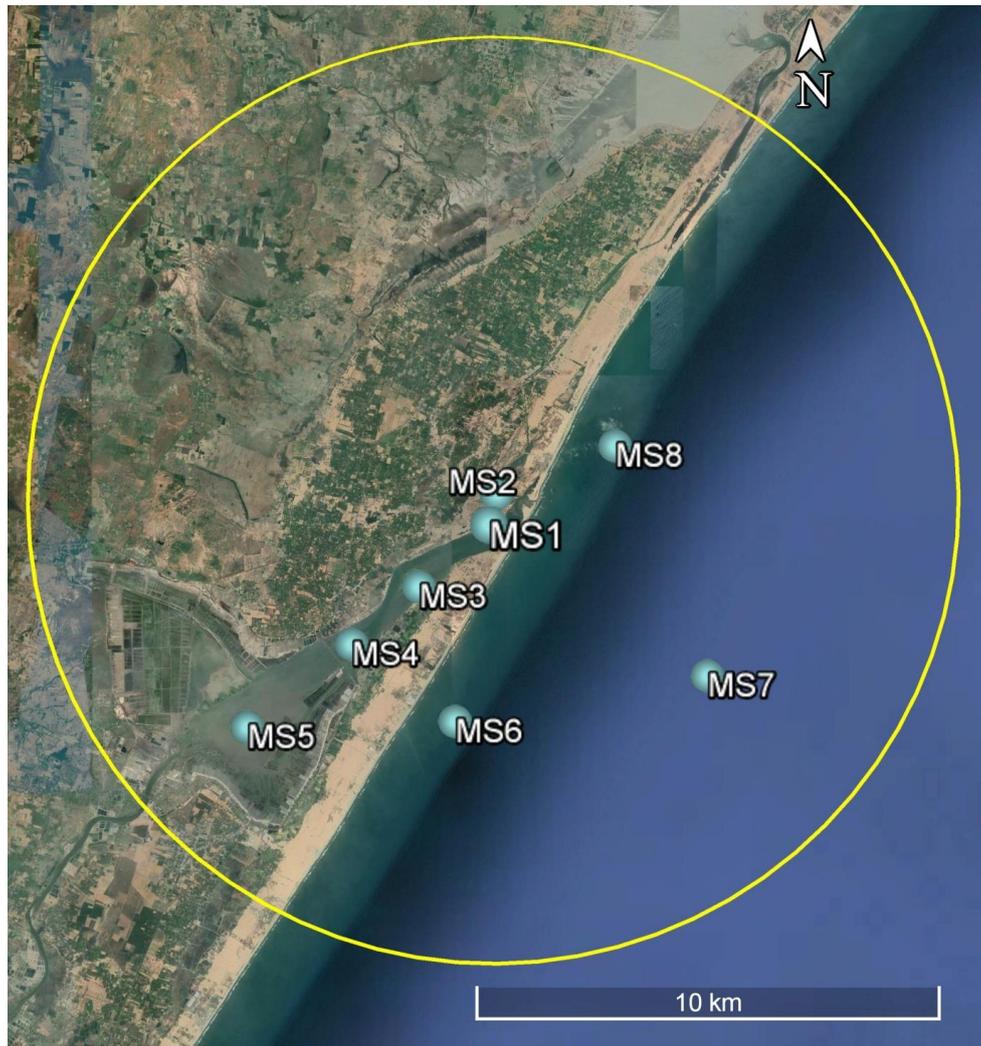
Figure 3-17 Marine water sampling within study area
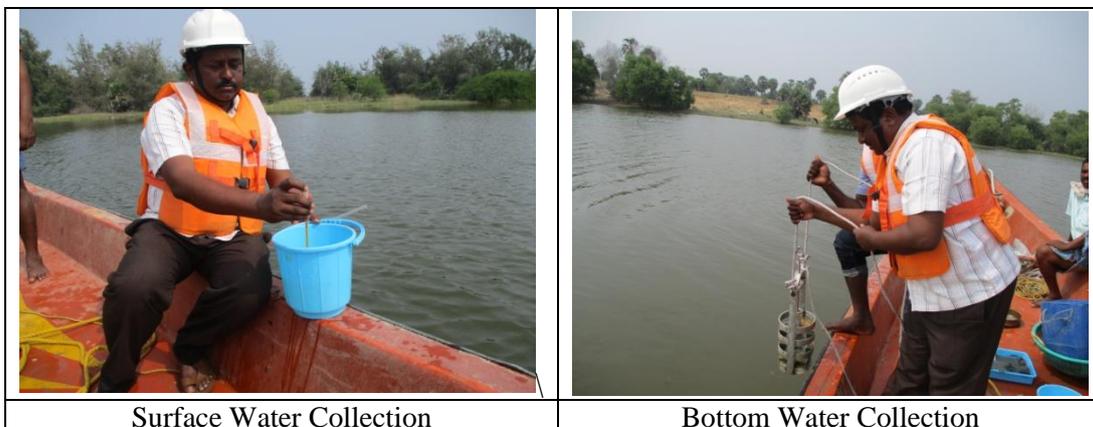
| Surface Water Collection | Bottom Water Collection |

| Phyto & Zoo plankton Collection | Benthos Collection |
| Sediment Collection | Sediment collection |

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Table 3-18Results Summary of Marine Surface Water Quality

S.NO	PARAMETERS	UNITS	MS 1	MS 2	MS 3	MS 4	MS 5	MS 6	MS 7	MS 8
1	Salinity	ppt	29.1	29.4	25.0	24.1	20.4	32.4	32.6	32.1
2	Conductivity	µs/cm	44156	42182	37480	35878	30392	47116	47458	46936
3	Temperature	°C	28.1	27.6	28.4	28.0	28.3	27.4	27.7	28.2
4	Total Suspended Solids	mg/l	20	16	8	6	21	4	6	10
5	pH @ 25°C	-	7.7	7.2	7.5	7.6	7.7	7.9	7.9	8.0
6	Dissolved Oxygen	mg/l	6.1	6.3	6.5	6.6	6.5	6.1	6.3	6.3
7	TDS	mg/l	29106	29444	25016	24064	20412	32488	32644	32072
8	Biochemical Oxygen Demand (BOD) 3 days at 27°C	mg/l	20	18	14	12	10	22	20	16
9	Chemical Oxygen Demand (COD)	mg/l	168	156	124	110	96	178	170	154
10	Nitrate as NO_3	µg/l	560	380	260	210	BDL(DL: 100.0)	640	710	580
11	Phosphate as PO_4	µg/l	140	BDL(DL:100.0)		190	120	280	BDL(DL :100.0)	140
12	Silica as SiO_2	mg/l	5.90	7.70	4.20	11.0	5.40	0.17	2.20	0.10
13	Sodium as Na	mg/l	8822	8600	7534	7172	5840	9694	9720	9672
14	Potassium as K	mg/l	310	298	272	256	210	322	326	324
15	Magnesium as Mg	mg/l	1179	1203	1031	982	908	1179	1129	1252
16	Iron as Fe	mg/l	0.54	0.25	0.23	0.06	1.06	0.05	BDL(DL:0.01)	
17	Calcium as Ca	mg/l	283	243	243	243	202	324	364	324
18	Copper as Cu	mg/l	0.05	0.06	0.04	0.04	0.05	0.04	0.05	0.04
19	Manganese as Mn	mg/l	0.08	0.13	0.09	0.14	0.15	0.08	0.09	0.07
20	Total Viable Count	CFU/ml	140	210	160	90	140	210	160	90

3.4.4.2 Marine Surface Water Quality

The pH of all the collected marine samples was found to be varying from 7.2-8. Total suspended solids ranged from 4-21 mg/L with location MS 5 and MS 6 having the highest and lowest concentration respectively. The temperature of all the sampling locations was found to be ranging from 27.4-28.4°C.

Calcium concentration for all the samples was found to be ranging from 202-364 mg/L. The highest concentration of calcium occurred for sample MS-7 (**Table 3-18**). Magnesium concentration ranged from 908-1252 mg/L. Sample MS-5 showed lowest concentration and Sample SW 8 showed the highest concentration. Sodium concentration ranged from 5840--9720mg/L. The sample MS-7 was found to have the highest concentration.

Salinity was found to be ranging from 20.4-32.6 ppt. The highest salinity was observed for Sample location MS-7.and lowest for MS-5. Total dissolved solids ranged from 20412-32644 mg/L. Highest concentration of Total dissolved solids was observed for MS-7. The conductivity of the marine water samples ranged from 30392 µS/cm for MS-5 location and 47458 µS/cm for location MS-7.

 Dissolved oxygen ranged from 6.1-6.6 mg/L. Lowest dissolved oxygen concentration was observed for MS-1 and MS-6and highest was observed for MS-4. The concentration of COD was found to be ranging from 96-178mg/L. Highest COD was observed for location MS-6and lowest was observed for location MS-5.

The concentration of biochemical oxygen demand was found to be ranging from 10-22 mg/L. The highest BOD was observed for location MS-6.

The concentration of phosphate occurred in the range from 120-280 µg/l. The highest phosphate concentration was observed for location MS-6. For location MS-2, MS3 and MS-7, the concentration of phosphates was found to be below detectable limits. The concentration of nitrate varied from 210-710 µg /L. Highest nitrate concentration was observed for location MS-7 and lowest was observed for location MS-4. The concentration of nitrate was found to be below detectable limits for MS-5. The concentration of potassium varied from 210-326 mg/L. Highest concentration was occurred for Location MS-7.

The iron concentration was found to be ranging between 0.05-1.06mg/L. Highest concentrations was observed for location MS-5. For location MS-7 and MS-8, the concentration of iron was found to be below detectable limits. The concentration of copper was found to be ranging from 0.04-0.06mg/L. The concentration of manganese ranged from 0.07mg/L for MS-8 and 0.15 for SW-5. The concentration of silica ranged from 0.10-11mg/L. It was found to be highest for MS-4 and lowest for MS-8.

The total viable count was found to be ranging from 90-210 CFU/ml. The highest viable count was observed for sample MS-2 and MS-6and lowest for Sample MS-4 and MS-8.

Concentration of nitrites was found to be below detectable limits for all the set of samples. The concentration of lead, cadmium, total chromium, zinc, arsenic, barium and mercury was found to be below detectable limits. The concentration of oil and grease was found to be below 2 mg/L. Total coliform and *E.coli* were found to be absent for all the set of samples. The test reports of the marine surface water are given in **Annexure IX**.

Table 3-19 Results Summary of Marine Bottom Water Quality

S.NO	PARAMETERS	UNITS	MS-1	MS-2	MS-3	MS-4	MS-5	MS- 6	MS-7	MS-8
1.	Salinity	ppt	29.6	29.8	26.2	30.6	23.4	32.5	33.4	32.6
2.	Conductivity	µs/cm	43157	43372	37674	44286	32192	45639	46702	45868
3.	Temperature	°C	27.8	28.1	28.6	27.6	28.1	28.4	27.8	28.2
4.	Total Suspended Solids	mg/l	466	17	14	23	12	4	8	21
5.	pH @ 25°C	-	7.1	6.9	7.4	6.9	7.6	7.6	7.4	7.9
6.	Dissolved Oxygen	mg/l	6.4	6.1	6.6	6.0	6.6	6.4	6.0	6.2
7.	TDS	mg/l	29574	29826	26208	30628	23368	32528	33490	32684
8.	BOD	mg/l	14	18	14	20	10	18	22	20
9.	COD	mg/l	138	164	128	172	102	166	180	174
10.	Nitrite as NO_2	mg/l	BDL(DL:0.01)			0.08	BDL(DL:0.01)			
11.	Nitrate as NO_3	µg/l	440	490	180	570	150	620	770	700
12.	Phosphate as PO_4	µg/l	230	180	BDL(DL:100.0)	260	BDL(DL:100.0)	230	290	210
13.	Silica as SiO_2	mg/l	6.8	10.2	5.4	4.8	3.9	0.2	0.4	0.7
14.	Sodium as Na	mg/l	8958	9168	8078	9668	6390	9824	9972	9868
15.	Potassium as K	mg/l	306	310	272	314	214	344	340	338
16.	Magnesium as Mg	mg/l	1203	1203	1080	1154	835	1203	1203	1154
17.	Iron as Fe	mg/l	6.4	0.66	0.55	1.43	0.62	0.11	0.82	0.46
18.	Calcium as Ca	mg/l	283	243	283	364	202	364	364	364
19.	Copper as Cu	mg/l	0.07	0.05	0.04	0.05	0.04	0.05	0.04	0.06
20.	Manganese as Mn	mg/l	0.20	0.10	0.09	0.09	0.10	0.11	0.08	0.16
21.	Total Viable Count	CFU/ml	90	80	90	100	50	70	60	30

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3.4.4.3 Marine Bottom Water Quality

The pH of all the collected marine samples was found to be varying from 6.9-7.9. Total suspended solids ranged from 4-466 mg/L with location MS 1 and MS 6 having the highest and lowest concentration respectively. The temperature of all the sampling locations was found to be ranging from 27.6-28.6°C.

Calcium concentration for all the samples was found to be ranging from 202-364 mg/L. The highest concentration of calcium occurred for sample 4,6,7 and 8. Magnesium concentration ranged from 835-1203 mg/L. Sample 5 showed lowest concentration and Sample 1 showed the highest. Sodium concentration ranged from 6390-9972mg/L. The sample MS-7 was found top have the highest concentration.

Salinity was found to be ranging from 23.4-33.4 ppt (**Table 3-19**). The highest salinity was observed for Sample location MS-7.and lowest for MS-5. Total dissolved solids ranged from 23368-33490 mg/L. Highest concentration of Total dissolved solids was observed for MS-7. The conductivity of the marine water samples ranged from 32192mS/cm for MS-5 location and 46702 mS/cm for location MS-7.

Dissolved oxygen ranged from 6.0-6.6 mg/L.Lowest dissolved oxygen concentration was observed for MS-4 and MS--7and highest was observed for MS-3 and MS--5. The concentration of COD was found to be ranging from 102-180mg/L. Highest COD was observed for location MS-7and lowest was observed for location MS-5.The concentration of biochemical oxygen demand was found to be ranging from 10-22 mg/L. The highest BOD was observed for location MS-7.

The concentration of phosphate occurred in the range from 180-290 µg/l. The highest phosphate concentration was observed for location MS-7. For location MS-3 and MS-5, the concentration of phosphates was found to be below detectable limits. Nitrite was found to be below detectable limits for all the locations except for location MS-4 where it was 0.08 mg/L. The concentration of nitrate varied from 150-770mg/L. Highest nitrate concentration was observed for location MS-7 and lowest was observed for location MS-5. The concentration of potassium varied from 214-344 mg/L. Highest concentration was occurred for Location MS-6.

The iron concentration was found to be ranging between 0.1-6.4 mg/L. Highest concentration was observed for location MS-1. The concentration of copper was found to be ranging from 0.04-0.07mg/L. The concentration of manganese ranged from 0.08mg/L for MS-7and 0.2 for MS-1. The concentration of silica ranged from 0.2-10.2mg/L. It was found to be highest for location 2 MS-2 and lowest for location 6 MS-6.

The total viable count was found to be ranging from 30-100 CFU/ml. The highest viable count was observed for sample MS-4 and lowest for Sample MS-8.

The concentration of lead, cadmium, total chromium, zinc, arsenic, barium and mercury was found to be below detectable limits. The concentration of oil and grease was found to be below 2 mg/L. Total coliform and E.coli were found to be absent for all the set of samples. The test reports of the marine bottom water are given in **Annexure X**

3.4.5 Marine Sediment Quality

Marine Sediments were collected in the same locations where a water sample was collected. The summary of marine sediment quality results is shown in**Table 3-20**.

A total of 17 parameters were tested, among which 6 were found to be below detectable limits in all the locations, these parameters are not presented in the results table. Marine sediment sampling photographs within the study area is presented in **Figure 3-17.**The test reports of the marine sediment are given in **Annexure XI.**

Table 3-20 Results Summary of Marine Sediment Quality

S.NO	PARAMETERS	UNITS	MS 1	MS 2	MS 3	MS 4	MS 5	MS 6	MS 7	MS 8
1.	Texture:									
	Sand	%	13.83	12.14	71.36	10.68	17.25	58.87	18.75	69.94
	Silt	%	7.00	11.50	16.63	6.05	11.10	25.24	12.42	15.17
	Clay	%	79.17	76.36	12.01	83.27	71.65	15.89	68.83	14.89
2.	pH	-	8.0	7.6	8.5	8.2	8.3	7.7	8.3	8.2
3.	Total Organic Carbon	%	3.24	1.78	1.65	1.52	2.40	0.76	1.46	1.74
4.	Calcium Carbonate as CaCO$_3$	%	2.9	9.2	11.8	9.4	7.4	3.2	4.0	6.5
5.	Organic Nitrogen	%	0.76	0.66	0.78	0.84	0.68	0.38	0.52	0.86
6.	Copper as Cu	mg/kg	3.19	3.50	BDL(DL:3.0)	BDL(DL:3.0)	3.58	BDL(DL:3.0)	BDL(DL:3.0)	BDL(DL:3.0)
7.	Zinc as Zn	mg/kg	24.05	32.16	14.19	19.59	27.88	27.35	24.69	22.34
8.	Iron as Fe	%	0.39	0.55	0.39	0.42	0.37	0.49	0.48	0.45
9.	Manganese as Mn	mg/kg	136.37	78.11	153.15	192.74	155.53	68.80	70.82	64.04
10.	Total Chromium as Cr	mg/kg	32.30	18.14	27.62	30.18	37.43	BDL(DL:5.0)	BDL(DL:5.0)	BDL(DL:5.0)

3.4.5.1 Results and Discussion

The sediment texture at location 3, 6, and 8 was observed to be sand and at location 1, 2, 4, 5, and 7, it was observed as clay. The sediments were neutral to mild basic in nature with pH values ranging between 7.6 and 8.5. Total Organic content was found to be in range from 0.76-3.24 %. Highest was observed at location 1 (3.24 %) and lowest at location 6 (0.76 %), The calcium carbonate was found to be ranging between 2.9-11.8 %. Lowest concentration was observed for location 1 and highest was observed for location 3.

Organic nitrogen ranged between 0.38 % (location 6) and 0.86 % (location 8).

Copper was found to be ranging from 3.19 mg/kg (location 1) to 3.58 mg/kg (location 5). For all other locations the concentration of copper was found to be below detectable limits.

Zinc content varied from 14.19-32.16 mg/kg. The concentration was found to be lowest at location 3 and highest at location 2. The concentration of iron was found to be varying between 0.37-0.55%. Highest concentration was observed for location 2.

Manganese levels were highest at location 4 (192.74mg/kg) and lowest at location 8 (64.04mg/kg). The concentration of total chromium varied between 18.14-37.43mg/kg. Highest concentration was observed for location 5. For location 6, 7, 8 the concentration of chromium was found to be below detectable limits.

Parameters such as Lead, Cadmium, Mercury, Arsenic, Barium and Petroleum Hydrocarbons were found to be below detectable limits. Oil and grease were also found to be below 10 mg/kg for all the set of samples.

3.5 Ecology and Biodiversity

Ecological studies give humans a deep insight into the principles of life; its forms and levels of existence and immortality on earth. Ecology reveals to us the truth that there is only "one life" on earth. Life exists infinitely in interrelations of diverse species in space and time. Ecology provides us with the wisdom that the supremacy and freedom, which humans enjoy over the diverse forms of life, are subject to the limits of nature's constitutions. Nature shows no special concern for any individual species, humans or otherwise unless and until the species prove to be successful in nature's quest for stability and sustenance of life on earth. Therefore, the primary

social need of every sustainable society is to protect and utilize all their natural resources in a wise manner.

Ecology also provides information about the benefits of ecosystems and how we can use Earth's resources in ways that leave the environment healthy for future generations. Living things are organized in to natural communities with mutual dependencies among their members, and they show various responses and sensitivities to the outside influences. However, the process of rapid development and industrialization has marked some prominent questions about survival of the flora and fauna. Fortunately, global awareness during past few years has been augmenting and worldwide programs for wild life conservation have been formulated. The worldwide-accepted concept of 'Sustainable development' has given a vision of eco-friendly project execution.

3.5.1   Necessity of the Ecology Management Plan

Monitoring the influence of anthropogenic activities on flagship species is an important part of conserving biodiversity, because the information gained is crucial for the development and adaptation of conservation management plans. Ecological monitoring provides feedback about the actual environmental impacts of a project. Monitoring results help judge the success of mitigation measures in protecting the environment. They are also used to ensure compliance with environmental standards, and to facilitate any needed project design or operational changes.

Regulatory bodies worldwide are increasingly recognizing the fact that human activities are causing environmental and ecological damage. To effectively deal with this environmental crisis, it is important to understand its dimensions and dynamics. What specifically are the damages, how are they changing over time, and the best means of prevention or mitigation. To develop precise ecology management plan, longer-term programs of monitoring and research must be designed and implemented. Such programs are capable of detecting environmental and ecological change over large areas, and of developing an understanding of the causes and consequences of those changes.

3.5.2 Objectives of Ecological Monitoring

1. Baseline data of Terrestrial biological environment by studying distribution pattern, community structure, population dynamics and species composition of Flora and Fauna.

2. To assess the impact of proposed jetty on marine and terrestrial flora, avifauna and mammals at the project area.

3. Areas used by protected, important or sensitive species of Fauna for breeding, nesting, foraging, resting, over wintering, migration shall be as ascertained.

4. Preparation of exhaustive list of Flora and Fauna of terrestrial and Marine and creek ecosystems of core and buffer zones with special reference to local status of the species.

5. Photography of flora and fauna including local habitats showing the status of the project site and study area for vegetation cover.

6. To recommend suitable environment management plan to minimize any adverse impact on adjacent area due to the proposed developments.

3.5.3 Survey Methodology

3.5.3.1 Flora survey

All accessible sites will be identified within the study area of 10km such that the ecosystems and land-use types are represented accordingly. The prediction of impacts on flora and fauna depends on understanding of the proposed project activities, its magnitude/extent, scale and ecological conditions in the surrounding area. Collection of rapid baseline information on flora and fauna is therefore a prerequisite for assessment of impacts of the development activities. All the accessible and identified sites will be divided into four zones with respect to their distance from the project site: Zone I - sites which fall in the project site i.e. core zone, Zone II mention the boundary of core zone to 2.5KM, Zone III indicate 2.5 to 5KM, Zone IV - sites which lie on the outermost zone extending from 5KM to 10KM. All the four Zones of lands would be mapped for their biological diversity.

Diversity assessment for different plant species and the analysis of Rare –Endemic – Endangered and Threatened flora was carried out. At each site, a study of floral diversity was carried out in

the following manner. A quadrant of approximately 20 m x 20 m was marked. The species of trees, shrubs and large climbers, as well as the number of individuals of each species, falling within this area were noted. A quadrant of approximately 5 m x 5 m was marked within this larger quadrate. The species of herbs, both grasses and forbs, and the number of individuals of each species, falling within this area were noted. Smaller quadrate of 1m x 1 m for the more prolifically-growing larger herbs, and 10 cm x 10 cm for prolifically-growing minute herbs, were employed when required.

3.5.3.2 Equipment / Instruments deployed:

- o Quadrates/Measuring Tape
- o Measuring tapes
- o GPS
- o Camera
- o Binocular and

3.5.3.3 Faunal assessment

A detailed study in has been carried out to cross check the list taken from secondary source and local villagers. In case of vertebrate species, no sampling could be done. Depending on as and when sighted, the species will be recorded if found within the delimited project and buffer areas, the animal species are listed on secondary data and circumstances evidence besides direct observations. These techniques are accepted in EIA studies as per the EIA Notification of 2006. Observations made on direct and indirect evidences for mammalian, avifauna and reptilian fauna within the study area. Analyses of Scheduled species identify Habitat/microhabitat diversity in the project site and surrounding areas within 10Km range from the site.

Flora and fauna studies in terrestrial were carried out during 18th October and on 05th – 8th November 2019 terrestrial, marine, creek sampling and coastal observations were to assess the list of terrestrial plant and animal species that occur in the core zone and in the buffer zone up to 10 km distance from the core zone boundary. The biodiversity of the survey area was then evaluated in terms of Species richness of the woody flora and the avifauna, percentage frequency, abundance and density of each floral species and Evenness.

3.5.3.4 Quantitative analysis of the vegetation

Plot-based random quadrate sampling method was adopted to generate the Phytosociological data *viz.,* density, frequency, abundance and important value index (IVI). Quadrates of 20 m x 20 m size were laid out for the enumeration of the tree species, quadrates of 5 m x 5 m for shrubs and saplings and quadrates of 1 m x 1 m for herbs and seedlings.

Diameter at breast height (DBH) of 130 cm was consistently used during the present study. In no case, the thicker part near branching position was considered. Instead diameter of the tree having a branch at about 130 cm was measured either below 30 cm from the branch or in case of all the stems above 30 cm from the branch and averaged.

All individuals above 10 cm of girth at breast height (GBH) were considered as trees and all individuals below 10 cm of GBH or 2 m of height as shrubs and saplings. In each unit, presence or absence of the species, number of individuals of each species, GBH (only for tree species) to estimate basal area of the tree species were recorded.

Other ecological parameters *viz.,* abundance, density, frequency, IVI, Shannon-Wiener diversity index, Simpson's dominance index, Abundance/Frequency (A/F) ratio for distribution pattern of species and Similarity Index were derived from the above basic data.

Frequency, density, abundance and basal area were calculated following Misra (1968).

$$\text{Frequency:} \quad \frac{\text{Number of sampling units in which a species occurs}}{\text{Total number of sampling units studied}} \times 100$$

The frequency of individual species is the number of times the species occurs in the sampling quadrant.

$$\text{Density:} \quad \frac{\text{Total number of individuals in all sampling units}}{\text{Total number of sampling units studied}}$$

Density is the measure of dense in the distribution of an individual species within a given area.

$$\text{Abundance:} \quad \frac{\text{Total number of individuals in all sampling units}}{\text{Total number of sampling units of occurrence}}$$

Total basal area or crown

$$\text{Dominance} = \frac{\text{Total basal area or crown}}{\text{Total area sampled}} \times 100$$

It reflects the species basal area covered by a species within the sampling area.

The relative density and dominance values of different species found in the study are shows that the dominant plants of various sites have a high percentage value of density and dominance. These values are incorporated in calculating the Importance value Index.

$$\text{Relative density:} \quad \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

$$\text{Relative frequency:} \quad \frac{\text{Number of occurrences of a species}}{\text{Total number of occurrences of all species}} \times 100$$

$$\text{Relative basal area:} \quad \frac{\text{Total basal area of individual species}}{\text{Total basal areas of all species}} \times 100$$

3.5.4   Results

The published literature studies reports are used for finalize the list of core and buffer zone species. Secondary data compared with the existing sighted species in the study areas. The flora and fauna list also cross checked with the local communities. An effort has been made to identify the impacts of the proposed expansion of paper and board mill at different stages. Floral and faunal resources used by local communities such as timber, medicinal and fishing etc are also collected. The mitigation measures were suggested and conservation of Scheduled species (if any) has been given.

3.5.5   General Characteristics of Floral Diversity

The flora of study area was represented by *Casuarina equsetifolia, Anacardium occidentaleAzadirachta indica, Cocus nucifera, Ficus sp. Borassus flabelifer, Thespesia populnea, Moringa oleifera, Odina wodier, Termialia sp.* over large area.

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Table 3-21 Density, abundance and frequency of occurrence of flora in the Core zone

S.No	Species Name	Family	Core (Zone I)		
			Frequency	Abundance	Density
1	*Acacia auriculiformis*	Euphorbiaceae	25.00	1.500	37.5
2	*Alstonia scholaris*	Apocyanaceae	50.00	1.000	25.0
3	*Azadirachta indica*	Meliaceae	12.50	1.000	25.0
4	*Bauhinia variegata*	Fabaceae	12.50	1.000	25.0
5	*Borassus flabellifer*	Arecaceae	12.50	1.000	25.0
6	*Callistemon citrinus*	Myrtaceae	12.50	1.000	25.0
7	*Calophyllum inophyllum*	Calophyllaceae	12.50	1.000	25.0
8	*Cassia siamia*	Fabaceae	25.00	1.500	37.5
9	*Nerium olienter*	Apocyanaceae	12.50	1.000	25.0
10	*Phoenix sylvestris*	Arecaceae	12.50	1.000	25.0

Buffer zone study: From Project site boundary to 10 Km radius is treated as buffer zone (2.5KM, 5KM and 10KM) and 30 samples of 20m^2 each were chosen by taking the following parameters into consideration.

- Villages Human settlements
- Agriculture cultivation
- River and Aquatic Vegetation
- Coastal zone
- Sand dune
- Inland Fisheries
- Aquatic Vegetation

3.5.5.1 Villages and Human settlements

Number of small villages like Kadapakkam, Kotttaikadu, Thenpakkam and Muttukadu situated in the 2.5 KM radius from the core zone, Vilambur, Edaikazhinadu, Vembanur and Naipanikuppam are situated in the 5KM radius whereas villages like Naravakkam, Othivilagam, Kadugalur and Vedal are situated in the 7Km and the villages like Ekkiarkuppam, Marakkanam, Chunampet, Kavanur, Chithrakadu and Vellankondagaram are present in the 10KM of the study area. The vegetation around villages was observed to be in healthy and in natural state. Species like *Casuarina equsetifolia, Azadirachta indica, Cocus nucifera, Anacardium occidentale, Ficus benghalensis, Ficus religiosa, Azadiracta indica, Tamarindus indica, Ziziphus jujuba, Ricinus communis, Terminalia catappa* etc were commonly observed near villages.

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3.5.5.2 Agriculture Area

The major crops are Paddy, Sugarcane, Black gram, Green gram and Groundnut. Study area has fertile soils in most of the regions. The network of the irrigation canals from dam overcomes deficiency of water to a certain extent. The cropping pattern of the study area is characterized by diversified cropping patterns exist and no single crop claims a large share of the gross cropped area. In canal fed areas Paddy occupies the largest area of cultivation followed by ground nut and sugarcane. Other crops grown in the region are ragi, pulses, groundnut and coconut, vegetables like brinjal, bhendi and chilies. Coconut and Mango grooves are also observed.

3.5.5.3 Flora in Zone II – project boundary to 2.5 km

The flora in vicinity of proposed project was mainly showed dominance of palms and *Anacardium occidentale, Azadirachta indica, Artocarpus heterophyllus, Casuarina equisetifolia, Cocus nucifera,Leucana leucophila, Pongamia glabra,Odina wodier, Samanea saman* and *Terminalia arjuna.* Shrubs like *Tecoma stansCalotropis gigantean, Ricinus communis, Lantana camera* and *Nerium oleander* were common along roadside. Shannon index value for this zone is

Table 3-22 Density, abundance and frequency of occurrence of flora in the Zone II

S.No	Species Name	Family	Buffer Core - 2.5 KM (Zone II)		
			Frequency	Abundance	Density
1	*Acacia auriculiformis*	Euphorbiaceae	25.00	1.000	25.0
2	*Acacia nilotica*	Mimosaceae	12.50	1.000	25.0
3	*Anacardium*	Anacardiaceae	50.00	2.750	68.8
4	*Annona squamosa*	Annonaceae	62.50	1.400	35.0
5	*Artocarpus*	Moraceae	37.50	1.667	41.7
6	*Azadirachta indica*	Meliaceae	62.50	1.800	45.0
7	*Bambusa arundinacea*	Poaceae	25.00	1.000	25.0
8	*Borassus flabellifer*	Arecaceae	50.00	1.500	37.5
9	*Cassia siamea*	Fabaceae	12.50	1.000	25.0
10	*Casuarina*	Casuarinaceae	62.50	2.600	65.0
11	*Ceiba pentandra*	Malvaceae	37.50	1.333	33.3
12	*Citrus limen*	Rutaceae	25.00	1.000	25.0
13	*Cocus nucifera*	Arecaceae	37.50	1.333	33.3
14	*Delanix regia*	Caesalpinaceae	25.00	1.000	25.0
15	*Delonix elata*	Caesalpinaceae	12.50	1.000	25.0
16	*Eucalyptus*	Myrtaceae	37.50	1.333	33.3
17	*Ficus bengalensis*	Moraceae	25.00	1.000	25.0

S.No	Species Name	Family	Buffer Core - 2.5 KM (Zone II)		
			Frequency	Abundance	Density
18	*Gliricidia sepium*	Fabaceae	37.50	1.000	25.0
19	*Gmelina arborea*	Lamiaceae	12.50	1.000	25.0
20	*Guazuma tomentosa*	Malvaceae	25.00	1.500	37.5
21	*Leucana leucophila*	Fabaceae	25.00	1.500	37.5
22	*Mangifera indica*	Anacardiaceae	50.00	1.500	37.5
23	*Manilkara sapota*	Sapotaceae	37.50	1.000	25.0
24	*Millingtonia hortensis*	Bignoniaceae	37.50	1.000	25.0
25	*Morinda tinctoria*	Rubiaceae	25.00	1.000	25.0
26	*Moringa oleifera*	Moringaceae	62.50	1.200	30.0
27	*Murraya koenigii*	Rutaceae	12.50	1.000	25.0
28	Odina wodier	Anacardiaceae	37.50	1.667	41.7
29	*Phyllanthus acidus*	Phyllanthaceae	50.00	1.000	25.0
30	*Plumeria alba*	Apocyanaceae	25.00	1.000	25.0
31	*Polyalthia longifolia*	Annonaceae	25.00	1.500	37.5
32	*Pongamia glabra*	Fabaceae	12.50	2.000	50.0
33	*Prosopis julifera*	Mimosoideae	25.00	1.000	25.0
34	*Psidium guajava*	Myrtales	37.50	1.333	33.3
35	*Samanea saman*	Fabaceae	12.50	2.000	50.0
36	*Syzygium cumini*	Myrtaceae	12.50	2.000	50.0
37	*Tamarindus indica*	Fabaceae	12.50	1.000	25.0
38	*Tecoma stans*	Bignoniaceae	37.50	1.000	25.0
39	*Tectona grandis*	Lamiaceae	37.50	1.000	25.0
40	*Terminalia arjuna*	Combretaceae	25.00	2.500	62.5
41	*Terminalia catappa*	Combretaceae	25.00	1.000	25.0
42	*Thespesia populnea*	Malvaceae	37.50	1.000	25.0
43	*Vitex negundo*	Lamiaceae	37.50	1.000	25.0
44	*Ziziphus jujupa*	Rhamnaceae	12.50	2.000	50.0

3.5.5.4 Flora of Zone III – 2.5 to 5 km from Project Site

Zone III was dominated by agriculture land and lakes hence, rich diversity was observed in this zone. Tree species like *Anacardium occidentale, Artocarpus heterophyllus, Casuarina equisetifolia, Borassus flabeliber, Cocus nucifera,Leucana leucophila, Pongamia glabra, Odina wodier* and *Terminalia arjuna.* Shrubs like *Tecoma stans, Calotropis gigantean, Ricinus communis, Lantana camera* and *Nerium oleander* were common along roadside.

Table 3-23 Density, abundance and frequency of occurrence of flora in the Zone III

S.No	Species Name	Family	Buffer Core - 5 KM (Zone III)		
			Frequency	Abundance	Density
1	*Acacia auriculiformis*	Euphorbiaceae	25.00	1.000	25.0
2	*Acacia nilotica*	Mimosaceae	25.00	1.000	25.0
3	*Anacardium*	Anacardiaceae	50.00	2.000	50.0
4	*Annona squamosa*	Annonaceae	37.50	1.333	33.3
5	*Artocarpus*	Moraceae	50.00	1.250	31.3
6	*Azadirachta indica*	Meliaceae	75.00	1.167	29.2
7	*Bambusa arundinacea*	Poaceae	12.50	1.000	25.0
8	*Borassus flabellifer*	Arecaceae	50.00	1.250	31.3
9	*Cassia siamea*	Fabaceae	25.00	1.000	25.0
10	*Casuarina*	Casuarinaceae	75.00	1.833	45.8
11	*Ceiba pentandra*	Malvaceae	37.50	1.000	25.0
12	*Citrus limen*	Rutaceae	37.50	1.333	33.3
13	*Cocus nucifera*	Arecaceae	75.00	1.833	45.8
14	*Delanix regia*	Caesalpinaceae	25.00	1.500	37.5
15	*Delonix elata*	Caesalpinaceae	37.50	1.667	41.7
16	*Eucalyptus*	Myrtaceae	75.00	1.000	25.0
17	*Ficus bengalensis*	Moraceae	37.50	1.333	33.3
18	*Ficus hispida*	Moraceae	25.00	1.500	37.5
19	*Gliricidia sepium*	Fabaceae	25.00	1.500	37.5
20	*Gmelina arborea*	Lamiaceae	12.50	1.000	25.0
21	*Guazuma tomentosa*	Malvaceae	37.50	1.333	33.3
22	*Leucana leucophila*	Fabaceae	50.00	1.250	31.3
23	*Mangifera indica*	Anacardiaceae	50.00	2.250	56.3
24	*Manilkara sapota*	Sapotaceae	62.50	1.400	35.0
25	*Melia azardirachta*	Meliaceae	37.50	1.333	33.3
26	*Millingtonia hortensis*	Bignoniaceae	50.00	1.250	31.3
27	*Moringa oleifera*	Moringaceae	62.50	1.600	40.0
28	*Murraya koenigii*	Rutaceae	25.00	1.000	25.0
29	*Odina wodier*	Anacardiaceae	50.00	1.000	25.0
30	*Peltophorum*	Fabaceae	50.00	1.000	25.0
31	*Phyllanthus acidus*	Phyllanthaceae	50.00	1.000	25.0
32	*Plumeria alba*	Apocyanaceae	50.00	1.500	37.5
33	*Polyalthia longifolia*	Annonaceae	62.50	1.000	25.0
34	*Pongamia glabra*	Fabaceae	37.50	1.000	25.0
35	*Prosopis julifera*	Mimosoideae	25.00	1.000	25.0

S.No	Species Name	Family	Buffer Core - 5 KM (Zone III)		
			Frequency	Abundance	Density
36	*Psidium guajava*	Myrtales	37.50	1.333	33.3
37	*Samanea saman*	Fabaceae	25.00	1.500	37.5
38	*Syzygium cumini*	Myrtaceae	37.50	1.000	25.0
39	*Tamarindus indica*	Fabaceae	25.00	1.000	25.0
40	*Tecoma stans*	Bignoniaceae	75.00	1.000	25.0
41	*Tectona grandis*	Lamiaceae	37.50	1.000	25.0
42	*Terminalia arjuna*	Combretaceae	37.50	1.333	33.3
43	*Terminalia catappa*	Combretaceae	37.50	1.000	25.0
44	*Thespesia populnea*	Malvaceae	50.00	1.250	31.3
45	*Vitex negundo*	Lamiaceae	25.00	1.500	37.5
46	*Ziziphus jujupa*	Rhamnaceae	12.50	1.000	25.0

3.5.5.5 Flora of Zone IV – 5 to 10 km from Project Site

Zone IV was dominated by agriculture land and Reserve Forest hence rich diversity was observed in this zone. Tree species like *Anacardium occidentale, Artocarpus heterophyllus, Casuarina equisetifolia, Cocus nucifera,Leucana leucophila, Pongamia glabra, Thespesia populnea, Borassus flabeliber* and *Terminalia arjuna.* Shrubs like *Zizyphys jujupa*, *Calotropis gigantean, Jatropa sp.* and *Ricinus communis* were dominant.

Table 3-24 Density, abundance and frequency of occurrence of flora in the Zone IV

S. No	Species Name	Family	Buffer Core - 10 KM (Zone IV)		
			Frequency	Abundance	Density
1	*Acacia auriculiformis*	Euphorbiaceae	20.00	1.000	25.0
2	*Acacia nilotica*	Mimosaceae	20.00	2.000	50.0
3	*Alstonia scholaris*	Apocyanaceae	20.00	1.500	37.5
4	*Anacardium*	Anacardiaceae	50.00	2.600	65.0
5	*Annona squamosa*	Annonaceae	60.00	1.333	33.3
6	*Artocarpus*	Moraceae	50.00	1.200	30.0
7	*Azadirachta indica*	Meliaceae	60.00	1.333	33.3
8	*Bambusa*	Poaceae	20.00	1.000	25.0
9	*Borassus flabellifer*	Arecaceae	50.00	1.200	30.0
10	*Calophyllum*	Calophyllaceae	20.00	1.000	25.0
11	*Cassia siamea*	Fabaceae	30.00	1.333	33.3
12	*Casuarina*	Casuarinaceae	60.00	1.833	45.8
13	*Ceiba pentandra*	Malvaceae	40.00	1.000	25.0
14	*Citrus limen*	Rutaceae	20.00	1.000	25.0

S. No	Species Name	Family	Buffer Core - 10 KM (Zone IV)		
			Frequency	Abundance	Density
15	*Cocus nucifera*	Arecaceae	60.00	1.000	25.0
16	*Dalbergia sissoo*	Fabaceae	30.00	1.333	33.3
17	*Delanix regia*	Caesalpinaceae	20.00	1.000	25.0
18	*Delonix elata*	Caesalpinaceae	30.00	1.000	25.0
19	*Eucalyptus*	Myrtaceae	60.00	1.167	29.2
20	*Ficus bengalensis*	Moraceae	40.00	0.750	18.8
21	*Gliricidia sepium*	Fabaceae	40.00	1.000	25.0
22	*Gmelina arborea*	Lamiaceae	20.00	1.000	25.0
23	*Guazuma tomentosa*	Malvaceae	50.00	1.400	35.0
24	*Leucana leucophila*	Fabaceae	30.00	1.000	25.0
25	*Mangifera indica*	Anacardiaceae	60.00	1.333	33.3
26	*Manilkara sapota*	Sapotaceae	50.00	1.000	25.0
27	*Melia azardirachta*	Meliaceae	30.00	1.333	33.3
28	*Millingtonia*	Bignoniaceae	30.00	1.667	41.7
29	*Moringa oleifera*	Moringaceae	60.00	1.000	25.0
30	*Murraya koenigii*	Rutaceae	20.00	1.000	25.0
31	Odina wodier	Anacardiaceae	40.00	1.500	37.5
32	*Phyllanthus acidus*	Phyllanthaceae	50.00	1.000	25.0
33	*Phyllanthus emblica*	Phyllanthaceae	30.00	1.000	25.0
34	*Pithocelopium dulce*	Fabaceae	30.00	1.000	25.0
35	*Plumeria alba*	Apocyanaceae	20.00	1.000	25.0
36	*Polyalthia longifolia*	Annonaceae	20.00	1.500	37.5
37	*Pongamia glabra*	Fabaceae	40.00	1.250	31.3
38	*Prosopis julifera*	Mimosoideae	30.00	1.667	41.7
39	*Psidium guajava*	Myrtales	60.00	1.000	25.0
40	*Pterocarpus*	Fabaceae	10.00	3.000	75.0
41	*Roystonia regia*	Arecaceae	10.00	2.000	50.0
42	*Samanea saman*	Fabaceae	20.00	1.000	25.0
43	*Syzygium cumini*	Myrtaceae	20.00	1.500	37.5
44	*Tabebuia rosea*	Bignoniaceae	20.00	1.500	37.5
45	*Tamarindus indica*	Fabaceae	30.00	1.000	25.0
46	*Tecoma stans*	Bignoniaceae	60.00	1.500	37.5
47	*Tectona grandis*	Lamiaceae	50.00	1.400	35.0
48	*Terminalia arjuna*	Combretaceae	30.00	2.333	58.3
49	*Terminalia catappa*	Combretaceae	50.00	1.400	35.0
50	*Thespesia populnea*	Malvaceae	20.00	1.500	37.5
51	*Vitex negundo*	Lamiaceae	20.00	1.500	37.5

S. No	Species Name	Family	Buffer Core - 10 KM (Zone IV)		
			Frequency	Abundance	Density
52	*Ziziphus jujupa*	Rhamnaceae	20.00	1.000	25.0

Figure 3-18Floral Species within Study Area

Acalypha indica	*Cassia auriculata*	*Catharanthus roseus*
Gloriosa superba	*Jatropha gossypifolia*	*Lucas aspera*
Nerium oleander	*Ipomea carnea*	*Pedalium murex*
Coastal plants		
Ipomoea pes-caprae	Salicornia virginica	*Sesuvium potulacastrum*

3.5.6 Faunal Diversity

3.5.6.1 Avifauna

Overall 49 species of birds were recorded from entire study area during this survey period. In the agriculture areas, large numbers of Bee-eaters, Mynas, Larks, Reed Warblers, Lapwings, Kites and Drongos were observed. Black Drongo, Ashy Drongo, Indian Roller, Bush Quail, Doves, Shrikes were observed in dry land. House sparrow, Common crow, Rock Pigeon, Magpie Robin, Spotted Dove and Baya Weaver were seen near villages. Predators and accipiter like black Kite, Black winged Kite were occasionally seen near farms and water bodies.

Majority of species were recorded from lakes and river. However, no migratory species were recorded during this study. Detailed survey during migration season is required for precise observations on avifauna. Species like Painted Stork, Open Billed Stork, Glossy Ibis, Black Ibis, Black Headed Ibis, Coot and Little Grebes were observed near water bodies while species like Little Egret, Cattle Egret, Pond Heron, Little Cormorant, Kingfishers and River Terns.

Table 3-25 Avifauna observed in study area during survey period

S. No	Scientific name	Common Name
1	*Accipiter badius*	Shikra
2	*Acridotheres tristis*	Common Myna
3	*Acrocephalus dumetorum*	Blyth's Reed Wabler
4	*Alauda gulgula*	Oriental Skylark
5	*Alcedo attbis*	Small Blue Kingfisher
6	*Anastomus oscitans*	Asian Open Billed Stork
7	*Ardeola grayii*	Indian Pond Heron
8	*Bubulcus ibis*	Cattle Egret
9	*Casmerodius albus*	Great Egret
10	*Centropus sinensis*	Greater Coucal
11	*Columba livia*	Rock Pigeon
12	*Copsychus saularis*	Oriental Magpie Robin
13	*Coracias benghalensis*	Indian Roller
14	*Corvus splendens*	Common House Crow
15	*Cuculus canorus*	Common Hawk Cuckoo
16	*Dendrocitta vagabunda*	Rufus Treepie
17	*Dicrirus macrocercus*	Black Drongo
18	*Dicrurus leucophaeus*	Ashy Drongo
19	*Dinopium benghalense*	Lesser Goldenback

S. No	Scientific name	Common Name
20	*Egretta garzetta*	Little Egret
21	*Elanus caeruleus*	Black Winged Kite
22	*Ficedula albicilla*	Red Throated Flycatcher
23	*Halcyon pileata*	White Throated Kingfisher
24	*Laniaus schach*	Long Tailed Shrike
25	*Copsychus saularis*	Magpie robin
26	*Megalaima haemacephala*	Copper Smith Barbet
27	*Megalaima zeylanica*	Brown headed Barbet
28	*Meropes leschenaaulti*	Chestnut - headed bee eater
29	*Meropus orientalis*	Green Bee-eater
30	*Milvus migrans*	Black Kite
31	*Motacilla cinerea*	Grey Wagtail
32	*Mycteria leucocephala*	Painted Stork
33	*Passsel domesticus*	House Sparrow
34	*Perdicula asiatica*	Bush Quail
35	*Phalacrocorax niger*	Little Cormorant
36	*Psittakula krameri*	Indian Rose ring Parakit
37	*Pycnonotus cafer*	Red Vented Bulbul
38	*Rhipidura auriola*	White Browed Fantail
39	*Streptopelia chinensis*	Spotted Dove
40	*Streptopelia decaocto*	Euarasian Collared Dove
41	*Streptopelia senegalensis*	Laughing Dove
42	*Tephrodornis gularis*	Large Wood shrike
43	*Terdoides striatus*	Jungle Babbler
44	Eremopterix griseus	Ashy Crowned Sparrow Lark
45	Calidris temminckii	Temminick stint
46	Vanellus indicus	Redwattled lap wing
47	Anas acuta	Northern Pin tail Duck
48	Ceryle rudis	Pied King fisher
49	Anastomus oscitans	Open bill stork

Figure 3-19 Avifauna observed in study area during survey period

Ashy Crowned sparrow Lark	*Black Drango*	*Black shouldered Kite*
Common Indian Myna	*Indian Bul Bul*	*Spotted Dove*
Rose ringed Parakeet	*Black winged stilt*	*Eurasian curlew*
Pied King fisher	Redwattled Lapwing	Northern Pin tail duck

Cattle egrett	Temminick stint	Open billed stork

3.5.6.2 Mammals and Reptiles

Villagers in the buffer area confirmed the presence of Indian Fox (Vulpes bengalensis), Wild Hare (Lepus nigricollis), and Grey Mongoose (Herpestes edwardsii). Other major reptiles are Cobra, Commom Krait, Vipers, Rat Snake, and Monitor Lizard.

3.5.7 Sand Dunes and Turtle Nesting Places in Azhagankuppam and Alamparai Coast

Coastal Sand Dunes are located at the interface of land and sea, and is serves as a support system for diverse range of flora and fauna. These ecosystems sustain various biotic assemblages and offers ecosystem services to millions of people around the world. The dunes inhabit dune grasses and other creepers which aid in anchoring the sand with their roots. Their presence serves as a protection for inland areas in the events of storm surges, hurricanes, flood-water, and wind and wave action. They also provide nesting habitat for coastal birds, including migratory birds, as well as for sea turtles. These sand dunes have become an accommodating area for turtles during their nesting seasons, as well as other faunal species. *Borassus flabellifer, Anacardium occidentalis, Spinifex littoreus, Ipomea pes-caprae and Pantanus sp.,* are the plants inhabiting the sand dunes near Azhagankuppam and Alamparai.

The olive ridley turtles, the smallest and the most numerous of the seven species of sea turtles, are famously known for their unique behavior of forming enormous nesting aggregations – a phenomenonknown as "**arribada**" (Spanish for arrival).

Figure 3-20 Sand dunes within Study Area

Sand dunes of the coast with *Spinifex littoreus, Pantanus sp., Ipomea pes-caprae And Turtle nesting zone along the coast*
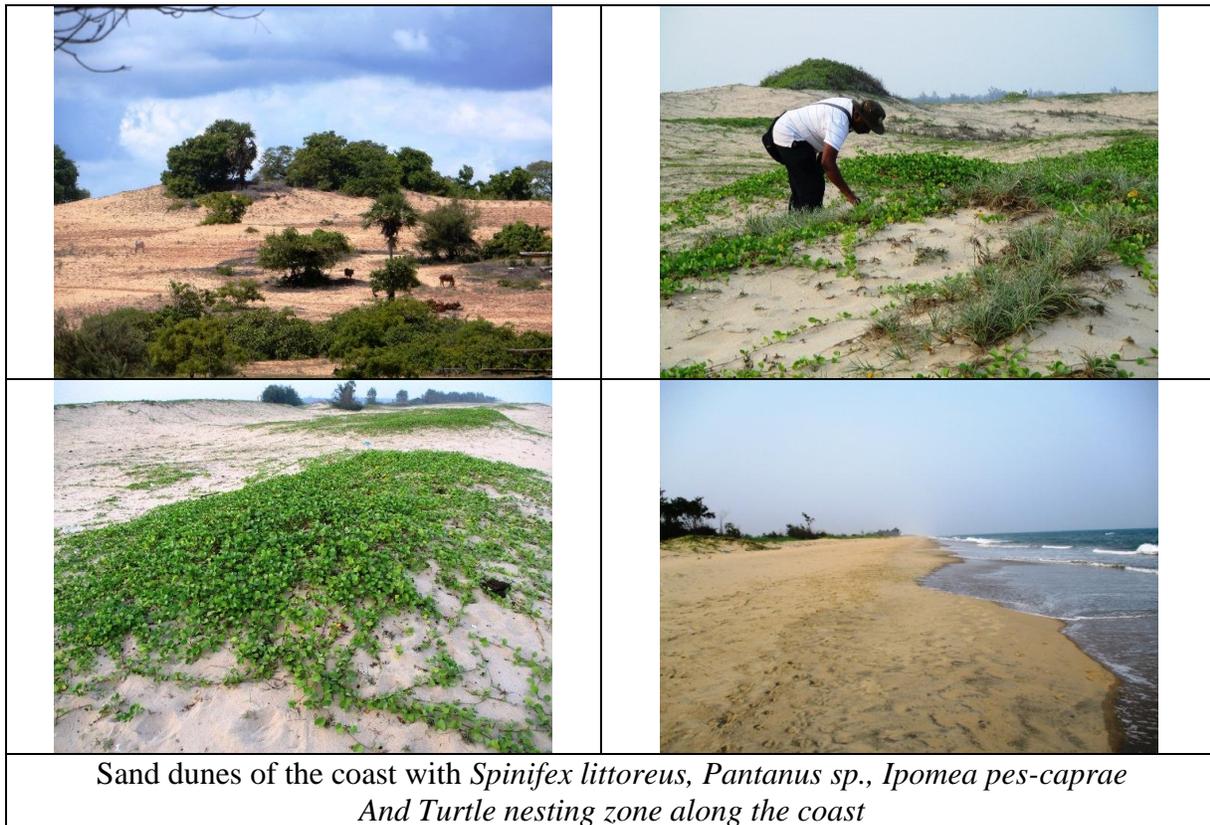
3.5.8   Diversity of Molluscan Fauna along Coast

The largest and most diverse Phylum in the tropical seas is Molluscs which includes bivalves and gastropods. The molluscs are soft - bodied, heterogenous group of animals with great antiquity and diversity. The majority of molluscs inhabit marine biotopes and they occur from the backwater zone, mangroves, intertidal, shelf and down to deeper waters.The following bivalve mollusks species were collected and identifiedin the study area are *Anadara* sp.*, Cardita* sp.*, Crassostrea gigas, Donax faba, Donax incarnates, Donax scortum, Pteria* sp.*, Siliqua radiate, Sunetta meroe, Tellina cancellata* whereas identified gastropods are as follows, *Babylonia spirata, Bullia vittata, Chicoreus virgineus, Fusinus forceps, Hemifusus cochlidium Murex trapa, Phalium glaucum, Rapana rapiformis, Tonna tessellate Glossaulax didyma didyma* and *Marginella angustata.*
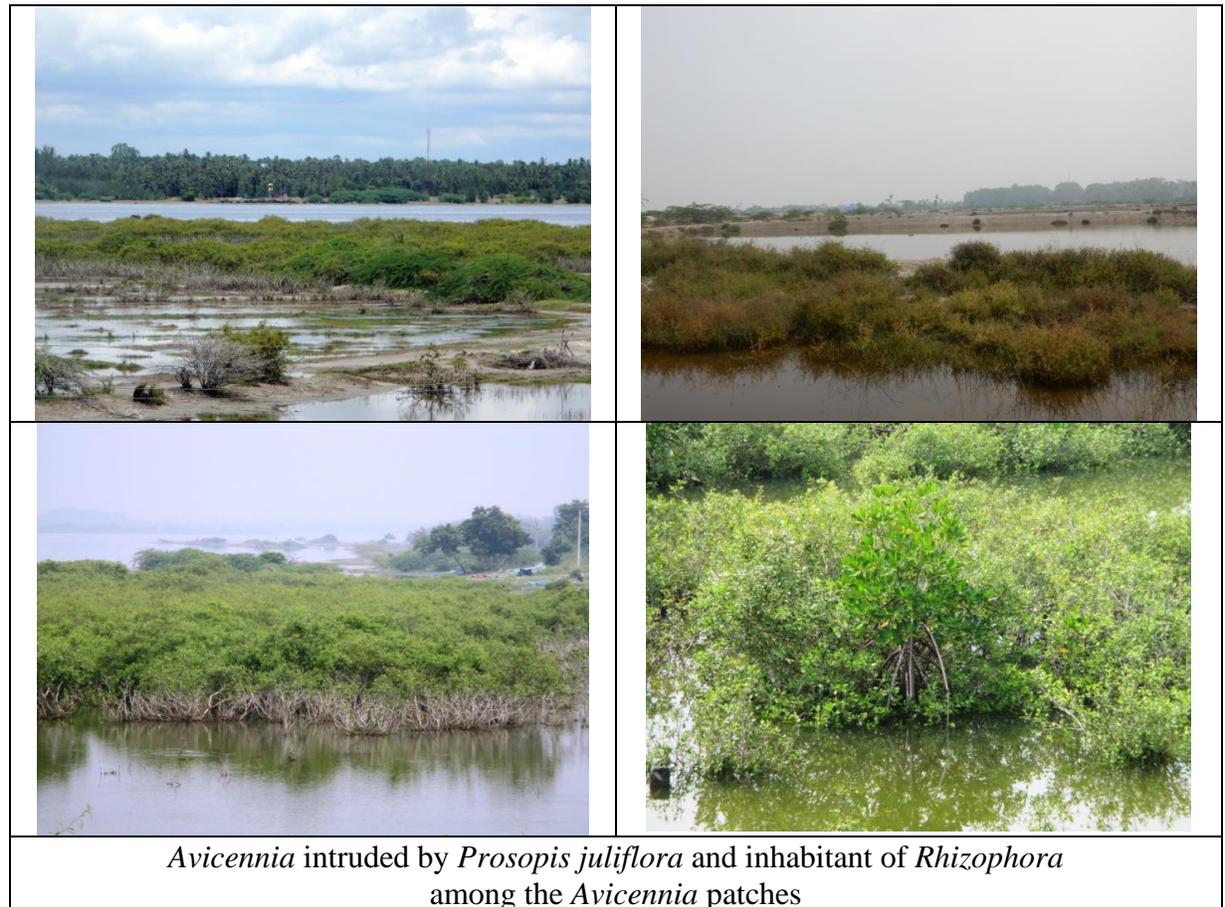
3.5.9 Backwater mangroves

The intertidal zone close to shore is characterized by sandy beaches, creeks and mudflats. Occurrence of mangrove species *Avicennia marina* was observed along the side of channel, the mangroves species were observed viz. *Avicennia marina* are very dense and occasional presence of *Rhizophora* and *Prosopis juliflora*. The density and diversity of the mangroves is distinctly lower in the smaller creeks. Along the smallest creeks true mangroves are present; adjoining areas instead only associates and non-mangrove halophytes are present.

Mangroves represent a rich and diverse living resource and are valuable to both the economy and protection of coastal environments. Mangrove plants belong to several families but possess marked similarity in their physiological characteristics and structural adaptations to similar habitat preferences. Mangrove vegetation in these four areas in buffer zone of the present project site deteriorates due to anthropogenic impacts, possible threats and future developmental activities.

Mangrove forests perform multiple ecological functions such as production of woody trees; provision of habitat, food, and spawning grounds for fin-fish and shellfish; provision of habitat for birds and other valuable fauna; protection of coastlines and accretion of sediment to form new land. Mangrove areas have high biological productivity, associated with heavy leaf production, leaf fall and rapid decomposition to form detritus. The mangrove ecosystem is dynamic, changing in both location and composition, and has great resilience with the ability to restore itself after heavy damage, as long as seed sources and water flow are maintained. There are also many economic benefits from mangrove resources; like as a source of firewood, self-replenishing areas of fishery resources, for collecting honey and for tourism.

Figure 3-21 Mangroves within Study Area

Avicennia intruded by *Prosopis juliflora* and inhabitant of *Rhizophora* among the *Avicennia* patches

3.5.10 Forest Blocks in Study Area

The forests represent peninsular mostly dry deciduous type of forest, mixed deciduous vegetation structure. There are three Reserve Forests in the study area Sittarkadu R F, Thottacherry R F and Agaram R F. The composition of Sittarkadu Reserve forest block mainly consist of shrubs species such as *Cassia auriculata, Lantana camera* and *Calotropis procera* trees species such as *Acacia leucophloea, Azadirachta indica, Eucalyptus sp., Prosopis juliflora, Laecaenal leucophloea,Ficus religiosa, Pithecelobium dulce, Acacia leucophloea, Pterocarpus marsupium* and *Borassus flabelliber*.

The composition of Thottacherry Reserve forest block mainly consist of shrubs species such as *Cassia auriculata, Lantana camera* and *Calotropis procera*, trees species such as *Ficus*

religiosa, Pithecelobium dulce, Acacia leucophloea, Pterocarpus marsupium and *Borassus flabelliber*.

Figure 3-22 Reserve Forests within Study Area

Thottacherry R F at the study area

Sittarkadu R F at the study area
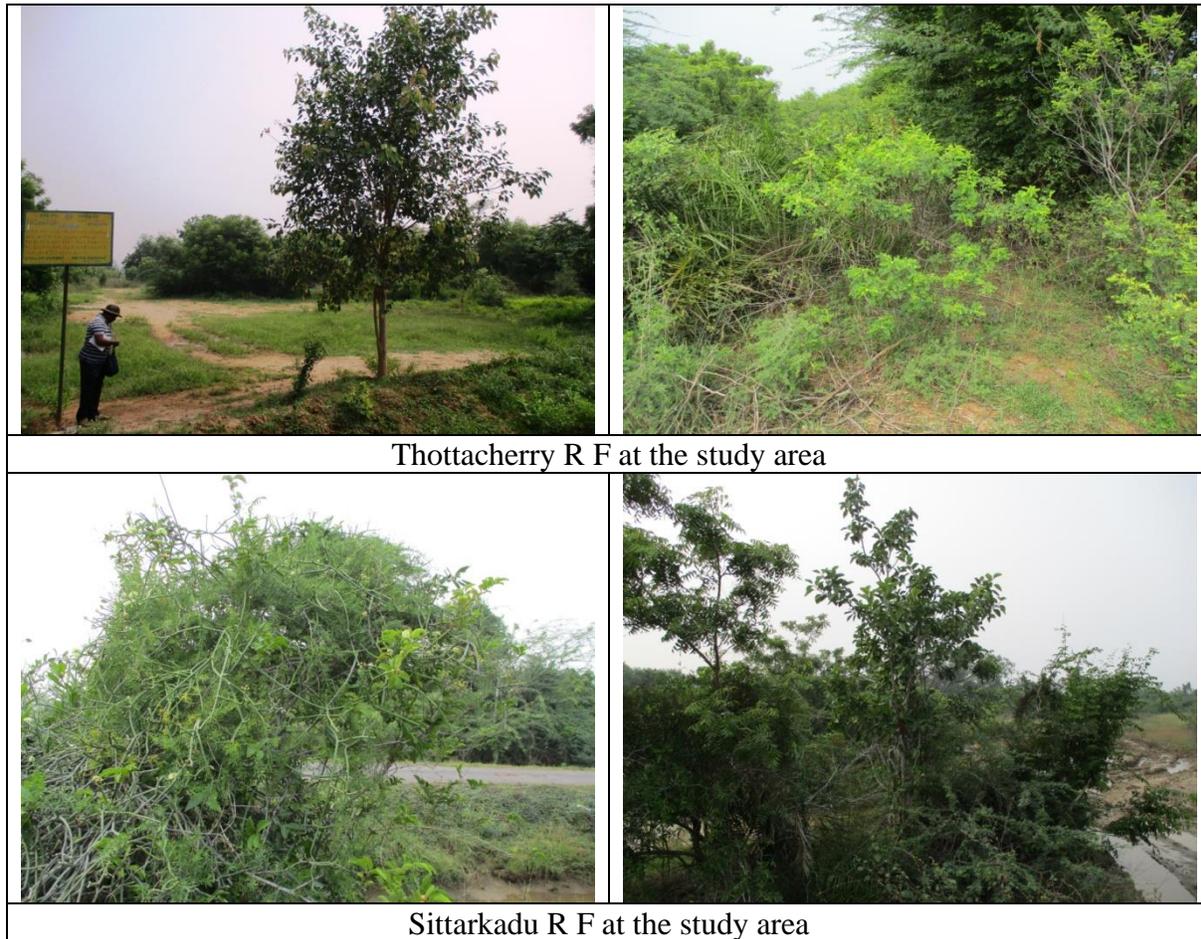
3.5.11 Marine Ecology

Coastal and marine ecosystems are among the most productive ecosystems in the world, provide many services to human society and are of great economic value (UNEP, 2006). The services include provision of food and water resources, and raw materials like sand, and other high-value heavy minerals like ilmenite, zircon, monazite etc., which are collected from beach sand. They also provide regulating and cultural services, like storm protection, erosion control, tourism and support functions such as climate regulation, oceans and coastal biomes may provide as much as, two-thirds of the ecosystem services that make up the planet's natural capital (TEEB, 2010).

Coastal habitats alone account for approximately 30% of all marine biological productivity. The diversity and productivity are also important for humans. These habitats provide a rich source of food and income. They also support species that serve as animal feed, fertilizers, additives in food and cosmetics. Habitats such as mangroves and sea grasses protect the coastlines from wave action and erosion. Other areas provide sediment sinks or act as filtering systems.

Marine ecosystems are a complex of habitats defined by the wide range of physical, chemical, and geological variations that are found in the sea. Habitats range from highly productive near shore regions to the deep-sea floor inhabited only by highly specialized organisms. Marine ecosystems are important to humankind both ecologically and economically, providing numerous vital goods and services, and supporting the processes that sustain the entire biosphere. Marine ecosystem services are provided at the global scale (for example. oxygen production, nutrient cycles, carbon capture through photosynthesis and carbon sequestration) and at the regional and local scales (for example stabilizing coastlines, bioremediation of waste and pollutants, and a variety of aesthetic and cultural values).

Marine services include several important economic benefits such as food provision and tourism. Some of the environmental changes taking place at the global levels are likely to have significant and far-reaching consequences for marine biodiversity. Changes in marine biodiversity are extremely complex processes driven by numerous factors, making it difficult to determine precisely which changes are results of direct human influence. It is clear, however, that deteriorating biodiversity impairs a marine ecosystem's capacity to provide food, maintain water quality and recover from perturbations.

3.5.11.1 Methodology

The marine monitoring for DHI project was conducted on 5th and 6h November 2019 starting 10:30 hrs and completed 15.30 hrs. Samples locations 1 to 3 are falls in offshore and locations 4 to 8 are in Creek area. The proposed sampling locations were identified off shore prior with the help of the co-ordinates. Based on the primary co-ordinates the sampling strategy was planned in such a manner so as to cover the entire area. The biological parameters considered for the present study were phytoplankton, zooplankton, macro-benthos biomass and population and fishery status. The first two reflect the productivity of a water column at the primary and secondary levels. Benthic organisms being sedentary animals associated with the sediment/rocky

beds, provide information on the integrated effects of stress, if any, and hence are good indicators of early warning of potential damage. Sample collections for marine ecological studies were done by mechanized boat. Geo-coordinates of sampling stations are given in **Table 3-26**.

Table 3-26 Marine Sampling Locations

Sr.No	Station Code	Latitude	Longitude
1	MS-1	12.259341°N	80.004041°E
2	MS-2	12.265406°N	80.005567°E
3	MS-3	12.247266°N	79.990151°E
4	MS-4	12.236057°N	79.976801°E
5	MS-5	12.219893°N	79.956083°E
6	MS-6	12.221011°N	79.997330°E
7	MS-7	12.229920°N	80.047387°E
8	MS-8	12.274702°N	80.029086°E

Figure 3-23 Sampling of Marine Biotic Components

Collection of Sediment, Water, Benthos and Plankton Measurement of physico- chemical parameters on Board,

3.5.11.2 Phytoplankton

Water samples were collected for Phytoplankton studies using standard water sampling depth water sampler. A measured amount of water (2 Litre) samples were fixed by adding "Lugol's Iodine" and stored in cool place under dark condition. Samples were allowed to settle and concentrated to approximate volume in laboratory. 1 ml of each of these concentrates was examined using Sedgwick - Rafter and microscope with standard reference manual.

3.5.11.3 Zooplankton

The zooplankton samples were collected as horizontal surface tow with a modified Heron-Tranter (HT) net (having 0.25 m^2 mouth area and 300 µm mesh size). All the samples were preserved in 5% neutralized formaldehyde solution. The zooplankton biomass was later estimated by displacement volume method and readings were converted for organisms/m^3. Different zooplankton were sorted, identified and enumerated under stereoscopic zoom binocular

microscope. The number were calculated for the whole samples and expressed for organisms/m^3 of water.

3.5.11.4 Benthos

Sediment samples for benthic community were collected from the intertidal as well near shore sub tidal regions. Sub tidal sediments were collected with a stainless steel Van Veen grab covering an area of 0.04m^2. The materials collected were preserved in 10% seawater formalin containing Rose- Bengal stain. In the laboratory, all the samples were again washed through a 500-µm-mesh sieve in running water to clear adhering sediment. Later all the organisms were sorted counted and identified (Convey et al, 2003) up to group level.

3.5.12 Marine Species Observations

3.5.12.1 Phytoplankton

Phytoplanktons recorded from the 8 locations of the project site are represented by 66 species among them 48 species belong to Bacillariophyceae and 8 species of Dinophyceae 5 species belongs to Cyanophyceae 5 species belongs to Chlorophyceae. The overall percentage composition of phytoplankton for the 8 locations revealed that the Bacillariophyceae was the dominant group observed species were *Bacteriastrum delicatulum, Chaetoceros affinis, Cheatoceros sp, Coscinodiscus gigas, Coscinodiscus sp., Gyrosigma sp, Lauderia annulata, Pleurosigma sp., Rhizosolenia bergonii, Rhizosolenia sp., Thalassionema nitzschioides, Thalassionema sp., Thalassiosira sp., Thalassiothrix fraunfeldii,* (75.57%) and followed by Dinophyceae (8.79%) represented by the following species *Ceratium furca, Ceratium fusus, Ceratium gibberum Ceratium inflatum, Ceratium macroceros, Ceratium trichoceros, Ceratium tripos, Dinophysis caudata* and *Pediastrum simplex Pediastrum dulex Protococcus vulgaris Chlorella sp Spirogyra belongs to* Chlorophyceae (6.91%), *Microcyst, Spirulina major, Anabaena macrospora, Lyngbya martensiana, Oscillatoria limosa belongs to* Cyanophyceae (8.73%).

Table 3-27 Percentage compositions of Phytoplankton species in the study area

S.No	Genera / Species	Stations							
		MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8
I	**Chlorophyceae**								
1	*Pediastrum simplex*	2.1	1.36	2.23	0	1.24	0.52	0	3.57

S.No	Genera / Species	Stations							
		MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8
2	*Pediastrum dulex*	1.44	0	0	1.29	0.52	4.37	1.11	1.84
3	*Protococcus vulgaris*	0	1.43	2.34	1.49	1.34	0.56	2.12	4.24
4	*Chlorella sp*	0	1.33	1.43	2.34	1.45	0	0	0
5	*Spirogyra*	1.4	2.17	0	2.59	3.4	0	1.49	2.54
II	**Cyanophyceae**								
6	*Anabaena macrospora*	0	0	1.76	1.24	1.42	1.17	2.14	2.47
7	*Lyngbya martensiana*	1.22	0	0	3.23	5.28	1	3.54	2.53
8	*Oscillatoria limosa*	0	3.65	1.64	1.54	6.4	0.65	2.35	1.44
9	*Spirulina major*	2.47	0	0	2.45	3.43	1.28	3.45	2.89
10	*Microcyst,*	0	2.36	0	0.85	2.43	0	0	3.56
III	**Bacilariophyceae**								
11	*Achnanthes brevipes*	1.45	0	3.97	0	0	1.34	0	1.78
12	*Amphora holsatica*	3.67	1.53	0	5.37	1.34	0	6.35	0
13	*Amphora ovalis*	0	0	3.53	0	0	0	7.43	1.44
14	*Amphora proteus*	3.57	0	1.54	6.31	2.19	0	0	8.27
15	*Asterionella glacialis*	0	2.38	0	0	0	4.71	2.19	9.43
16	*Bacillaria paradaxa*	0	7.89	2.39	0	2.32	3.14	0	0
17	*Bacteriastrum*	0	0	0	2.35	0	0	6.89	2.94
18	*Bellerochea malleus*	1.59	0	4.38	7.39	1.53	2.75	0	0
19	*Biddulphia heteroceros*	5.15	9.63	9.47	1.46	0	0	2.35	0
20	*Biddulphia mobiliensis*	0	8.36	0	0	2.88	2.87	2.47	2.14
21	*Chaetoceros affinis,*	3.54	0	8.48	1.56	0	4.34	4.78	0
22	*Cheatoceros sp,*	12.16	3.29	0	0	3.98	0	0	1.34
23	*Coscinodiscus gigas,*	4.67	0	3.56	2.36	0	6.98	2.88	2.46
24	*Coscinodiscus centralis*	1.48	0	3.56	0	2.56	0	1.35	0
25	*Coscinodiscus curvulatus*	0	2.43	2.75	1.38	0	4.76	2.46	3.85
26	*Coscinodiscus*	2.46	0	0	0	3.5	0	3.98	1.24
27	*Coscinodiscus sp.,*	1.35	2.34	3.96	3.15	4.41	11.27	0	0
28	*Ditylum brightwelli*	0	6.45	5.24	3	0	0	0	5.67
29	*Fragilaria intermedia*	1.34	0	0	1.8	2.46	3.44	1.66	0
30	*Gyrosigma sp,*	2.49	7.45	0	0	4.67	2.56	0	0
31	*Lauderia annulata*	2.19	0	2.87	1	0	1.33	0	1.43
32	*Melosira sulcata*	0	0	0	2.89	1.25	0	2.78	3.34
33	*Navicula capitata*	3.24	0	0	1.46	0	0	0	0
34	*Navicula gastrum*	2.19	2.17	1.81	0	1.46	2.67	0	0
35	*Navicula lyra*	0	2.59	2.53	1.34	0	2.35	1.22	2.89
36	*Nitzschia closterium*	2.37	0	0	0	2.46	0	0	0

GOVERNMENT OF TAMILNADU
DEPARTMENT OF FISHERIES

Development of Fishing Harbour in Kaluveli Waters at Azhagankuppam Village, Marakkaram Taluk, Viluppuram District and Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu

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S.No	Genera / Species	Stations							
		MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8
37	*Nitzschia longissima*	1.3	1.54	2.49	2.54	0	0	0	2.08
38	*Nitzschia seriata*	2.38	1.24	0	0	1.75	2.14	1.65	3.54
39	*Pinnularia ambigua*	1.03	0	1.56	4.48	0	2.57	0	0
40	*Planktoniella sol*	0	0	1.22	1.45	0	0	0	0
41	*Pleurosigma aestuarii*	6.37	0	0	0	0	0	1.78	4.62
42	*Pleurosigma balticum*	0	2.13	2.18	2.68	3.35	2.53	4.45	0
43	*Pleurosigma carinatum*	3.29	4.3	0	0	0	1.44	0	1.42
44	*Pleurosigma normanii*	0	0	1.83	7.37	2.79	0	2.34	2.53
45	*Pleurosigma sp.,*	2.15	0	0	0	2.65	2.98	2.35	0
46	*Rhizosolenia alata*	0	2.6	0	0	0	0	0	0
47	*Rhizosolenia cylindrus*	2.15	0	1.45	2.18	0	1.45	2.35	0
48	*Rhizosolenia styliformis*	0	1.36	0	0	2.47	2.2	0	2.5
49	*Rhizosolenia bergonii,*	3.24	0	1.43	2.66	4.56	2.53	2.14	1.44
50	*Rhizosolenia sp.,*	0	2.44	1.64	2.19	0	1.6	0	0
51	*Skeletonema coastatum*	2.19	0	0	0	2.45	0	0	1.6
52	*Surirella elegans*	0	2.73	0	2.65	0	0	2.83	0
53	*Synedra formasa*	2.14	0	1.45	0	3.28	2.89	1.76	0
54	*Thalassionema*	0	1.57	0	3.13	0	0	0	0
55	*Thalassionema sp.,*	0	0	0	0	1.35	0	1.35	0
56	*Thalassiosira*	1.23	0	1.24	1.34	2.53	0	0	0
57	*Thalassiothrix*	0	2.48	1.39	0	3.28	2.57	2.14	0
58	*Triceratium reticulatum*	0	0	1.13	0	0	0	0	0
IV	**Dinophhyceae**								
59	*Ceratium furca,*	2.19	0	2.54	0	0	0	0	0
60	*Ceratium fusus,*	0	1.68	1.22	1.8	0	1.45	2.34	2.5
61	*Ceratium gibberum*	3.24	0	0	0	0	2.2	2.35	1.44
62	*Ceratium inflatum*	0	1.44	2.18	0	3.02	0	0	0
63	*Ceratium macroceros,*	0	0	2.35	2.89	1.25	2.53	2.35	1.43
64	*Ceratium trichoceros,*	2.37	4.3	1.83	0	0	2.37	0	0
65	*Ceratium tripos,*	0	0	0	1.34	0	0	2.83	1.6
66	*Dinophysis caudata*	1.19	1.38	1.43	1.46	1.35	2.49	0	0

The overall percentage composition of phytoplankton for the 8 locations revealed that the Bacillariophyceae was the dominant group (75.57%) and followed by Dinophyceae (8.79%), Cyanophyceae (8.73%) and Chlorophyceae (6.91%).

Hierarchy as follows;

Bacillariophyceae > Dinophyceae > Cyanophyceae > Chlorophyceae
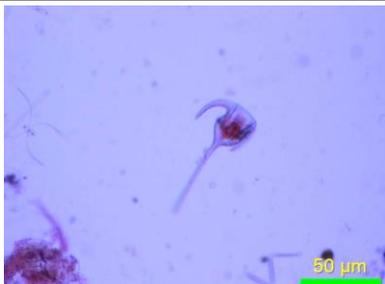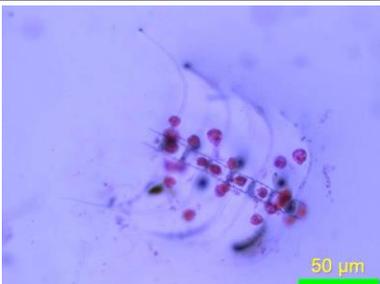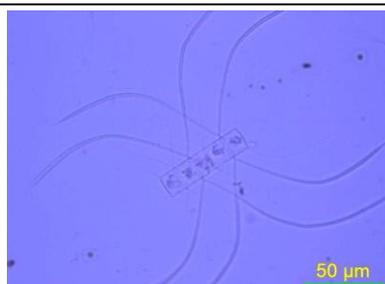
Richness and abundance

Phytoplankton community of study area showed wide variation in abundance though species richness remained more or less similar over entire study area (**Table 3-28**). However, significant temporal variations were observed. Maximum number of species (39 nos.) was observed at station 4. Minimum number of species (32 nos.) was observed at station 2. Maximum cell count was found at station 4 (74.5 X 10^3/L) minimum cell count was found at Station 2 (11.3 X 10^3/L).

Table 3-28 Abundance and species richness of phytoplankton

Station	November 2019		Dominant Genera
	Cell count Nos.X10^3/L	Total Species	
1	14.2	37	*Chaetocerus, Pleurosigma*
2	11.3	32	*Biddulphia, Ceratium*
3	15.2	38	*Coscinodiscus, Ceratium*
4	74.5	39	*Amphora, Pleurosigma*
5	12.7	38	*Coscinodiscus, Pleurosigma*
6	24.3	37	*Coscinodiscus, Ceratium*
7	21.4	36	*Amphora, Pleurosigma*
8	19.4	35	*Amphora, Pleurosigma*

Figure 3-24 Phytoplankton observed within Study Area

| *Bacteriastrum delicatulum* | *Gyrosigma sp.* | *Microcyst* |
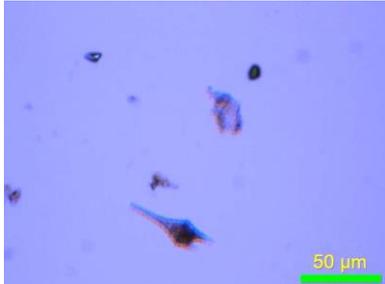
Ceratium fuscus	*Ceratium furca*	*Ceratium gibberum*
Coscinodiscus gigas	*Ceratium tripos*	*Chaetoceros* sp
Chaetoceros affinis	*Coscinodiscus* sp	*Pleurosigma sp.*

3.5.12.2 Zooplankton

Zooplankton community in the study area exhibited very diverse population and high abundance during November 2019 **(Table 3-29)**. Altogether 12 different faunal groups were recorded from the study area viz. Foraminiferans, Tintinnids, Rotifers, Chaetognatha, Cladocera, Copepoda, Ostracoda, Larvae, Fish Eggs, Fish Larvae, Bivalves Larvae and Gastropod larvae.

Composition

During present study zooplankton community in all the stations were mainly dominated by Copepoda (average percentage composition68.1%) followed by the Larvae6.5%, Rotifers 3.7% Chaetognatha 3.7% Gastropoda larvae 3.4% Bivalves larvae 3.3% Cladocera 3.3% Tintinnids 2.8% Ostracoda 2.1% Fish Eggs 1.3% Foraminiferans 1.3% and Fish Larvae 0.5%

Table 3-29 Percentage compositions of Zooplankton species in the study area

S.No	Groups	Stations							
		MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8
1	Foraminiferans	2.16	4.34	2.36	1.23	0.00	0.00	0.00	0.00
2	Tintinnids	6.36	5.24	6.41	1.32	3.20	0.00	0.00	0.00
3	Rotifers	1.39	2.33	2.48	3.56	6.31	4.12	5.34	4.36
4	Chaetognatha	2.26	3.45	5.86	2.65	5.31	1.34	6.28	2.41
5	Cladocera	0.00	0.00	0.00	5.00	4.75	4.94	6.49	5.27
6	Copepoda	66.53	69.23	73.43	68.39	62.98	71.75	63.20	69.38
7	Ostracoda	0.00	0.00	0.00	1.37	3.18	6.33	2.38	3.32
8	Gastropoda larvae	4.43	6.20	2.84	4.54	3.37	0.00	2.64	3.50
9	Bivalves larvae	3.41	3.46	3.45	3.28	2.42	6.67	1.32	2.53
10	Larvae	8.14	3.54	1.71	6.18	8.48	4.32	10.22	9.23
11	Fish Eggs	5.32	0.00	0.00	2.48	0.00	0.53	2.13	0.00
12	Fish Larvae	0.00	2.21	1.46	0.00	0.00	0.00	0.00	0.00

Hierarchy of the zooplankton

Copepoda >Larvae>Rotifers >Chaetognatha >Gastropoda larvae >Bivalves larvae >Cladocera >Tintinnids >Ostracoda >Fish Eggs >Foraminiferans >Fish Larvae
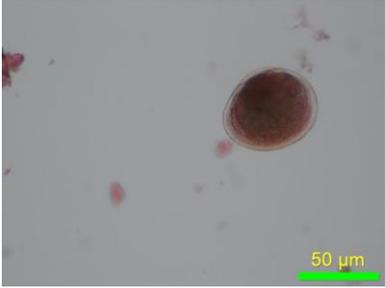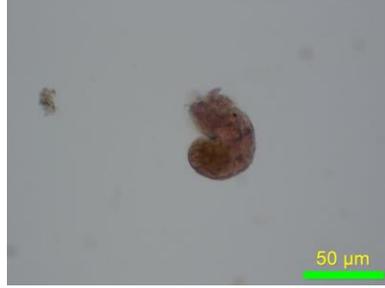
Abundance and richness

It was evident that there was not much variation in spatial distribution (abundance as well as richness) of zooplanktons over entire study area. Maximum zooplanktons were observed at Station 4 (2564 nos./m^3) while that of minimum were observed at Station 8 (1322 nos./m^3) **Table 3-30**

Table 3-30 Abundance and group richness of Zooplankton

Station	November 2019		Dominant Groups
	Number of Organisms/m^3	Total Groups	
S 1	1690	9	Copepod, Larvae
S 2	1847	9	Copepod, Gastropod Larvae
S 3	2319	9	Copepod, Tintinnids
S 4	2564	11	Copepod, Larvae
S 5	1633	9	Copepod, Larvae
S 6	1565	8	Copepod, Bivalves Larvae
S 7	1543	9	Copepod, Larvae
S 8	1322	8	Copepod, Larvae

Figure 3-25 Zooplankton observed within Study Area

Oithona nana	Acartia sp	Centropagus abdominalis
Clausocalanus arcuicornis	Euterpina acutifrons	Coreciousa typicus
Favella ehrenbergii	*Early Trochophore larvae*	Bivalve veliger larvae
Gastropod veliger	*Oikoplura larvae*	Tintinnopsis sp

3.5.12.3 Benthos

Benthic community responses to environmental perturbations are useful in assessing the impact of anthropogenic perturbations on environmental quality. Macro benthic organisms which are considered for the present study are animal species with body size larger than 0.5 mm. Six groups of macro benthos were recorded in the study area during the present investigation. The macro fauna was constituted mainly by Foraminifera, Nematodes, Bivalvia, Gastropods, Crustacean and Polychaetes.

Composition

During present study macro benthos community in all the stations were mainly dominated by Nematodes (average percentage composition 24.75) followed by Foraminiferans (average percentage composition 18.36), Ostracods (average percentage composition 16.53), Bivalvia (average percentage composition 16.53), Gastrapods (average percentage composition 14.52), Polychaetes (average percentage composition 9.32).

Hierarchy as follows;

Nematodes > Foraminiferans > Ostracods > Bivalvia > Gastrapods > Polychaetes

Table 3-31 Distribution of Benthos in the study area

S. No	Group (Nos./m²)	Stations							
		MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8
1	Foraminiferans	45	56	32	34	23	11	0	0
2	Nematodes	11	34	56	34	45	23	23	45
3	Polychaetes	23	11	45	23	0	0	0	0
4	Ostracods	0	11	23	34	11	34	23	45
5	Bivalvia	23	45	11	23	45	0	34	0
6	Gastropods	34	11	34	23	23	23	0	11

Figure 3-26 Molluscs observed within Study Area

Anadara sp	*Babylonia spirata*	*Bullia vittata*
Cardita sp	*Chicoreus virgineus*	*Crassostrea gigas*
Donax faba	Donax incrnatus	*Donax scortum*
Fusinus forceps	Glossaulax didyma	*Hemifusus cochlidium*

3.5.13 Statistical Analysis

3.5.13.1 Diversity Index

Following indices were used for estimation of ecological status of this area

Shannon's index

Margalef's index

Simpson's index

The indices were applied to phytoplankton, zooplankton and benthos.

Shannon' Index

Typically the value of the index ranges from 1.5 (low species richness and evenness) to 3.5 (high species evenness and richness), though values beyond these limits may be encountered. Because the Shannon Index gives a measure of both species numbers and the evenness of their abundance, the resulting figure does not give an absolute description of a sites biodiversity. It is particularly useful when comparing similar ecosystems or habitats, as it can highlight one example being richer or more even than another. There is always the need to inspect the data or use another index to unpack the true reasons for the difference.

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i)$$

Where: where S is the total number of species and p_i is the frequency of the *i*th species.

Average value of Shannon's index of phytoplankton community in the present study was observed to be 3.43 (**Table 3-32**), while that of zooplankton community is 1.246 **(Table 3-33).** Hence, the phytoplankton diversity is above moderate and zooplankton diversity of this area is below moderate.

Margalef's Index

It is calculated from the total number of species present and the abundance or total number of individuals.

Margalef Index (D) = S – 1/ log e N Where: S – total number of species

N – total number of individuals

The higher the index the greater is the diversity. Average value of Margalef's index for phytoplankton was observed to be 7.709 while that of zooplankton was 1.737.

Simpson's Index

Simpson's Index measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

Simpson's Indexλ = ∑ n(n-1)/N(N-1)

Where: n – total individuals of each species

N – total individuals of all species

With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give:

Simpson's Index of Diversity 1 - λ

The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species. Simpson index values of phytoplankton is very close to 1 zooplankton index is not close to 1 (0.961 and 0.519 respectively) phytoplankton indicating high diversity whereas zooplankton shows below moderate diversity.

Table 3-32 Diversity Indices for Phytoplankton community

Sample	*Richness*	*Simpson_1-D*	*Shannon_H*	*Evenness_e^H/S*	*Margalef*
MS 1	37	0.959	3.426	0.831	7.817
MS 2	32	0.952	3.253	0.808	6.732
MS 3	38	0.962	3.463	0.839	8.034
MS 4	39	0.965	3.506	0.854	8.252
MS 5	38	0.968	3.525	0.894	8.034
MS 6	37	0.959	3.411	0.819	7.817
MS 7	36	0.964	3.463	0.887	7.600
MS 8	35	0.960	3.396	0.853	7.383
Average	**36.5**	**0.961**	**3.430**	**0.848**	**7.709**

Table 3-33 Diversity Indices for Zooplankton community

Sample	*Richness*	*Simpson_1-D*	*Shannon_H*	*Evenness_e^H/S*	*Margalef*
MS 1	9	0.540	1.288	0.403	1.737
MS 2	9	0.508	1.240	0.384	1.737
MS 3	9	0.450	1.098	0.333	1.737
MS 4	11	0.520	1.311	0.337	2.171
MS 5	9	0.583	1.400	0.450	1.737
MS 6	8	0.471	1.095	0.374	1.520
MS 7	9	0.577	1.355	0.431	1.737
MS 8	8	0.502	1.178	0.406	1.520
Average	**9**	**0.519**	**1.246**	**0.390**	**1.737**

3.6 Socio-Economy

3.6.1 Study Area

The proposed fishing harbor is to be developed in the Kaluvali waters which lie between Kancheepuram and Villupuram district, the proposed harbor is located adjacent to the ruins of Alamparai fort which lie near to the Kadappakkam, a village 50 km Mamallapuram and Puducherry. The proposed project is developed along the Buckingham canal and does not attract Rehabilitation and Resettlement process under "*Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013*". Hence Rehabilitation and Resettlement aspects are not applicable and not covered in this report. However to map the socioeconomic conditions of the local people, the villages falling within the 10km radius of the project site is considered for the Social Impact Assessment study. Based on Administrative Atlas published by Directorate of Census Operations, there are only about 15 Administrative divisions which include 13 revenue villages, Two Town Panchayat. Among the study area, the Hamlets / revenue villages falling within 2.5 km from the project site is considered for primary survey namely Alagankuppam, Vasavankuppam and Alambaraikuppam. **Table 3-34-** shows the administrative structure of the study area.

Table 3-34 Administrative Status of Study Area Villages/Towns

S.No	State	District	Taluk	Administrative Status	Name
1	Tamil Nadu	Kanchepuram	Cheyyur	Revenue Village	Kolathur
2				Revenue Village	Cheyyur
3				Revenue Village	Chitharkadu
4				Revenue Village	Kokkaranthangal
5				Revenue Village	Thenpakkam
6				Revenue Village	Panayadivakkam
7				Revenue Village	Vedal
8				Revenue Village	Kottaikadu
9				Revenue Village	Kadukalur
10				Revenue Village	Othivilagam
11				Revenue Village	Chunampet
12				Revenue Village	Vellankondagaram
13				Town Panchayat	Edakalinadu
14		Villupuram	Tindivanam	Town Panchayat	Marakkanam

Source: Census 2011

Figure 3-27 Administrative Map of the Study Area
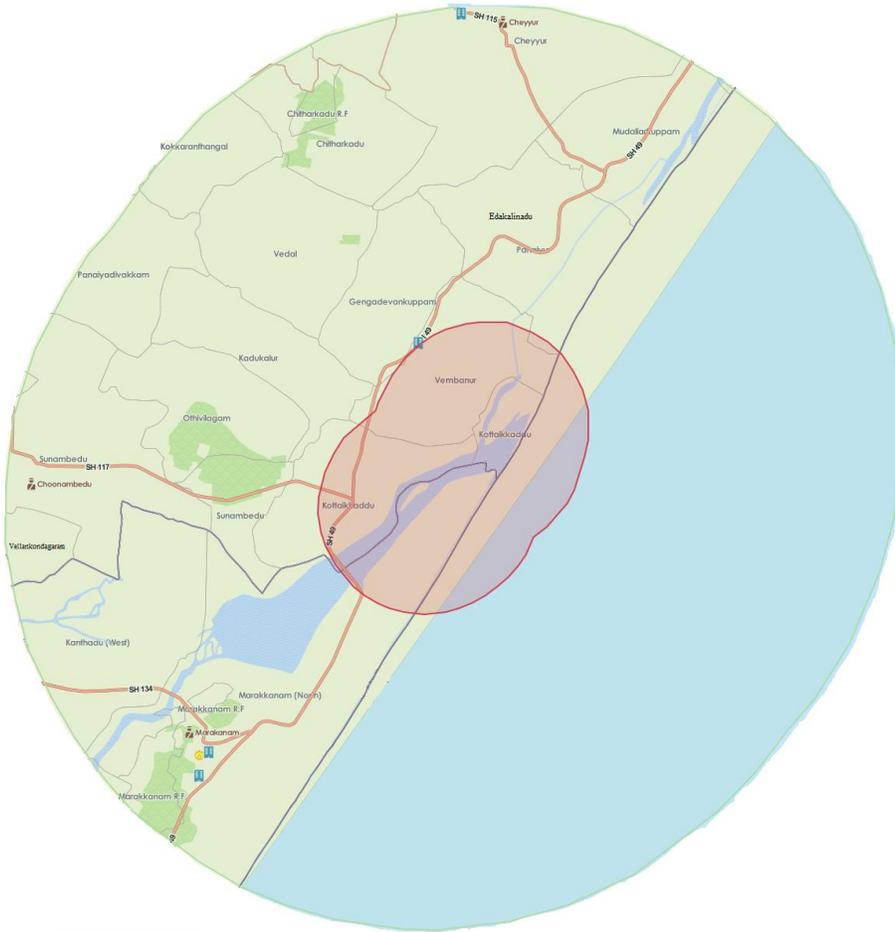
Source: Tamil Nadu Geographical Information System (TNGIS); https://tngis.tn.gov.in/

3.6.2   Socioeconomic Indicators considered

For the purpose of this study, socioeconomic indicators such as demography, literacy, health, livelihood, amenities and cultural aspects were collected. Secondary Published data such as population and amenities obtained from Directorate of Census Operations, Health indicators such as immunization levels, institutional births from District Level Household Survey-3, Households availing safe sanitation details are collected from Baseline Survey-2012, published by Ministry

of Drinking Water and Sanitation, Income level of the households from 'Socioeconomic and Caste Census 2011' published by Ministry of Rural Development.

3.6.3 Primary Survey

Primary Survey was undertaken from 5th to 8th November 2019. During this survey, primary data in relation to geographical features, settlements, roads and amenities in the respective study area villages were observed. In addition to the site observations, primary survey was focused on colleting both qualitative and quantitative data with an objective of collecting the socioeconomic indicators of the study area. The primary survey was carried out with the village/town representatives from the villages falling within 2.5 km of the project site. The discussion was mainly focused on mapping the existing amenities in the respective villages, felt basic needs, difficulties faced by the fishermen in anchoring their fishing gears, etc. The study team met fishermen association members, administrative representatives, fishermen, etc. The discussion was carried out with the village representatives who had good knowledge about the area they live and happenings.

Figure 3-28 Primary Survey

Discussion with Oyster Collecting Women	*Discussion with Vasavankuppam Fishermen*

Discussion with Alagankuppam Fishermen	Alamparai Fort

Primary School - Alamparaikuppam	PHC – Idikazhi Nadu

3.6.4   Socioeconomic Profile of Study Area

3.6.4.1 Demography and Culture

The proposed fishing harbor is to be developed in the Kaluveli waters at Azhagankuppam and Alamparaikuppam in Tamil Nadu. The major source of livelihood in the study area is agriculture, however the coastal study areas are majorly dependent on the salt production, fishing and allied activities. Hinduism is the majority religion professed by the study area population, followed by Islam and Christianity. The Cumulative population in the study area is 93,456 with 46,386 males and 47,070 females. The children population below 6 years old was found to be 10,051 which was at 10.75% of the total population. The population density of the study area was about 257 per square kilometer. The Sex Ratio was found at 1015 females per thousand males. The Vulnerable populations such as Scheduled Caste and Scheduled Tribes population were 45% and 0.9% respectively.

3.6.4.2 Livelihood and Economic Activity

The major source of livelihood in the study area is agriculture, salt production and fisheries. The coastal population is mostly dependent on fishing and allied activities. Salt production is another major activity and second largest producer after Tuticorin in Tamil Nadu. According to Fisherfolk census 2010 major fishing villages are Kadapakkam, Alambaraikuppam, Vilamburkuppam, Thenpakkam, Kottaikadu, Soonambedu and Muttukkadu with the total fisherfolk population of 3030. Based on the primary survey about majority of the fishermen are traditional fishermen from the nearby villages. Men are mostly undertaking marine fishing usually 3-4 person are employed in each boat and women are involved in fish drying and processing. In addition to the fisheries, number of shrimp / fish hatcheries located within the study area provides considerable amount of employment opportunities to the locals.

Agriculture is extensively carried out in the landside of the study area, the major crops cultivated are Paddy, Sugarcane, Black gram, Green gram and Groundnut. Socio-Economic Caste Census-2011, published by Ministry of Rural Development reported that in study area, 82.39% of the household's monthly income with highest earning household member was less than ₹5000 and 14.2% of households with income range of ₹5000 to ₹10000.

According to Census 2011, the percentage of working population in the study area was 43.3% and as against the state's level percentage was 45.5%. 63.1% of the working populations are main workers employed for more than 6 months in the year. And about 51.37% of the total working population in the study area was engaged in agricultural activity. The percentage of Household and Other workers group were 2.6% and 46% respectively.

Figure 3-29 Workers Group Dstribution
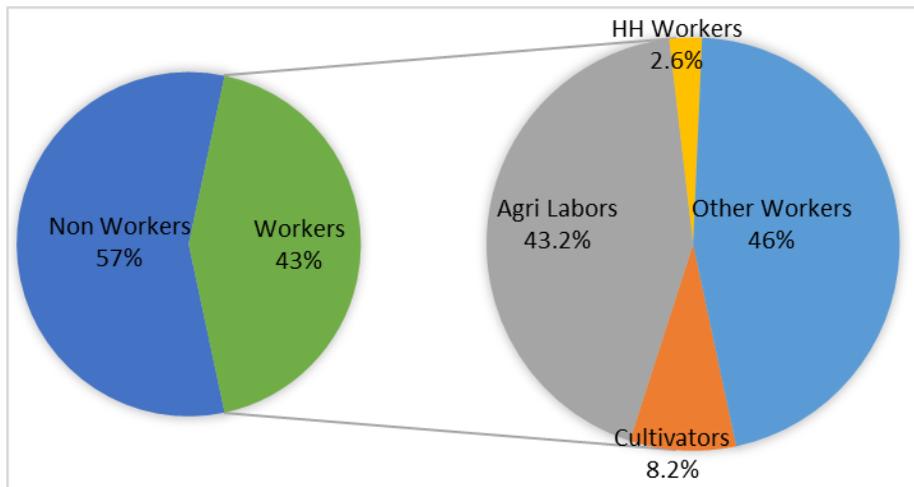
Source: PCA, Census 2011.

3.6.4.3 Education Indicators

In the study area about 76.6% of the total populations are literates, where national literacy rate was at 64.8% and state's literacy rate of 80%. The rate of male literacy rate (84.2%) is more when compared with the female literacy rate (69.9%). Most of the villages in the study area are accessed to primary education facilities, for higher education facilities higher secondary schools are available within the panchayat and for colleges students are travelling to Pondicherry, Thindivanam and Chennai. The average education level of the fishermen in the villages are primary or secondary level schooling.

4 ANTICIPATED IMPACT & MITIGATION MEASURES

4.1 Introduction

The assessment of the environmental impacts associated with the development of the proposed fishing harbours in Kaluveli Waters at Azhagankuppam and Alamparaikuppam and devising an able mitigation measures is essential for the project to limit the effect of the construction and operation on the environment. Activities during the construction phase and operation phase of the project, which are likely to cause an impact on the various environmental components, have been listed. Based on the collected baseline environmental data from the monitoring and secondary information collected and stakeholder consultation, the impacts have been assessed and discussed in the following sections of the chapter.

4.2 Identification of Impact

The impacts that are likely to result during the construction and operation phase of the said developments are identified and listed below. The impacts that are identified are,

4.2.1 Construction Phase

- Site Preparation and Excavation.
- Construction of Training Wall.
- Construction of Diaphragm Wall.
- Capital Dredging.
- Construction of supporting infrastructure.
- Construction of Slipway.
- Reclamation using the dredged material.
- Transportation of materials and equipment.
- Piling.
- Internal Road construction.
- Cleanup Operations.

4.2.2 Operation Phase

The impacts that are likely to be caused during the construction and operation phase of the said developments are identified. The impacts that are identified are,

- Maintenance Dredging.
- Fish Handling, Processing and Storage.
- Vessel Navigation.
- Landscaping and Greenbelt Development.

4.3 Environmental Components

The various environmental components that are subjected to impact due to the proposed development are considered for impact identification and quantification. The environmental components considered for the study are Land, Air, Noise, Water, Marine Environment, and Socio-economics. The following sections would detail the impacts that each of the above-mentioned components would incur and their corresponding mitigation measures in order to control any environmental damage to the surrounding environment.

4.4 Impacts & Mitigation Measures

4.4.1 Impacts on Land Environment

4.4.1.1 Construction Phase

The proposed fishing harbor will be developed on a land of area 3.43 Ha, within a land of 6 Ha and 5 Ha, at Azhagankuppama and Alamparaikuppam respectively, which are registered in the name of Fisheries Department, which is designated by Government of Tamil Nadu (GoT) for Fisheries Department. Therefore, no additional land will be acquired for the proposed development of the two fishing harbours. The proposed fishing harbor will be developed by levelling low lying area and reclaiming the existing intertidal area.

The impacts on the land environment that is envisaged during construction phase are due to construction of the harbour and its associated facilities such as auction hall, net mending shed, fear room, power room, admin building, fresh water sump, overhead tank, toilet blocks, ice plant and cold storage rooms and internal roads. The common activities that will be undertaken to

establish the said facilities are site clearance, site preparation and excavation. During site clearance and preparation, debris that is generated shall be disposed safely. Improper stacking of excavated bottom soil could affect the fertility of the topsoil in the event of run-off due to rain. Proper stacking and covering of excavated soil will avoid the run-off. The topsoil that is obtained from excavation shall be retained and used for greenbelt development since it is rich in minerals.

Run-off from construction materials are expected due to improper handling and storage of materials. Materials shall be stored under covered temporary sheds to prevent the run-off into the water bodies. Fuel/ Oil leakage are expected from poorly maintained construction equipment and material carrying trucks. These leakages will have impact on the land environment by affecting the chemical properties of the soil. Proper maintenance of vehicles and construction equipment will prevent such impacts.

The solid wastes that are generated from the domestic activities can affect the soil quality if disposed improperly. The solid wastes will be ensured to dispose in municipal solid waste disposal location to prevent the impact. Proper sanitation facilities will be provided for the construction workers. Mixing of concrete for small scale requirement on open land surface will cause percolation of cementations water deep into the land environment which will have an impact on the soil quality. This impact can be mitigated by mixing the concrete only on impervious surface or lined surfaces.

Reclamation from the dredged sediments will have impact on the land environment by altering the physical properties and increasing the organic load on the topsoil. This will result in change in the nutrient profile of the soil. Since the land area will not be utilized for any other activities other than fishing harbor development, this impact is ignored.

The proposed project has a positive impact on the land environment in which wastelands are converted to greenbelt area as part of the development.

4.4.2 Water Environment

4.4.2.1 Construction Phase

During construction phase, water requirement for construction activities will be met from water supplied through tankers. No ground water withdrawal will be made for the construction

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activities. Hence there is no impact on the ground water during construction phase. Approximately 9.6 KLD of sewage is expected to be generated from domestic and construction activities. The generated sewage will be treated in the soak pits and construction waste water will be stored in temporary retention tanks to avoid contamination of water environment due to run-off.

4.4.2.2 Operation Phase

During operation phase, water for activities such as fish processing, fish washing, fish box washing will be sourced from treated water from the STP and the Water Treatment plant, which will be sourced by water tankers. Water for the proposed ice plant, fishing vessel needs will be met from the fresh water. No withdrawal of ground water is envisaged during the operation period. Other than fish catch, no handling of liquid or solid cargo will be done during operation phase, therefore there will not be any impact on the ground water environment due to leaching. Surface-runoff from due to rain from roads and buildings will be collected and treated in the STP. This water will be utilized for greenbelt development and boat washing.

Refuse materials generated during the cruise shall be collected in a bag and stored on board until they are disposed to solid waste collection units. Disposal of such wastes will have an impact on the marine water quality and to marine organisms causing entanglement and ingestion. Diesel used in the vessel has a potential to contaminate the marine water if leaked due to refueling and storing.

4.4.3   Marine Environment

4.4.3.1 Construction Phase

The proposed training walls will be formed with natural stone of desired gradation. During dredging and construction of civil structures in waterfront area, the quality of marine water will be affected due to increased turbidity caused by suspension of sediments and construction materials (cement, concrete, oil and other lubricants) in the water column. The diaphragm walls will be of pile foundation and in-situ concrete super structure will also cause turbidity. These activities are temporary, and the physicochemical characteristics of the marine water will return to its natural condition, if not to its undisturbed condition, upon completion of construction activities. This impact can be localized by deploying silt curtains/booms around the activity area.

Sediments obtained from dredging will be utilized for land reclamation based on the suitability after proper screen and testing. The excess sediments after reclamation will be disposed off near the coast 200 m away from the proposed training wall. The disposed sediments will act as sand bank and prevent the loss of shoreline due to erosion as the coast above the northern training wall is identified as eroding zone from the model studies.

4.4.3.2 Operation Phase

Wash water from the boat deck can carry pollutants into the marine water. This will increase the turbidity of the marine water. This impact is considered to be localized temporary impact which will tend to disperse due to currents. But care should be taken to minimize the act of boat washing when the boat is berthed since the near shore currents are weak and are unable to carry the spilled waste water for dispersion.

Maintenance dredging will be carried out as and when required to the tune of 110000 Cum, causing increased suspension of sediments in the water column. Deployment of silt screens/booms will prevent the dispersion of suspended sediments away from the dredging area and mitigate the impact of surface sediment clouding.

4.4.4   Air Environment

4.4.4.1 Construction Phase

The major impacts on the air environment that are predicted to be caused during construction phase are dust arising due to construction activities. Airs borne dust generation are also expected to be caused during handling of bulk construction materials and cement bags. These dust emissions pose health risk to the persons involved in construction activity at site. Care should be taken in handling such materials. Covering of construction materials shall be done to prevent the dust generation. PPE shall be given to construction employees to protect them from the exposure to harmful cement dusts. Dust is also expected during site preparation and cleaning activities. Spraying of water, is recommended, on the surface of the working ground which will greatly reduce the generation of such dusts.

Air emissions from the D.G. sets used at construction site and emissions from material carrying vehicle and other construction equipment will have an impact on the air environment. Emissions

from the D.G. stack shall be mitigated by providing adequate stack height for safe dispersion into the atmosphere. Since D.G. that is complying with environmental regulations is used, no impact is envisaged. Vehicles entering the site shall maintain valid PUC certificate. Material carrying trucks shall be covered with tarpaulin to prevent the dust dispersion in to the atmosphere.

4.4.4.2 Operation Phase

The source of impacts on the air environment during operation phase is emission from boat engines, movement of vehicles, loading and unloading operations, D.G. sets when used and foul odor from fish drying and waste.

Due to unavailability of berthing space, boats keep their engines idle and near the berths. This will cause additional emissions to the air environment. This can be mitigated by proper planning of berthing facilities and proper boat traffic management. Since the internal roads of the proposed fishing harbor are paved, dust emissions from road due to vehicle movement are prevented. D.G. sets should be provided with stacks of adequate height for effective dispersion of emissions.

4.4.5   Noise Environment

4.4.5.1 Construction Phase

The noise sources that could cause impact during construction phase are earth moving machines such as roller, tractors and trucks, material handling machines such as concrete mixers and cranes, stationary machines such as generators and pumps and power tools.

The noise emissions from the above said sources will have an immediate impact on the personnel who are involved in operation of such units. The surrounding areas are also expected to be impacted from the noise during activities like pile driving and other heavy construction activities. Provision and usage of PPE during operation of such units must be strictly followed to mitigate the direct impacts. Proper lubrication and maintenance of machineries could reduce the generation of noise from the equipment.

Acoustic enclosures and mufflers for the D.G. sets and other power tools will also bring down the noise generation drastically. Potential noise impacts can be minimized by scheduling the construction works during daytime.

4.4.5.2 Operation Phase

The main sources of noise during operation phase are compressors, pumps and D.G. sets during operation in case of power failure.

Providing proper acoustic enclosure, silencers or mufflers, anti-vibrating pads will reduce the noise generation from the above said machineries. Persons who are employed in high noise areas shall be provided with PPEs/earplugs for protection.

4.4.6   Ecological Environment

4.4.6.1 Construction Phase

The development of the two fishing harbours is proposed on the intertidal region. Since the proposed area is devoid of sensitive vegetation, there are no major impacts envisaged on the intertidal flora. However, the proposed project area at Alamparaikuppam is sparsely vegetated with mangrove saplings which is of significant ecological importance. Removal of these species is proposed as part of site preparation activities. These mangrove saplings at site shall be transplanted at appropriate areas away from the project site upon consultation with the forest department.

Activities such as dredging pile driving, construction of berths may generate fine sediment into the water environment. These dispersed sediments will increase the suspended loading in the water column and thereby hindering the photosynthesis. This impact is said to be of temporary nature and the water environment will attain its original state after these activities are completed. This impact can be localized by deploying silt curtains/booms around the activity area.

In the proposed project area, no faunal species were observed. However, noise from the construction equipment could disturb the shore birds during its operation. Since the noise generation is not a permanent activity the activity would not affect the avifaunal population in the area on a longer term.

4.4.6.2 Operation Phase

During the operation phase, maintenance dredging of quantity 110000Cum is anticipated foreseen, therefore suspension of sediment particles in the water column is envisaged. But, due to gravity, settling will cause a layer of sediment on the surface of the marine bottom dwellers

that live adjacent to the dredging area. Therefore, to restrict the zone of impact due to the maintenance dredging deploying silt curtains/booms around the activity area is recommended.

4.4.7 Socio-Economic Environment

Livelihood enhancement: Viluppuram being a coastal district, there is a huge potential for large scale fishing activities. Since there are no fishing harbor located in the district and the nearest fishing harbor is located in Chennai or Puducherry. The local fishermen are doing small scale fishing as there is no scope for engaging large scale fishing as well as marketing the larger catches. The proposal for construction of fishing harbor in the Kaluveli waters will support the fishermen in effective utilization of the potential fishing region and safe anchoring of the vessels during the natural calamities.

Increase in the regional economy: Due to non-availability of the fishing harbor in the region, fishing is carried out in the smaller scale. The proposed fishing harbor will facilitate the large-scale fishing along with the associated facilities such as ice manufacturing industries, storage units, fish processing unites, etc. in the nearby vicinity which will improve the economic status of the region and also promotes foreign exchange through exports.

Traffic: The proposed fishing harbor is located in Azhagankuppam village which is adjacent to and connected by East Coast road which is prone to road accidents. Due to the proposed fishing harbor there will be a considerable increase in the traffic volume in the area. Measures such as proper signages, warning signals, etc. shall be taken up as part of the project to avoid accidents in the region.

5   ANALYSIS OF ALTERNATIVES

5.1   Azhagankuppam

5.1.1   Location Alternatives

Alternative site analysis for the proposed fishing harbour at Azhagankuppam of Villupuram district was done at 2 locations. The locations that were considered for analysis are shown in **Figure 5-1**.

Figure 5-1 Alternative locations considered for the proposed fishing harbor

Out of the 2 locations, the site located near Azhagankuppam (Loc-2) was selected for the proposed fishing harbour development. Site selection was done based on weightage given to the proposed locations on various aspects such as coastal stability, tranquility conditions, land acquisition, security concerns and several other factors. **Table 5-1** shows the site selection matrix with various factors on which the proposed locations were assessed.

Of all the two locations, Location 2 requires lesser dredging activity to be carried out to achieve the nominal depth to berth the fishing vessels. Also, lesser number of tree cutting is envisaged when compared to the other locations.

From the analysis, Location 2 seemed to be more feasible and with lesser impacts in comparison with the other two locations.

Table 5-1 Site Selection Matrix

S.No	Parameter	Marks Assigned	Location – 1	Location-2
1	Coastal Stability	5	5	5
2	Tranquility	5	5	5
3	Acquisition of Land	5	5	5
4	Resettlement & Rehabilitation	5	4	5
5	Capital Cost	5	2	3
6	Maintenance Cost	5	2	2
7	Security and Safety concerns	5	5	2
8	Stakeholder Benefit	5	4	5
9	Road Connectivity	5	4	4
10	Tree Cutting	5	2	4
11	Dredging	5	3	4
	Total	**50**	**41**	**44**

5.2 Alamparaikuppam

5.3 Location Alternatives

Alternative site analysis for the proposed fishing harbour at Alamparaikuppam of Chengalpattu district was done at 3 locations. The locations that were considered for analysis are shown in **Figure 5-2**.

Figure 5-2 Alternative locations considered for the proposed fishing harbor

Out of the 3 locations, the site located near Edaikazhinadu (Loc-3) was selected for the proposed fishing harbour development. Site selection was done based on weightage given to the proposed locations on various aspects such as coastal stability, tranquility conditions, land acquisition, security concerns and several other factors. **Table 5-2** Shows the site selection matrix with various factors on which the proposed locations were assessed.

Of all the three locations, Location 3 requires lesser dredging activity to be carried out to achieve the nominal depth to berth the fishing vessels. Also, land acquisition is not necessary for the proposed developments.

From the analysis, Location 3 seemed to be more feasible and tend to cause lesser impacts in comparison with the other two locations.

Table 5-2 Site Selection Matrix

S.No	Parameter	Marks Assigned	Location – 1	Location-2	Location-3
1	Coastal Stability	5	5	5	5
2	Tranquility	5	4	5	5

S.No	Parameter	Marks Assigned	Location – 1	Location-2	Location-3
3	Acquisition of Land	5	1	3	5
4	Resettlement & Rehabilitation	5	1	5	5
5	Capital Cost	5	3	4	4
6	Maintenance Cost	5	3	2	2
7	Security and Safety concerns	5	1	4	4
8	Stakeholder Benefit	5	2	4	5
9	Road Connectivity	5	1	5	5
10	Tree Cutting	5	5	2	2
11	Dredging	5	3	3	4
	Total	**50**	**29**	**42**	**46**

6 ENVIRONMENTAL MONITORING PLAN

The environmental monitoring plan is a systematic sampling of air, noise, water, soil and marine water to observe and study the environment based on the effectiveness of the mitigation measures applied. Environmental monitoring plan takes into account the mitigation measures that are highlighted in the **Chapter 4** of Environmental Assessment Report and to report to the regulatory authorities. This plan also helps in managing environmental as well as health and safety issues associated with the project. The adverse impacts or the potential risks arising from the implementation of the proposed project development can be prevented with a sound environmental monitoring plan that would support the Environmental Management Plan.

The baseline environmental conditions are studied to find out the existing scenario and the Environmental monitoring plan is developed in order to maintain the same environmental conditions or to maintain the environment with less damage or prevent from further damage that will be caused because of the proposed project. The primary objectives of the environmental monitoring plan are as follows,

- To define monitoring mechanisms and identify monitoring parameters.
- To monitor the performance of the project and implement the mitigation measures.
- To report to the designated authorities/statutory bodies in terms of the compliance with regulatory requirements.

The environmental monitoring plan is developed for two phases,

- Construction Phase
- Operation Phase

Environmental monitoring plan is suggested to monitor the environmental parameters during the above-mentioned phases of the proposed project and to provide caution in case if any environmental control measures fail to achieve.

6.1 Environmental Monitoring Plan during Construction Phase

The activities that will be undertaken during the construction phase are site preparation, earthwork, reclamation/ level raising, training wall construction and construction of building blocks, dredging and laying of internal roads. The impacts due to construction are discussed in

Chapter 4 and their respective mitigation measures are effectively applied during the construction phase in order to avoid the possible impacts.

The environmental monitoring plan during construction phase for Terrestrial and Marine environment is given in **Table 6-1**.

6.2 Environmental Monitoring Plan during Operation Phase

The major activities that will be undertaken during the operation phase are processing and storage of fish catch and maintenance of fishing vessels. During operation phase, regular inspections will be carried out and the environmental parameters as mentioned. The frequency of monitoring will be defined based on the operation. The environmental monitoring plan during operation phase for Terrestrial and Marine environment is given in

Table 6-2.

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Table 6-1 Environmental Monitoring Plan during Construction phase

Project Activity	Potential Risks and Impacts	Proposed Mitigation Measures	Indicators or Parameters to be monitored/ measured	Applicable Regulatory Requirement	Frequency of Measurement/ Monitoring	Institutional Responsibility	Implementation Schedule	Any other
Terrestrial Environment								
Land Environment								
Excavation for civil structures	Disposal of excavated soil	Excavated soil will be used for back-filling the excavated pits after completion of concreting and the balance quantity will be used for filling low-lying areas within harbor.	Site Inspection after completion of construction	Hazardous and Other Wastes Rules 2015, Solid Waste Management Rules 2015	After construction works complete	Main/ Sub- Contractor	During Soil Excavation Period	Physical Supervision
Air Environment								
Excavation and Civil Foundation Works	Dust emission and Air Pollution	Ambient Air Quality Monitoring near project site	$PM_{2.5}$, PM_{10}, SO_2, NO_2	NAAQS	Once in a month and random sampling will be done	Fisheries Department/Main Contractor	Construction Period	Ambient Air Quality Monitoring conducted through NABL Accredited Laboratory
Vehicle Exhaust	Gaseous Emission and Air Pollution	BS IV/VI Emission Norms complied Vehicle to be deployed	Pollution Under Control (PUC) Certificate shall be furnished to Main Contractor for vehicles deployed for project related works	NAAQS and CPCB guidelines for vehicular exhaust	Once in a year	Main Contractor/Sub Contractor	Construction Period	PUC certificate shall be obtained from Agency authorized by State Transport Authority, Government of Gujarat
Noise Environment								
Vehicle Movement	Nuisance and Noise Pollution	Proper maintained vehicles will be deployed for project related activities	Noise Level in Leq	NAAQS for Noise	Once in a month	Main Contractor	Construction Period	Noise Monitoring shall be monitored by Contractor using handheld noise meter
DG Set, Compressor, Construction Equipment Operation	Noise Pollution and Affects Hearing Loss of Workers	Acoustic Enclosure for DG Sets, Barriers for Compressor, Construction Equipment Isolation during works	Noise Level in Leq at 0.5m distance from DG Sets. For others ambient noise level shall be monitored	CPCB guidelines for emission from DG set and other construction equipment/machineries	Once in a month	Main/Sub Contractor	Construction Period	Contractor shall procure and train the person to monitor the noise level during construction period on daily basis.
Waste Management								

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Project Activity	Potential Risks and Impacts	Proposed Mitigation Measures	Indicators or Parameters to be monitored/ measured	Applicable Regulatory Requirement	Frequency of Measurement/ Monitoring	Institutional Responsibility	Implementation Schedule	Any other
Civil and Mechanical Works	Concrete Waste, Metal Scrap Waste and Waste Management	Concrete Waste shall be disposed to Landfill. Recyclable Scrap Waste shall be disposed to recyclers	Commitment from Sub/Main Contractor	Hazardous and Other Wastes Rules 2015, Solid Waste Management Rules 2015	Daily	Main Contractor	Construction Period	Log Book to be maintained for Waste Disposal
Capital Dredging of 411000 m³	TSS and Turbidity of Marine Water Quality	Silt Curtain and Boom shall be deployed	TSS, Turbidity and heavy metals viz., heavy metals viz., Cu, Zn, Hg, Fe, As, Se, Pb, Cd, Mn, Ni, Cr, Ba	Environmental (Protection) Rules 1986	Pre Dredging, Capital Dredging Period and Post dredging	Fisheries Department	At the time of Dredging Schedule	NABL accredited Lab shall be engaged for Monitoring Sea water quality
Marine Ecological Environment								
Construction of Training Wall	TSS and Turbidity of Marine Water Quality	Silt Curtain and Boom shall be deployed	pH, TSS, Turbidity, Salinity, and heavy metals viz., Cu, Zn, Hg, Fe, As, Se, Pb, Cd, Mn, Ni, Cr, Ba	Environmental (Protection) Rules 1986	Monthly	Main Contractor	Entire Construction Period	NABL accredited Lab shall be engaged for Monitoring Sea water quality
Capital Dredging	Migration of marine species and loss of Benthic species	Silt Curtains and Boom Dispersion Equipment	Collection of benthic samples	Environmental (Protection) Rules 1986	Monthly	Fisheries Department	Construction Operation Period	NABL accredited Lab shall be engaged for Monitoring Sea water quality
Oil Spill from Construction Equipment during Construction	Oil spill in to shoreline and seawater	Spill absorbing material shall be made available at project site Oil spill collection tray shall be provided at potential oil leak source if any	Visual Inspection of Stock contains Oil Spill absorbing material and Oil Spill Tray provided at Site shall be done by Supervisor appointed by Sub-Contractor/ Main Contractor	Hazardous and Other Wastes Rules 2015,	Daily	Main Contractor	Entire Construction Period	Log Book maintained for Oil Spill if any

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Table 6-2 Environmental Monitoring Plan during Operation phase

Project Activity	Potential Risks and Impacts	Proposed Mitigation Measures	Indicators or Parameters to be monitored/ measured	Applicable Regulatory Requirement	Frequency of Measurement/ Monitoring	Institutional Responsibility	Implementation Schedule	Any other
Terrestrial Environment								
Air Environment								
Vehicular Movement within Harbor Premises	Gaseous Emission – Affect Air Quality	Emission norms prescribed by Transport Authority of State Government	Sulphur Di-Oxide(SO_2), Nitrogen Di-Oxide (NO_2)	NAAQS and CPCB guidelines for vehicular exhaust	Twice a Week as per NAAQ Standards of CPCB	Fisheries Department	Operation Period	NABL Accredited Lab shall be engaged
Noise Environment								
Vehicular Movement within Harbor Premises	Ambient Noise Nuisance	Speed Limit of 30 KMPH shall be prescribed	Sign Board of 30KMPH displayed at Service Road	NAAQS for Noise	Every Day	Fisheries Department	Operation Period	Speed Governor on Vehicle shall be installed
Liquid Waste Management								
Sewage and Stormwater runoff from the harbour premises	Ground water contamination and hygiene	Establishment of STP, which is part of the proposed harbour development and recycling treated water for plantation	pH, TDS, DO, BOD, COD	CPCB guidelines	Once in a Year	Fisheries Department	Operation Period	
Waste Management								
Hazardous Waste – Used/Waste Oil	Hazardous Waste	Authorized Recyclers shall be identified for Reuse/Recycle	As per HWM Rules, 2016	Hazardous and Other Wastes Rules 2015	Once in a Year	Fisheries Department	Operation Period	As per HWM Rules, 2016 all records shall be maintained.
Green Belt Development								
Green Belt Development	Positive Impact	Pit Technique of Size 60x60x60cm to grow native species	Regular and Liberal Watering shall be provided for species	MoEF&CC guidelines	Monthly	Fisheries Department	Operation Period	Forests and Environment shall be consulted
Marine Environment								
Marine Ecological Monitoring								
Maintenance Dredging	Affect Marine biodiversity	Control the rate of dredging	Phytoplankton, Zooplankton and Benthos	Environmental (Protection) Rules 1986	During Dredging	Fisheries Department	Operation Period	Log Book
Marine Water Environment								
Maintenance Dredging	Affect Marine biodiversity	Control the rate of dredging	TSS, Turbidity,	Environmental (Protection) Rules 1986	During Dredging	Fisheries Department	Operation Period	Log Book

7 ADDITIONAL STUDIES

7.1 Modelling of Change in Coastal Features

The proposed northern and southern training wall will aid in achieving tranquil conditions which is necessary for the vessels for safe navigation. The impacts on the coastal features due to construction of training wall are discussed below.

7.1.1 Impact due to Training wall Construction

7.1.1.1 Impact on Hydrodynamics

Due to the proposed training wall, there is a significant reduction in the current speed within the harbor entrance region. In all the tidal conditions there is at least 30% reduction od current speed due to the proposed training wall. In the berthing region there is a slight increase (0.1 m/s) in the current speeds which meager when compared to the prevailing baseline conditions. This will not have an impact on the berthed vessels. Therefore, the proposed training wall has a positive impact on the hydrodynamics by aiding safe navigation and berthing of fishing vessels within the harbor basin. **Table 7-1**&**Table 7-2** show the current speeds which are observed during various tidal conditions for baseline and proposed development. The spatial variation of the current velocities during baseline and proposed conditions are shown in **Figure 7-1**&**Figure 7-2**.

Table 7-1 Modeled Current speed for baseline conditions

Location	Max. Spring Current[m/s]		Max. Neap Current [m/s]	
	Flood	Ebb	Flood	Ebb
Harbor Entrance	0.8-0.9	Above 1.2	0.4-0.5	0.9-0.1
Berthing	Below 0.1	0.1-0.2	Below 0.1	Below 0.1

Table 7-2 Modeled Current Speed due to Proposed Training wall

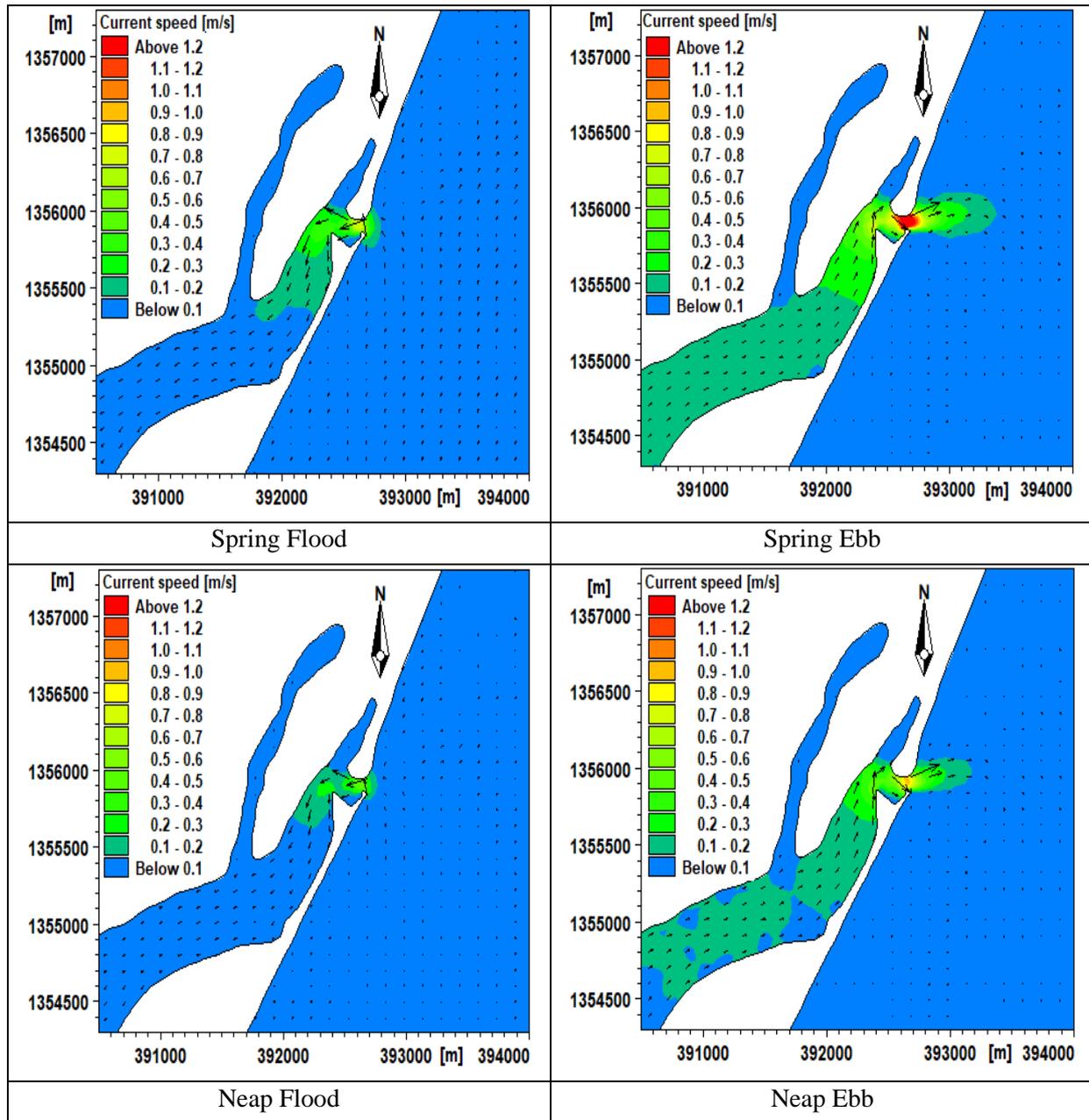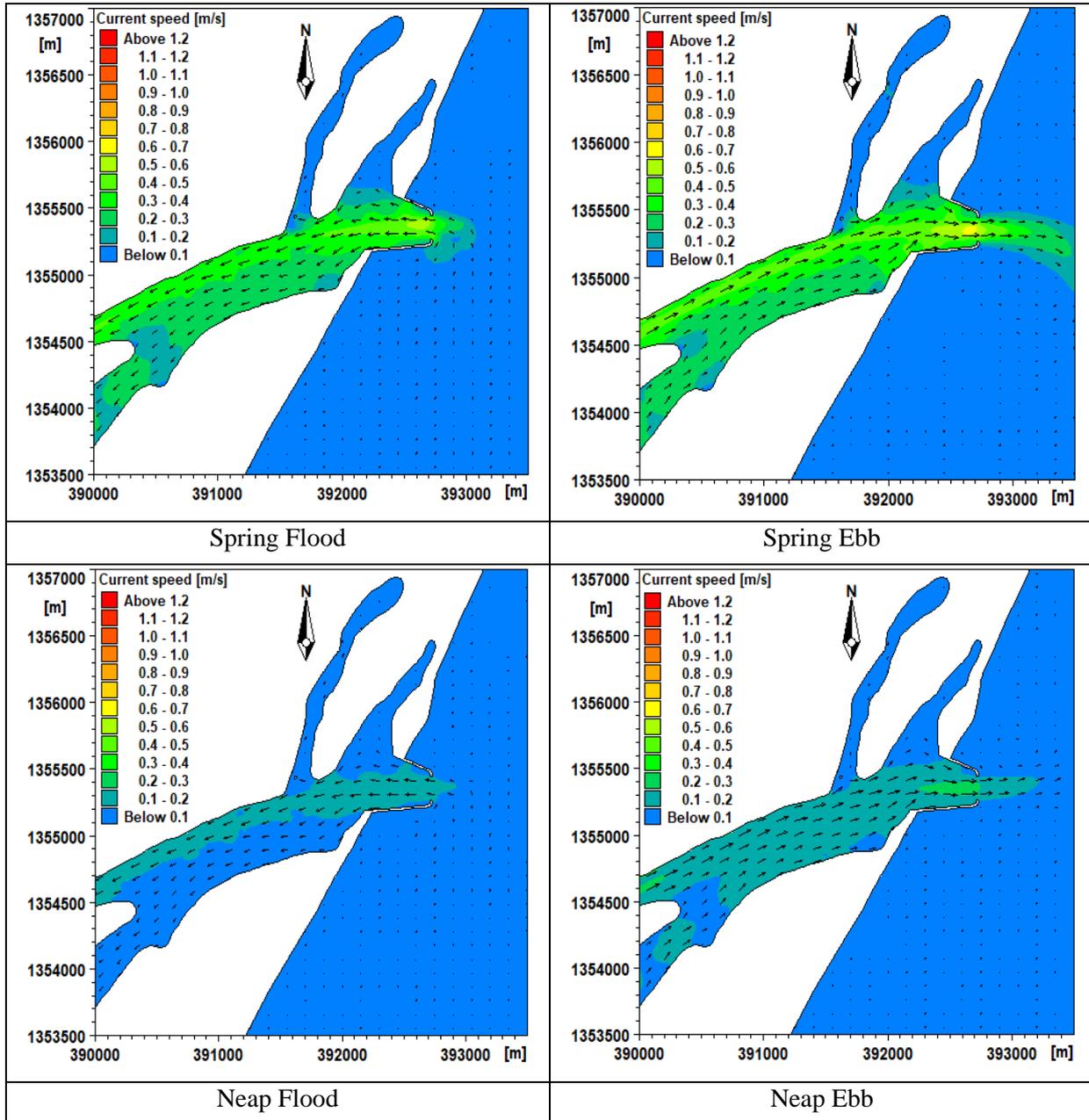| Location	Max. Spring Current[m/s]		Max. Neap Current [m/s]	
	Flood	Ebb	Flood	Ebb
Harbor Entrance	0.5-0.6	0.6-0.7	0.1-0.2	0.3-0.4
Berthing	0.1-0.2	0.2-0.3	Below 0.1	Below 0.1

Figure 7-1 Modeled Current Speed for baseline conditions

Spring Flood

Spring Ebb

Neap Flood

Neap Ebb

Figure 7-2 Modeled Current Speed due to Proposed Training wall

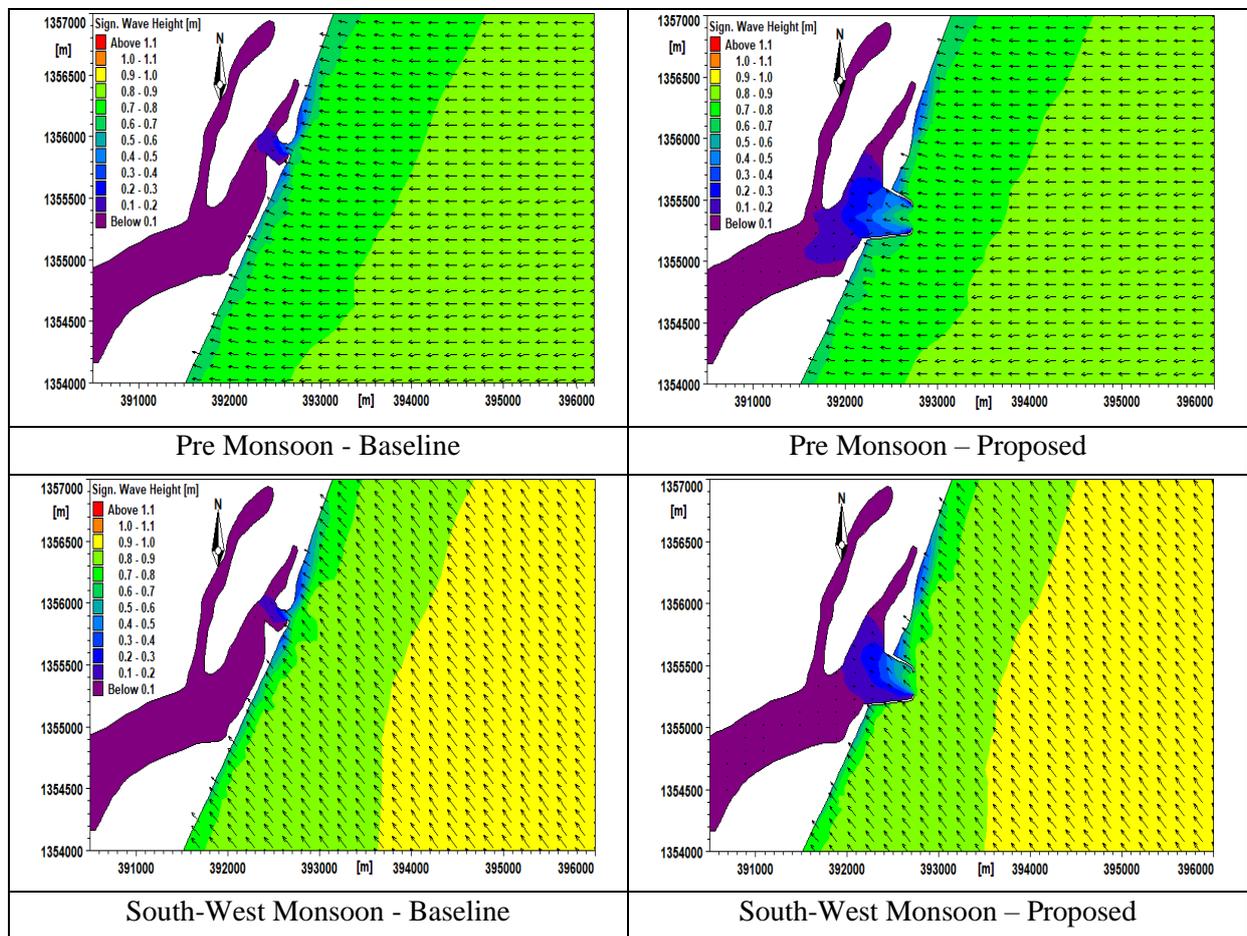| Spring Flood	Spring Ebb
Neap Flood	Neap Ebb

7.1.1.2 Impact on Tranquility

In the approach channel region, the significant wave height observed during baseline and proposed developments are similar in each case of the monsoon conditions. Only the spatial extent of occurrence of the waves has been altered due to the proposed training wall. Since the alteration in the wave conditions is local and limited within 500 m from the mouth opening of the estuary, there is no major change in the basin tranquility. This will help in safe navigation of fishing vessels inside the basin. The significant wave height observed during
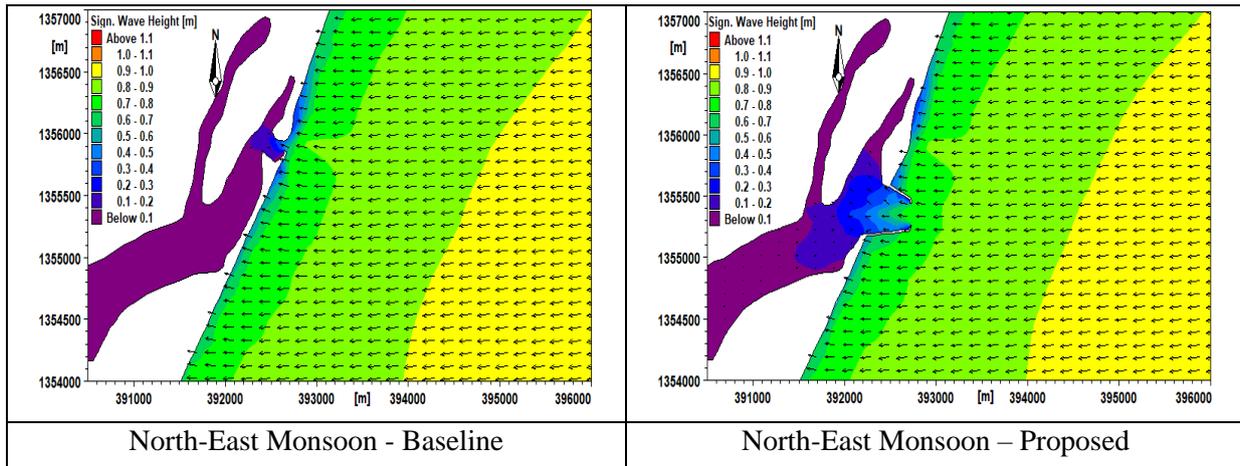
existing and proposed conditions are given in **Table 7-3** and the spatial variation is shown in **Figure 7-3**.

Table 7-3 Significant wave height for existing and proposed conditions

Location	Significant Wave Height (Baseline)			Significant Wave Height (Propsoed Developments)		
	Pre-Monsoon (m)	SE Monsoon (m)	NE Monsoon (m)	Pre-Monsoon (m)	SE Monsson (m)	NE Monsoon (m)
Harbor Entrance	0.4-0.5	0.4-0.5	0.4-0.5	0.4-0.5	0.4-0.5	0.4-0.5
Berthing	Below 0.1	Below 0.1	Below 0.1	Below 0.1	Below 0.1	Below 0.1

Figure 7-3 Significant wave height for existing and proposed conditions

Pre Monsoon - Baseline

Pre Monsoon – Proposed

South-West Monsoon - Baseline

South-West Monsoon – Proposed

North-East Monsoon - Baseline	North-East Monsoon – Proposed

7.1.1.3 Impact on Shoreline

Shoreline change model was done for the proposed developments to ascertain the littoral sediment transport. The model predicted shoreline changes for 1 year and 5 year are shown in Figure 7-4. Accretion is expected in the immediate vicinity of the proposed structures. The simulations indicate that under the baseline conditions the northward movement of the transport is in the order of 2,32,043 m^3/year, southward movement is in the order of 35,316 m^3/year and the net transport in the order of 1,96,727 m^3/year for the given wave conditions.

The following results have noticed from the littoral drift prediction:

- Northward movement of sand in the order of 2,32,043 m^3 and southward movement of sand in the order of 35,316 m^3 is noticed with the baseline conditions for 1 year.

- Northward movement of sand in the order of 1,56,482 m^3 and southward movement of sand in the order of 49,419 m^3 is noticed with the proposed training wall conditions for 1 year.

- Northward movement of sand in the order of 5,98,430 m^3 and southward movement of sand in the order of 1,15,867 m^3 is noticed with the proposed training wall conditions for 5 years.

The long shore sediment transport for the proposed development is given in **Table 7-4**.

Table 7-4 Long shore Sediment transport

Scenario	Northward movement (m^3)	Southward movement (m^3)
Baseline scenario- 1yr	232043	35316
Groyne scenario- 1yr	156482	49419
Groyne scenario- 5yr	598430	115867

Figure 7-4 Model predicted shoreline
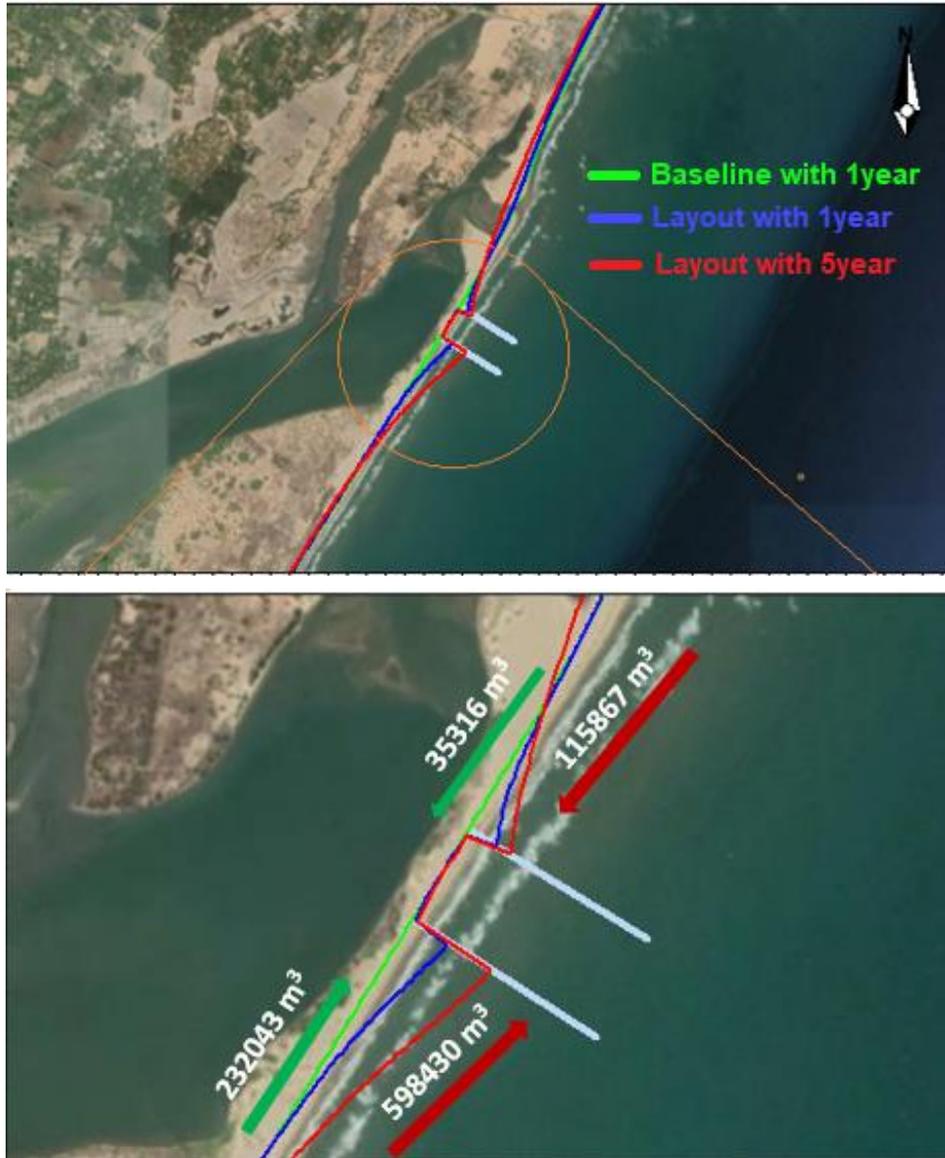
7.2 CRZ Mapping

CRZ mapping for the 7 Km study area was done by National Centre for Sustainable Coastal Management (NCSCM), Chennai, which is one of the MoEF&CC authorized CRZ mapping agency. According to CRZ notification 2011, CRZ zonation, HTL/LTL lines and sensitive areas (if any) identified within the study area were superimposed on CRZ maps of scale 1:4000 and 1:25000. The CRZ map prepared by NCSCM is attached as **Appendix I**.

The proposed developments are falling in the CRZ area as follows,

Proposed Development	CRZ Area
Proposed Fishing Harbor	CRZ – IB,

Proposed Development	CRZ Area
	CRZ-III (Alamparaikuppam), CRZ-II (Azhagankuppam)
Proposed Training Wall	CRZ-IB, CRZ – II, CRZ-III, CRZ-IVA.
Proposed Dredging	CRZ-IVB
Proposed Reclamation	CRZ – IB, CRZ-III (Alamparaikuppam), CRZ-II (Azhagankuppam)

7.3   Risk Analysis

Identification of risks that would arise due to the proposed project is necessary to draw up proper management plan during the time of disaster. These management plans would help in construction an action plan that would result in timely acknowledgement and effective mitigation/management of impacts. The following sections deals with the identification of various disasters and their counter responses for effective disaster management.

7.3.1   Natural Disasters

Since the project is proposed on the coastal region, it is more susceptible to natural disasters such as storm surge, cyclone and flooding events.

7.3.1.1 Cyclone

The Bay of Bengal experiences more cyclones than the Arabian Sea due to the increased sea surface temperature (SST) than in the Arabian Sea. As a result, the coastal regions of the east receive a greater number of cyclones. The cyclone hazard map published by Building Materials and Technology Promotion Council (BMTPC) is shown in **Figure 7-5**. From the figure, it is understood that the proposed project is exposed to cyclones of maximum sustained wind speeds of 64-90 Knots (118 to 166 Kmph).

Figure 7-5 Cyclone Hazard Map
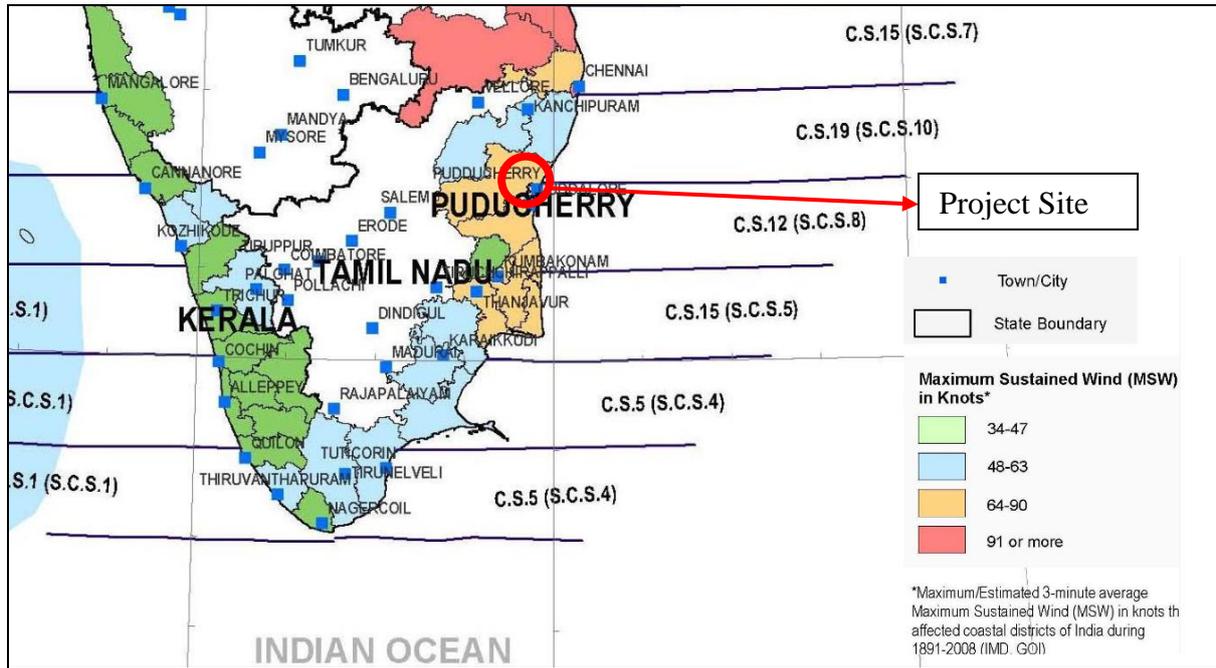
7.3.1.2 Flood & Storm Surge

Urban areas are more susceptible to flooding in short duration of time. The highly built-up environment possesses impervious layers which contribute to absolute run-off during adverse rainfall conditions. Since the major part of the study area is rural it does not experience flood during stormy weather conditions. This can be inferred from the flood hazard map published by BMTPC as shown in **Figure 7-6**.
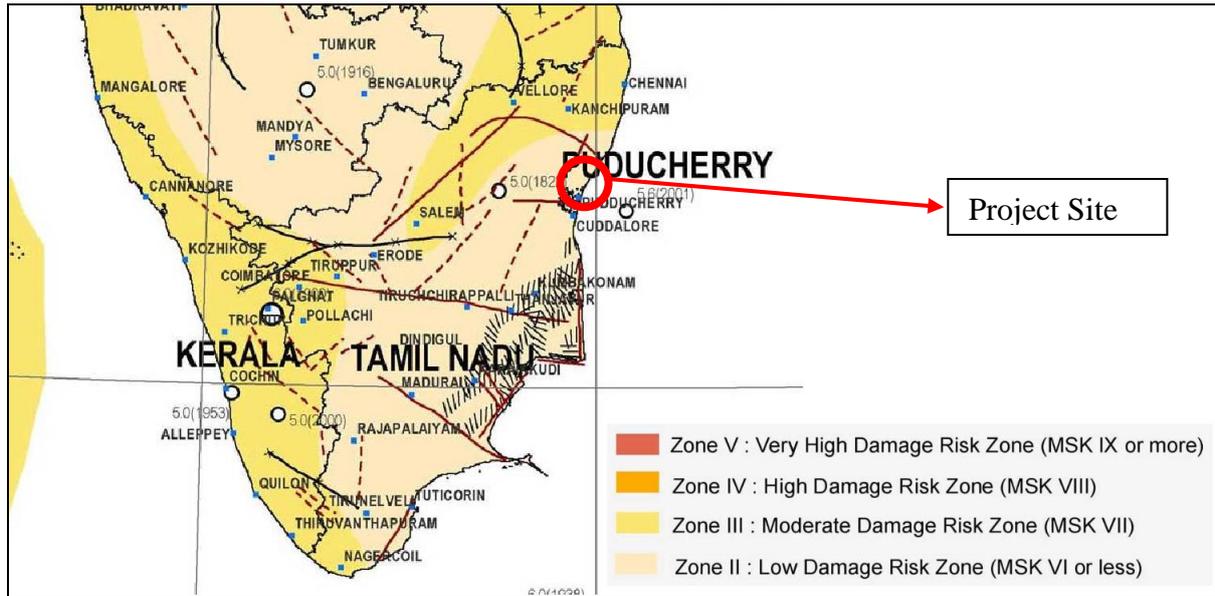
Figure 7-6 Flood Hazard Map
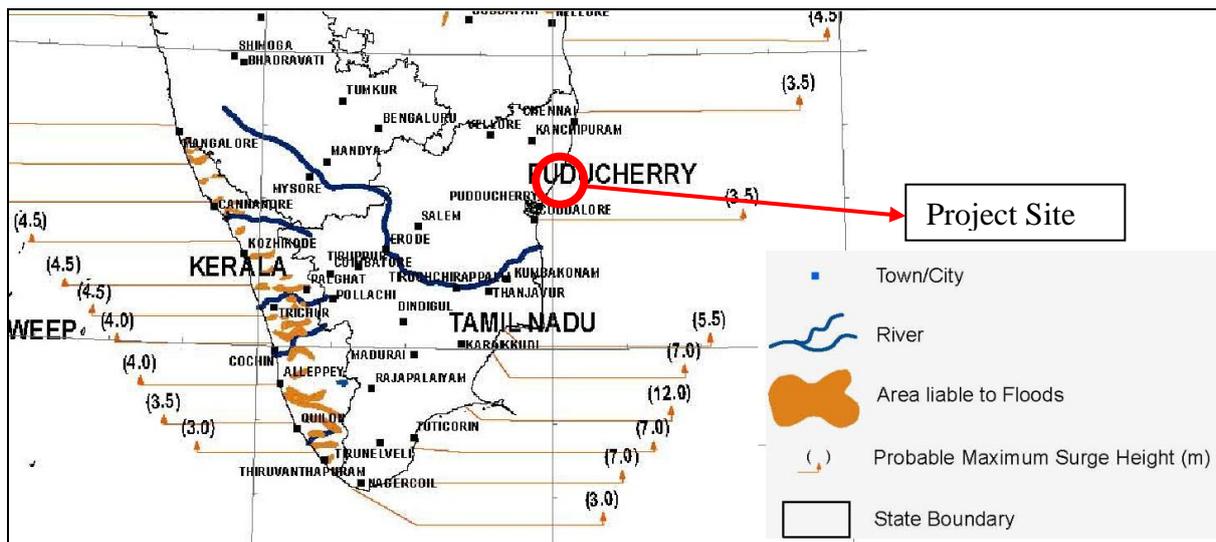
7.3.1.3 Earthquake

The proposed project site falls under Seismic Zone-II (Low damage risk zone – MSK VI) as identified in the map published by BMTPC as shown in **Figure 7-7**. The intensity of past earthquakes that hit Chennai region was in the range of 4.5-4.99 Mw (Moment Magnitude Scale)[8].

Figure 7-7 Earthquake Hazard Map

7.3.2 Manmade Disasters

In the event of negligence or absence of knowledge and supervision while conducting work, disasters could happen which may be catastrophic that could cause serious injuries and claim lives. Such disasters are termed as manmade disasters which happen due to human error. The possible manmade disasters that could take place are explained in the following sub sections.

7.3.2.1 Fire Hazard

The common hazard that could happen in any industry is fire hazard. This could happen due to short circuit, conducting hot work in unsafe environment and improper handling of combustible materials. Improper earthing of electrical equipment and generators that are used for backup power could cause fire outbreak. Improper storage of diesel for usage in generators may also lead to fire outbreak. To manage the fire hazard, the following firefighting instruments shall be located as follows,

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[8]*Menon, Et al,. (2010). Probabilistic Seismic Hazard Macrozonation of Tamil Nadu in Southern India. Bulletin of The Seismological Society of America*

Area	Type of Extinguisher	
	Foam Type	**Dry Chemical Powder**
Near Berthing area	2	2
In Harbor Office	1	2
In Auction Hall	1	1
In each fishing boat	-	1

7.4   Disaster Management Plan

7.4.1   Emergency Preparedness Plan

- Emergency Evacuation shall be initiated in the event of disaster.

- Emergency escape routes should be kept free from obstructions and sign boards showing the safe assembly points should be displayed all over the plant.

- Emergency alarms shall be installed in the plant and trigger points should be kept in easy reach. Presence of emergency alarm trigger points should be clearly displayed.

7.4.2   Storm Surge & Cyclone Management

The following management practices shall be done in the event of storm surge and cyclone,

- Generation of bulletin and notifications from INCOIS regarding storm surge shall be followed continuously for updates.

- Storm surge bulletins can be downloaded from INCOIS and actions can be planned accordingly.

- Based on the bulletins, evacuation plan shall be initiated.

- Workers should be evacuated to nearby cyclone shelters in the event of adverse impacts where assistance and medical help are readily accessible.

7.4.3   Fire Hazard Management

The following management practices will aid in preventing the fire hazards,

- Avoiding hot work if there is a possible alternative.

- Proper training of personnel about the site-specific hazards, proper policies and procedures and educating about the usage of safety equipment.

- Ensuring that the area is free from any flammable or combustible materials.

- Works safety manager issuing the work permit should do make a thorough assessment of the work site before issuing the work permit.

- Strict work permits system to be adopted and personnel without proper work permit should not be allowed to carry out works.

- Hot work should be carried out in the presence of safety supervisors.

- Proper wiring of exposed and damaged circuits.

- Overloading the electrical equipment should be done as it may cause an electrical fire.

- Implementation of reporting system in the event of electrical fires risks.

- Worker fire safety management trainings to be conducted to educate the personnel.

7.4.4 Oil Spill Contingency Plan (OSCP)

Diesel will be used as fuel for fishing vessels, ice crusher and other handling vehicles. To cater the fuel needs of the above said vehicles, a fuel yard is proposed as part of the fishing harbour development. The possibilities of oil spill are,

- Spill during refuelling.

- Spill during handling of diesel.

- Spill form boats engines and diesel storage in boats.

The proposed fishing harbour will be equipped with best oil spill management strategies, containment units and disposables.

7.4.4.1 Need for OSCP

Marine accidents and spillages from onboard diesel storage tanks will have an impact on the marine environment. Advanced preparedness for such foreseen events are of paramount importance to mitigate the impacts.

7.4.4.2 Classification of Oil Spills

According to Coast Guard, oil spill has been categorized into three types based on the quantity of spill involved.

- **Tier 1: <700 Tons**

Tier 1 is concerned with preparedness and immediate response to small spill within the capabilities of the facility. The facility should have the trained manpower and equipment to provide first response to spill in their areas. If additional assistance is required, help can be taken from local port authority. The proposed fishing harbour development falls in Tier-1 category.

- **Tier 2: >700 Tons, < 10000 Tons**

The ports that handle POL and chemicals fall into Tier-2 category.

- **Tier 3: >10000 Tons**

Spills requiring full resources of the district/region and which may require National assistance.

7.4.4.3 Spill Response

Assessment of spill based on weather conditions prior to the spill control will give an insight on the spill extent and direction. Based on the assessment procedures and containments can be adopted. The proposed fishing harbour will be have a dedicated spill response unit with the following team,

- Technical Team.
- Environmental Team.
- Logistics Team.

7.4.4.4 Oil Spill Containment and Control equipment

The following oil spill response equipments will be store in the port premises for emergency situations,

- Fixed type oil spill booms
- Oil Skimmer
- Oil absorbent roll
- Dispersant system hand pumps.
- Oil absorbent pads.

7.4.5 On-Site Emergency Plan

This management plan deals with the emergency situations due to accidents that may take place in harbour premises. The following information shall be archived for execution of effective emergency plan.

- Layout plan of the fishing harbour.
- Location of PPEs, portable fire extinguishers and other safety materials.
- Sources of water for firefighting systems.
- List of key personnel and their contact numbers.
- List of Government officials and areas for help with contact numbers.
- Communication facilities such as phones.

- Standby power arrangements.

In addition to the emergency management plan, the following facilities shall be developed,

- Emergency control centre.

- Safe assembly point.

- Safety Cell.

- Emergency Siren.

- Fire Pump.

- Marine rescue team.

GOVERNMENT OF TAMILNADU
DEPARTMENT OF FISHERIES

Development of Fishing Harbour in Kaluveli Waters at Azhagankuppam Village, Marakkaram Taluk, Viluppuram District and Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District, Tamil Nadu

Chola MS
RISK SERVICES

8 PROJECT BENEFITS

The proposed development of fishing harbors at Azhagankuppam and Alamparaikuppam by the Tamil Nadu Fisheries Department will contribute significantly towards increased fish catch and proper processing of fish for distribution to other parts of the district and the state. The proposed projects would result in direct and indirect benefits which are detailed below.

8.1 Direct Benefit

The project will give rise to increased employment to not only the fisher community at Azhagankuppam and Alamparaikuppam but also to the neighboring fishing villages who are devoid of the infrastructure. The processing and storage units that are proposed as part of the fishing harbors would lead to proper and hygienic handling of fishes which would aid in reducing the damage to the catch. The infrastructure proposed would facilitate in harboring both mechanized and motorized boats which subsequently increase the fish catch.

8.2 Induced Development

The proposed projects will lead to the development of small-scale fish-based cottage industries as well as large scale industries which will lead to further increase in employment in the region. The increased in employment and the improved revenue for the fisherfolks in the villages around the proposed fishing harbor will lead to improvement in the socioeconomic status. The quality of life in the region is likely to improve due to the improved employment and revenue generation. This improve revenue would also result in the increased contribution of the district to the state's economy.

9 ENVIRONMENTAL MANAGEMENT PLAN

This section presents the plan to manage the environment for effective sustenance of the environment from any potential impacts that may hamper the ambient condition of that environment due to the proposed development of the fishing harbours at Azhagankuppam, Viluppuram District and Alamparaikuppam, Chengalpattu District. The effectiveness of Environment Management Plan (EMP) shall be assessed by developing a post project monitoring program (PPMP), which has been presented in Chapter 6. Upon successful implementation of EMP and by adopting good engineering and operational practices during the construction and operation phases of the fishing harbor, there will be only a minimal impact on the environment, which can otherwise be considered as insignificant. The objectives of the Environmental Management Plan are as below.

- To identify key environmental issues envisaged to be encountered during construction and operation phases of the project
- To provide guidelines for appropriate mitigation measures
- To establish systems and procedures for implementing mitigation measures
- To ensure the mitigation measures are implemented
- To monitor the effectiveness of mitigation measures

9.1 Air Quality Management Plan – Construction Phase

9.1.1 Dredging/Excavation and Reclamation Processes

- To prevent sliding of soil from nearby areas during excavation process proper barriers and sheet pilling needs to be provided around the defined excavation area as falling/sliding soil causes suspended particulate matter leading to air pollution.

- Proper maintenance of excavation machinery and utilizing, machinery of latest emission standard will reduce pollution load on Air environment.

- During reclamation process dumping of excavated soil shall be restrained to a minimal height.

- Employing skilled workers for project activities to reduce human error and accidents.

- All the engine machinery, equipment and generators shall comply with CPCB vehicle engine test protocols and the reports should be submitted to Tamil Nadu Fisheries Department prior to deployment to the site and on yearly basis.

- Vehicles and machinery shall not be kept on idling mode when not in use.

- Regular maintenance of dredger/excavation vessel shall be done to limit the gaseous emission within minimal range.

- Regular wetting of land before excavation to reduce suspended particulate matter.

- During land reclamation process the site must be regularly watered and kept wet to avoid dust arising from dried up dredged materials.

9.1.2 Vehicle movement and Civil Construction Works

- Any stock pile of construction materials like stones, aggregate, etc shall be kept covered or water sprayed.

- During both loading and unloading activities of dusty materials water should be sprayed on them to maintain optimum moisture content.

- Emission from DG sets shall be monitored on periodical basis and maintained within prescribed standards.

- Open Stock yard or storage sheds where construction materials are stored shall be provided with wind barriers and screens to prevent dispersion.

- Vehicle movement on unpaved roads carrying construction materials, workers and equipment shall maintain optimal speed; reduce traffic induced dust dispersion and re-suspension of dust particles.

- Every vehicle shall be washed to remove dust from its body and wheels before leaving the site.

- The trucks carrying loads shall be cover with clean impervious tarpoline sheeting to ensure that the dusty materials do not disperse from the vehicles.

- All vehicles shall be free from any high noise and emissions polluting the environment. Vehicle emitting undesirable smoke and noise shall be withdrawn from service and properly maintained, or replacement shall be provided,

9.2   Air Quality Management Plan – Operation Phase

- The emission levels of DG sets shall be monitored regularly to maintain it below CPCB standards and regular maintenance shall be done.

- Sweeping of roads with mechanical equipment shall be followed

- Boats when offloading the catch shall turn of the engines to reduce the emissions

9.3   Noise Quality Management Plan – Construction Phase

- Installation of noise barriers around construction and reclamation site to prevent the spread of noise and reduce noise levels.

- Regular maintenance of construction equipment shall be done to maintain the levels below CPCB prescribed noise standards.

- All proposed project activities shall be executed during day time and avoid night time operations to prevent noise pollution at night.

- Auger piling method shall be adopted to minimize noise arising during piling. Hammer method of piling shall be avoided as it produces high noise levels.

- All vehicles utilized for the harbour associated activities shall be installed with mufflers to suppress noise levels.

- Noise levels arising from DG sets shall be maintained with CPCB standards.

- Ear plugs shall be provided to workers engaged in high noise areas.

9.4   Noise Quality Management Plan – Operation Phase

- Utilizing well maintained vehicles and machinery for harbour operation to avoid unnecessary noise.

- Noise levels arising from DG sets shall be maintained with CPCB standards.

- Harbour operation shall be limited to only daytime and night-time operation shall be avoided.

- Noise levels arising from DG sets shall be maintained with CPCB standards.

- Ear plugs shall be provided to workers engaged in high noise areas.

9.5   Water Quality Management Plan – Construction Phase

- Installation of silt screens and barriers shall be done along ends of the straights to prevent sliding of soil/sediments into adjacent water area during dredging and reclamation process.

- Regular monitoring of Kaluveli Waters' quality during dredging and reclamation process to monitor and regulate its characteristics.

- Proper management plan of water shall be adopted to utilize the approved water quantity in a sustainable way.

- Discharge of any surface runoff or drainage into the water bodies shall be regulated and treated in STP.

- Waste water/ storm water from construction site and other facilities needs to be routed through proper drains and collection pits. The treated water should meet the CPCB discharge standards.

- Skilled personnel shall be deployed at project site to avoid an accidental spillage of oil or other waste into the sea or estuary environment.

- Any hazardous chemicals and waste that may be generated due to the proposed construction activities shall be appropriately stored on site and stored on an impervious surface. Any accidental spills shall be handled promptly and disposed of in accordance with applicable TNPCB standards and regulations. The hazardous wastes shall be disposed through TNPCB authorized vendors.

- Hazardous Chemical Storage area shall be provided beyond CRZ area and clearly labelled and material safety data sheets maintained.

9.6   Water Quality Management Plan – Operation Phase

- The proposed STP shall be maintained on periodical basis to ensure the quality of water recycled and reused within the premises.

- Discharge of any form of pollutants or accidental spillage shall be regulated to avoid contamination of surface water bodies and groundwater table.

- The water sourced by tankers shall be treated in the water treatment plant and be made available for potable purpose for the users and workers within the harbour facility

- During operation, the sewerage system will be provided to collect the sewage from harbour administration and other utilities for treatment in the sewage treatment plant (STP) and the treated water can be used for non-potable purpose within the harbour and greenbelt development.

9.7 Soil Quality Management Plan – Construction Phase

- Storage of construction materials, equipment and heavy machinery shall be done on a clean impermeable surface.

- Any spill of concrete or other construction materials onto the soil shall be removed immediately and cleaned.

- During excavation and reclamation process sheet piling shall be done to avoid sliding of soil onto the surrounding environment.

- Suitable materials for reclamation process shall be selected.

- Spillage from trucks during transportation shall be avoided.

9.8 Soil Quality Management Plan – Operation Phase

- Mulching of soil shall be done to avoid soil erosion in the greenbelt area and land exposed to open air.

- During operation, the sewerage system will be provided for harbour administration and other utilities for treatment in the sewage treatment plant (STP) and no leakage onto soil is permitted.

9.9 Waste Management Plan

9.9.1 Construction and Demolition Waste

- The Contractor indulged for the harbor construction activity will be responsible for collection, segregation of concrete, soil and storage of construction and demolition waste generated, as directed or notified by the concerned local authority in consonance with Construction and Demolition Waste Management Rules, 2016

- Contractor shall ensure that other waste (such as solid waste or liquid) does not get mixed with this waste and is stored and disposed separately.

- Contractors shall ensure that project which generates 20 tons or more waste in one day or 300 tons per project in a month to be noted and shall be segregated into concrete, soil, steel, wood and plastics, bricks and mortar for which waste management plan will be submitted for getting appropriate approvals from the local authority before starting construction or demolition or re-modelling work and keep the concerned authorities informed regarding the relevant activities from the planning stage to implementation stage.

- Contractor shall keep the construction and demolition waste within the harbour premise or get the waste deposited at collection centers so made by the local body or handover it to the authorized processing facilities of construction and demolition waste;

- Also, ensure that there is no littering or deposition of construction and demolition waste so as to prevent obstruction to traffic or public or drains.

9.9.2 Hazardous Waste

- As per Hazardous Waste Management Rules, 2016, waste generator shall follow the hierarchy for management of hazardous waste namely prevention, minimization, reuse, recycling, recovery, utilization and safe disposal.

- A safe and environmentally sound management for disposal of hazardous waste shall be prepared and followed.

- Hazardous waste generated from the site shall be sent or sold to an authorized vendor or shall be disposed of in an authorized disposal facility in accordance with provisions of Hazardous Waste Management Rules 2016.

- Waste Generator shall take all steps while managing hazardous waste to contain contaminants and prevent accidents and limit their consequences on human beings and environment.

- Persons working in the site should be given appropriate training, equipment and the information necessary to ensure their safety.

- Proper Personal Protective Equipment (PPE) shall be provided to workers handling these wastes.

9.9.3 Solid Waste

- Proper collection and disposal of solid waste from all harbour facilities shall be in accordance with the Solid Waste management Rules, 2016.

- The solid waste from utilities like restaurant and fish storage units will be segregated as biodegradable and non-biodegradable waste and collected separately by providing bins at all these facilities.

- The collected biodegradable waste shall be subjected to composting and the compost will be used as manure for the development of green belt within the harbour.

- The non-consumable fish catch or the fish trash can be segregated and stored and be sent as raw material for fish meal industries.

- The non-biodegradable waste like plastic shall be disposed, as per the guidelines of Solid Waste Management Rules, 2016, through authorized vendors of TNPCB.

9.9.4 Stormwater Management Plan

The construction site Storm Water Management Plan shall include the following to prevent the contaminants from entering into storm water drain

- Designate areas for equipment maintenance and repair which include appropriate waste receivables for spent oil, used oil, greases and solvents and regular collection and disposal schedules to oil water separator facility.

- Storage areas shall be protected from storm water in accordance with MSDS for storage of chemicals, paints, solvents, acids and other potentially toxic water pollutants

- Storage areas for raw materials to be used in construction which can be carried over by stormwater run-off shall be located only in drainage areas controlled by retention type sediment catch basin.

- Routine site housekeeping can minimize non-sediment related pollutants from entering storm water run-off

- Sediments that may enter stormwater drain during rainfall, wash-down of construction equipment or from dust control activities can be controlled by properly maintained sediment catch basin.

- Avoid installation of storm drainage catch basins that discharge directly into water bodies.

9.9.5 Wastewater and Sewage Management Plan

- Sewage from Offices, buildings and other harbor facilities needs to be treated in the STP and utilized within the harbour premises for green belt development and dust suppression.

- Under no circumstance the sewage water, even post treatment shall be let into the sea or other surrounding water bodies.

9.10 Marine Environment Management Plan – Construction Phase

9.10.1 Dredging Management

As per IFC Guidelines for Ports and Harbours, dredging and dredge spoil disposal may impact marine habitats and pose a significant hazard to human health and environment, particularly if the sediments are contaminated by any form of pollutants. The following recommendations shall be implemented to avoid, minimize or control impacts from dredge materials as part of Marine Dredging Management Plan

9.10.1.1 Dredge Planning Activities

Prior to initiation of dredging activities, the following activities shall be undertaken

- Sediment sampling shall be done in areas where dredging is proposed and analyzed for their physical, chemical, biological and engineering properties in order to determine their purpose for reuse or disposal.

- Dredging shall be undertaken only when necessary, based on the assessment of the need for new infrastructure components or vessel navigation access to create or maintain safe navigation channels

9.10.1.2 Dredging

- The method of excavation and dredging should be selected to minimize the suspension of sediments, minimize destruction of benthic habitat, increase the accuracy of the operation, and maintain the density of the dredge material, especially if the dredge materials are composed of contaminations.

- There are several dredging methods which are commonly used depending on the depth of the sediment occurrence, type of sediments, occurrence of rocks and environmental concerns such as the need to minimize sediment suspension and increase dredging accuracy.

- Suitable dredging method shall be adopted based on the aforesaid parameters to minimize impact on the marine environment.

- Areas sensitive of marine life such as feeding, breeding, calving and spawning should be identified. In case of presence of sensitive species habitant area, dredging should be conducted in a manner to avoid fish migration or spawning seasons, routes and turtle nesting grounds.

- Use techniques (e.g. silt curtains for reclamation areas) to minimize adverse impacts on aquatic life from the re-suspension of sediments.

- Periodic inspection and monitoring of dredging activities should be conducted to evaluate the effectiveness of impact prevention strategies, and re-plan if necessary.

9.10.1.3 Disposal of Dredged Material

- Dredged material should be analysed in order to select appropriate disposal options (land reclamation).

- In the current proposal, the dedged spoil is proposed for reclamation for the development of the fishing harbour to a height of 3.00 m.

- The sand that is to be excavated for the construction of the training wall will be disposed on the shore at a distance of 200m from the northern training wall.

9.10.1.4 Civil Construction Works

- Construction of civil structure in the marine environment may lead to the spillage of concrete or other construction materials into water during construction of diaphragm wall and civil works on the landside, which shall be avoided by sheet piling techniques and immediate responsive action for collection of such spillage.

- Oil and chemicals from construction activities have to be cleaned; oil skimmers or suctions can be used if spillage has happened.

- Physicochemical properties of water need to be monitored post construction phase to verify non-contamination of baseline water quality.

- All construction works have to be carried out in such a manner duly complying with safety norms to avoid accidents resulting in loss of lives or contamination.

9.10.1.5 General Requirements

- The project proponent shall appoint a supervisor to be present always at construction site to monitor the activities.

- Construction site near waterfront needs to be kept clean to prevent tools and debris from falling into water and damaging the environment

- Any construction at or near the water edge or where debris can be washed or blown in to water requires silt screens, to be placed in the water before initiation of work.

- Screen/barriers shall be placed around storage areas, to prevent waste blowing away and sediment run-off into the waters.

- Storage areas for sand, soil and other construction material must be placed at least 20m away from the highwater mark.

- Deployment of sediment screen to minimize the sediment load in marine water as a result of capital and maintenance dredging.

- Setting up of sediment screens shall be carried out prior to commencement of dredging/ excavation activity.

- Monitoring sites shall be established to provide information on the water quality variation at dredge site and adjacent areas.

- Control of surface run off shall be directed through drains to settling tanks and guard ponds to prevent the sediments from the stockyard and other facilities entering into marine waters.

9.11 Marine Environment Management Plan – Operation Phase

The proposed fishing harbour will handle over 10,000 TPA of fish catch that will be undertaken by mechanized and motorized vessels. Also, the proposal contains boat building facility and repair dock. The movement of vessels and the activities in the aforesaid facilities could affect the marine environment. Besides, any unlikely event of vessel collision near the harbor could result in spillage of fuel and affect the marine environment. To avoid these accidents, the following measures shall be followed:

1. The spillage and wastewater from the fishing vessels should be prevented from discharging into the sea. The accidents caused due to vessel collision can be avoided by proper vessel traffic control and manoeuvring.

2. Fishermen shall be educated on oil spill response to tackle any unlikely event of fuel leak or spillage from vessels.

3. Regular maintenance of fishing vessels to avoid any spillage or leakage of fuel.

4. All the wastewater and sewage generated from the harbour operations must be treated in the STP. The treated water from STP should be used for non-potable purposes and greenbelt and park development within the proposed harbour.

5. Any pollution in the form of oil, solid waste, and wastewater spill will affect the marine ecosystem. To prevent this, treatment of such waste and proper waste management techniques shall be implemented.

9.12 Greenbelt Development

In consonance to the standard terms of reference for EIA report for project requiring environment clearance under EIA Notification 2006 of the Environment (Protection) Act, 1986, it is mandate to develop greenbelt for industries, commercial sites, buildings, and township. As part of the proposed development certain area within the layout has been earmarked for greenbelt development along the avenue of the harbour as well as in the form of a park. The greenbelt of area 0.1 Ha will be developed at either harbours and will be irrigated using the treated water from the proposed STP.

9.12.1 Objectives of Greenbelt Development

- To control the stormwater runoff, soil erosion and to improve the biological diversity of the area.

- To control air pollution caused due to harbour operation by strategic planning of plantation and floral species selection for the greenbelt, and to serve as a barrier to the noise produced from the harbour by absorbing the sound intensity.

9.12.2 Guidelines for Greenbelt

- Planting of local/native fast-growing trees around various sites of the proposed project

- Tree plantation should be undertaken in appropriate rows around the project site

- The trees should be protected by plantation of non-palatable shrubs species

- The greenbelt plantation should comprise of three tiers of zonation where tier 1 comprises of herb vegetation, tier 2 comprises of shrub vegetation, and tier 3 comprises of tree vegetation.

- The greenbelt should be efficiently landscaped for effective absorption and neutralisation of pollutants arising from the harbour operations and activities such as SO_x, NO_x, particulate matters, CO_2, and Volatile Organic Compounds (VOC).

- The selection of species for the development of greenbelt shall be done in accordance to the 'guidelines for developing greenbelt' by Central Pollution Control Board. Further, species selection shall be done in consultation with the forest department.

9.13 Administrative Aspects

The key benefits of EMP are that it provides the organization with the means of managing and improving its environmental performance thereby allowing it to contribute to better environmental quality. In order to administer the Environment Management Plan and to monitor its efficiency it is a mandate to establish an Environment Management Cell (EMC)

9.13.1 Environment Management Cell

The Environment Management Cell will closely monitor the environmental aspect of the proposed project and identify problems and accordingly suggests certain measures to mitigate

the same. The major duties and responsibilities of Environment Management Cell are as found below.

- Assure regulatory compliance with all relevant rules and regulations

- Ensure operation and maintenance of pollution control devices

- Adherence to EMP to minimize environmental impacts of construction and operation of the harbor.

- Implementation of environmental monitoring program

- Documentation of environment related and public grievance redressal records

The typical structure of the environmental cell is presented in **Figure 9-1**.

Figure 9-1 Organizational Setup of Environment Management Cell
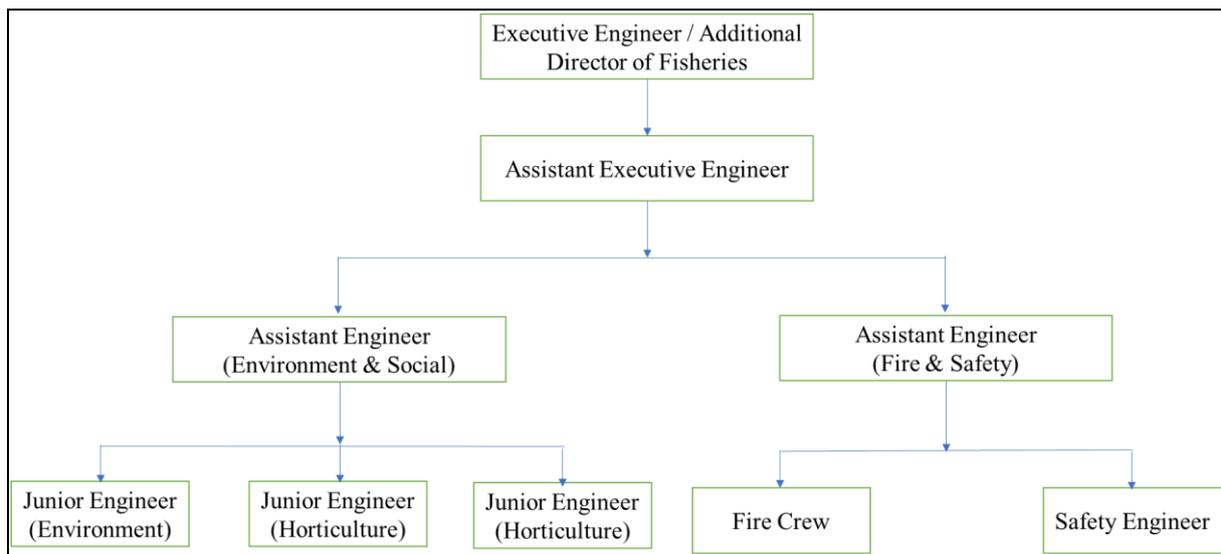
9.14 Environmental, Health and Safety Policy

The Tamil Nadu Fisheries Department shall adhere to the standard EHS policies for ports and harbours sector. Applicable ISO accreditations conforming environmental, health and safety shall be obtained once the harbour operations commence.

10 SUMMARY AND CONCLUSION

The Tamil Nadu Fisheries Department was established in the year 1974 as a state-owned public sector undertaking. Fisheries Department is making sincere efforts to create awareness on the positive health aspects of sea food.

The existing fishing harbors in the state are overcrowded and unavailability of fishing harbors with adequate facilities in many districts. There is an exigency to develop a fishing harbor which will help the fishermen in increasing the monetary value of their fish catch by providing facilities that would offer hygienic processing and storage.

In this regard, the Government of Tamilnadu (GoT) intends to develop two fishing harbor of capacity 12000 TPA each with all amenities in Kaluveli Waters at Azhagankuppam in Viluppuram District and Alamparaikuppam in Chengalpattu District. The two proposed fishing harbours at Azhagankuppam and Alamparaikuppam would facilitate handling of 110 mechanized fishing vessels and 300 motorized boats in each harbour.

The two fishing harbours would be developed in the land owned by the Fisheries Department, Govt. of Tamil Nadu. The area of the two harbours is 3.23 Ha for Azhagankuppam Fishing Harbour and 3.43 Ha for Alamparaikuppam Fishing Harbour, respectively. To facilitate the movement of fishing vessels into the Kaluveli Waters excavation of the sand bar is proposed along with the construction of two training walls. The two fishing harbours will be developed allied facilities to handle the fish catch with storage facilities, auction hall, net mending areas, etc. They are also facilitated with 15 KLD STP to treat the sewage and waste water from the buildings and cleaning of the fish catch.

Environmental baseline studies have been conducted based on which impacts have been identified. Environmental management plans (EMP) have been derived based on the identified impacts. The devised management plan will be sufficient to mitigate the impacts that would arise during the construction and operation of the project.

The project will give rise to increased employment to not only the fisher community at Azhagankuppam and Alamparaikuppam, but also to the neighboring fishing villages who are devoid of the infrastructure to process and store their daily catches. The processing and storage units that are proposed as part of the fishing harbor would lead to proper and hygienic handling of fishes which would aid in reducing the damage to the catch.

The proposed project will lead to the development of small-scale fish-based cottage industries as well as large scale industries which will lead to further increase in employment in the region. The increased in employment and the improved revenue for the fisherfolks in the villages around the proposed fishing harbor will lead to improvement in the socioeconomic status. The quality of life in the region is likely to improve due to the improved employment and revenue generation. This improve revenue would also result in the increased contribution of the district to the state's economy.